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Cold-Rolling Strip Steel

by Edward K. Hammond

As its name implies, cold-rolled steel is produced by rolling the metal cold, and two noteworthy advantages are obtained in this way: First, the tendency to oxidize and form a scale, which cannot be avoided when steel is rolled hot, is entirely overcome by cold-rolling, so that the steel may be given what is known as a "bright" finish. Second, the avoidance of oxidation enables the gage of the steel to be held within very close limits; on the thicker gages the limit of accuracy is within 0.0015 inch, while the thinnest gages are guaranteed to be within 0.00025 inch of the specified thickness. Also, the process of cold-rolling enables steel to be rolled true to gage as thin as 0.003 inch, which would not be practicable with hot metal because of uneven heating and expansion.

BELIEF in the possibility of keeping trade secrets has been more strongly relied upon in conducting various metallurgical operations than has been the case in many other industries. Progressive manufacturers of the present generation have generally acknowledged the fact that it is exceedingly difficult, if not impossible, to hold a trade secret inviolate; and recognizing this fact, they have come to place more reliance upon perfecting every detail of each manufacturing operation, instead of expecting to attain or hold commercial supremacy by the possession of secret methods with which competitors are unfamiliar. Reliance in trade secrets has probably been responsible for the lack of published information concerning methods employed in the manufacture of cold-rolled steel; at least very little information has been published on this subject, and, as a result, the following article which describes the methods employed in the production of cold-rolled strip steel at the plant of the Schwartz-Herrmann Steel Co., Floral Park, Somerville, N. J., should prove of material interest to readers of MACHINERY.

Cold-rolled steel possesses several advantages which cannot be secured with metal that is rolled hot. Most noteworthy of these is the fact that rolling the metal cold enables it to be given a so-called "bright" finish; that is to say, there is no oxide or stains on its surface. Where the steel is rolled hot, this advantage cannot be obtained, because hot metal is easily attacked by oxygen of the air that results in forming the well-known scale with which heated metal is covered. Those who have had experience in the working of sheet steel know that this oxide scale is exceedingly hard, and that it exerts a very harmful effect on the dies. For this reason, cold-rolled steel is in demand for use in the manufacture of various pressed steel products. In addition to the advantage secured through the absence of scale in working cold-rolled steel under the punch press, the possibility of rolling steel without forming any scale has another important advantage. Sheet metal produced in this way can be rolled very thin—the limit being about 0.003 inch—and the thickness can be held within close limits. It will be evident that this would be utterly impossible if the metal were at a red heat, because the production of scale would not only cause considerable variation in the gage of the metal, but with extremely thin sheets it would actually result in its complete destruction.

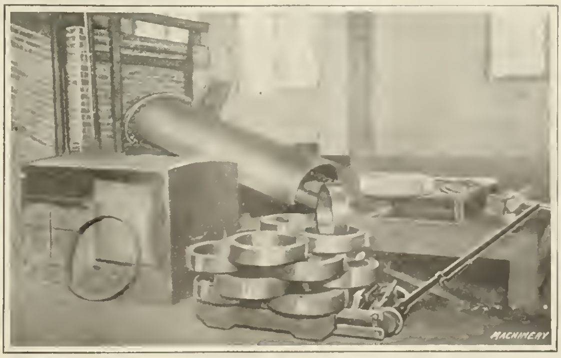

Fig. 1. Entering End of Gas Medium Furnace for annealing Steel

Raw Materials of the Industry

Mills engaged in the manufacture of cold-rolled steel secure their raw material in the form of hot-rolled ribbon stock of thickness somewhat greater than that of the cold-rolled steel which is to be produced. The treatment of this material in early stages of the process will differ according to its carbon content. With steel which does not contain over 0.30 per cent of carbon, it is unnecessary to conduct a preliminary annealing process; but steel with more than 30 points of carbon must be annealed before the rolling

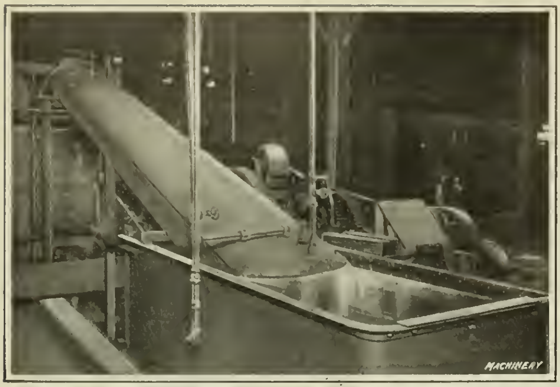

Fig. 2. Delivery End of Gas Medium Furnace—note Arrangement of Water Seal

can be started. For the purpose of describing the method of manufacturing cold-rolled steel in this article, we will assume that the mill is working on high-carbon steel which requires a preliminary annealing in order to make it soft enough to be rolled advantageously. Three forms of annealing furnaces are employed for this purpose, and the selection of the particular form of furnace to use will depend upon the analysis of the metal. These furnaces are known as the "gas medium" annealing furnace, the "pot" annealing furnace, and the "muffle" annealing furnace. In the muffle furnace the metal is heated in contact with the air, so that an oxide scale is formed over it, while in the pot furnace and the gas medium furnace the metal is protected from the air, so that all tendency to oxidize is avoided. One of the latter types of furnaces is generally used, but the muffle or "scale" annealing furnace is employed where the stock which is to be converted into cold-rolled steel

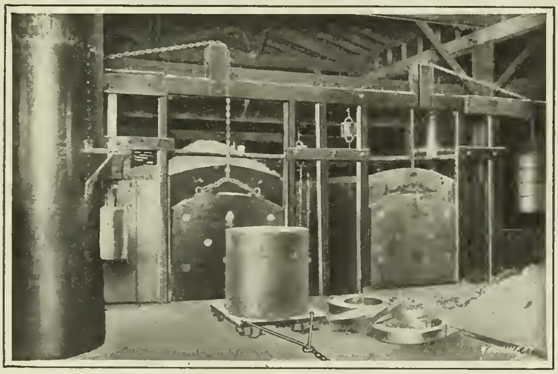

Fig. 3. Pot Annealing Furnace, showing Pot just drawn out

has been treated in such a way that its surface has become decarbonized. With such material the production of a scale on the surface of the steel is an advantage, because it removes that part of the metal from which the carbon has been withdrawn. This will be referred to in more detail in connection with the description of the pickling process. In all types of furnaces, the temperature employed varies from 1150–1300 degrees F., according to the carbon content of the steel.

Gas Medium Furnace

The process of annealing steel in the gas medium furnace consists primarily of raising its temperature to the required degree and then allowing the metal to cool slowly. This result is accomplished by placing the coils of ribbon stock on a chain conveyor which carries them through the furnace. The conveyor is driven by an electric motor which transmits power through a train of high reduction gearing, so that it takes about six hours for the steel to pass through the furnace. The conveyor carries the steel through a steel tube surrounded with firebrick in the heating furnace, which is built around the portion of this tube in which the heating of the steel is conducted. The furnace is of simple construction, consisting of a checker work of firebrick which is kept at a red heat by the combustion of producer gas; and in order that the furnace may operate at the maximum economy, the draft in this furnace is arranged in such a way that the gas and hot products of combustion pass through the furnace in a winding course which has somewhat the form of the letter S. In this way the gases leave the furnace at a relatively low temperature, having given up most of their heat to the brick checker work.

As the essential difference between hot-rolled and cold-rolled steel is that the latter is entirely free from oxide scale—and

Fig. 4. Pots of Steel and Special Hoist for lifting them—note Central Hole in Pots to allow Heat to enter from All Sides

as the method of manufacture is carried on with the view of eliminating scale—it will be evident that in the preliminary treatment of the metal it is desirable to avoid scaling as far as possible. Such being the case, the annealing must be conducted in an atmosphere which is free of oxygen, and this result is obtained by having the tube in the annealing furnace filled with produced gas. This gas enters the tube at one end and passes through to the opposite end, where there is a burner that provides for consuming the gas as it leaves the tube. It will be seen from Fig. 1 that the conveyor tube rises at a gradual angle until it has passed through the furnace, after which it drops to the floor level, where the end of the tube dips into a water seal shown in Fig. 2. In passing through

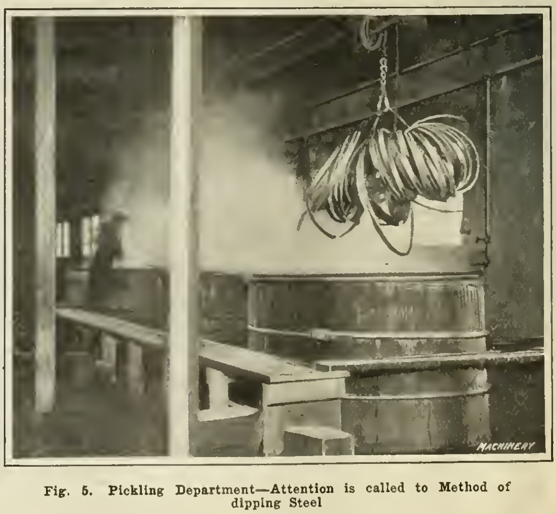

Fig. 5. Pickling Department—Attention is called to Method of dipping Steel

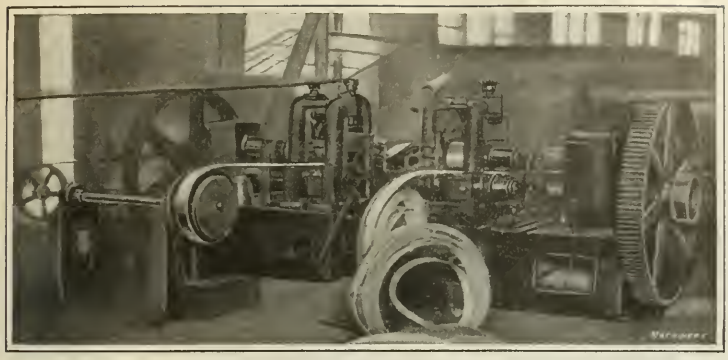

Fig. 6. Cold-rolling Strip Steel

the portion of the tube contained in the furnace, the temperature of the steel is raised to the degree required by the composition of the steel, after which it is carried along by the slowly moving conveyor, so that its temperature is allowed to drop very gradually, and this results in annealing the steel so that it is soft enough to be worked under the rolls. The steel is quite cold at the time it reaches the water seal at the far end of the tube, and although it is immersed in the water before leaving the conveyor, this does not result in the production of any serious amount of scale or rust. It takes about six hours for a coil of steel to pass through the furnace, and the rate of production is from 15,000 to 20,000 pounds in twenty-four hours. The furnace is in operation continuously.

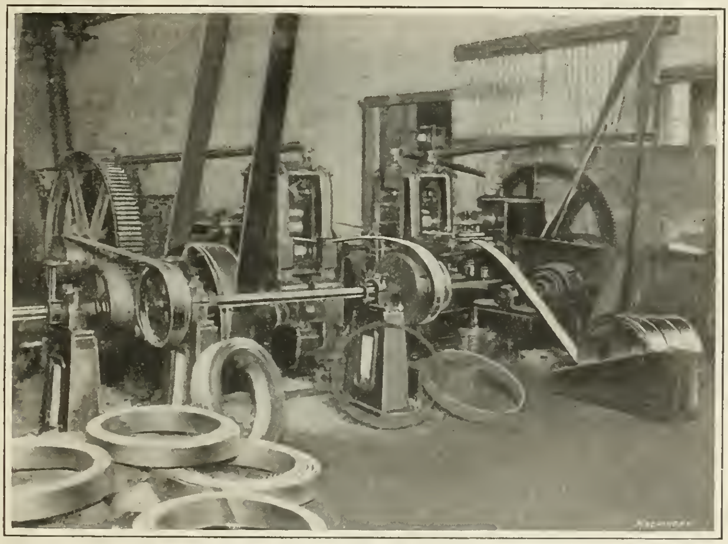

Fig. 7. Rolling Strip Steel—First Pass is made through Mill in Background, and Second Pass through Front Mill

Pot Annealing Furnace

In the pot annealing furnace, as in the type of furnace which has just been described, the object is to conduct the annealing operation in such a way that there will not be any tendency to form scale on the metal. In pot furnaces, the coils of metal are placed in steel pots and packed with fine iron borings, after which the cover is put on the pot and the joint sealed with fireclay. The iron borings serve to exclude air from the pot and also to assist in taking up oxygen from the small amount of air which is left; in addition, they have been found to possess the power of absorbing foreign matter from the surface of the steel which would otherwise result in the production of stains on the bright surface of the cold-rolled metal. Each of the pots in which the steel is annealed has a capacity of 1000 pounds of steel coils, and they are of the form shown in Figs. 3 and 4. It will be evident from these illustrations that there is a draft up through the center of the pot and lid, the purpose of this construction being to allow the heat to reach the metal from all sides. Eight pots can be held in each furnace at a time. It takes about twelve hours to anneal the steel in this furnace, making the capacity about 16,000 pounds of steel in twenty-four hours.

The furnaces in which the pot annealing operation is conducted are similar in form to muffle furnaces except that they are provided with doors at the front and back. Gas and air enter the furnace through ports arranged alternately all the way down one side. The flame rises to the arch, from which it is deflected to the opposite side of the furnace and escapes through a similar series of ports to those through which the air and gas are admitted. Running along the floor of the furnace there is a track for the wheels of trucks on which the annealing pots are carried. In connection with the annealing operation, the method of withdrawing the pots is important. It has been mentioned that there is a door at both ends of the furnace, and when one pot has been in the furnace for the required length of time, the back door is opened and this pot is withdrawn and allowed to stand for about eighteen hours in order to allow the steel to become quite cool before the cover is taken off. After withdrawing this pot, the back door is closed and the front door of the furnace is then opened and a truck carrying a pot of unannealed steel coils is pushed in, with the result that all the pots in the furnace are moved toward the back. It will be evident from this that the operation is continuous. Small "peep holes" in the furnace doors provide means of viewing the interior of the furnace without opening the large door.

Muffle Annealing Furnace

The muffle furnace, in which the steel is given what the cold-rolled steel maker designates a "scale anneal," is of exactly the same form as the furnace in which the pot annealing operation is conducted; but in operating this furnace the coils of steel are placed on trucks where they are exposed to the action of an oxidizing atmosphere. These trucks are passed through the furnace in the same way that trucks carrying the annealing pots are handled, and the steel comes out coated with an oxide scale which results in removing a certain amount of metal from the surface of the stock during the subsequent process of pickling. As previously mentioned, this method of an-

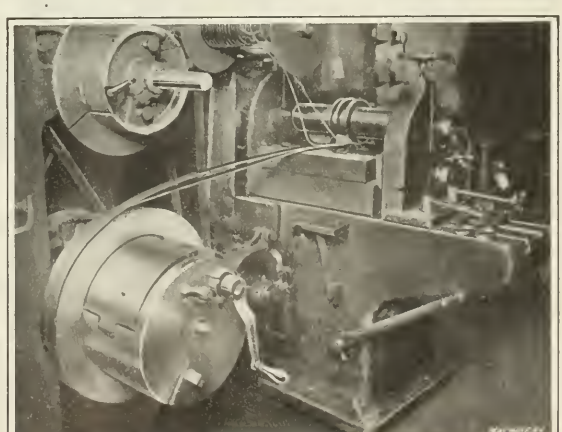

Fig. 8. Splitting Wide Strip into Two Narrow Strips and trimming Edges—note how Scrap is wound up on Upper Reel

nealing is only employed in the case of steel which has become decarbonized at the surface, the scale anneal serving to remove the decarbonized metal. It requires about $2\frac{1}{2}$ hours to perform the annealing process in this type of furnace; and after being removed, three hours are required for the steel to cool sufficiently to be sent to the pickling department. The rate of production is about the same as that of the pot annealing furnace.

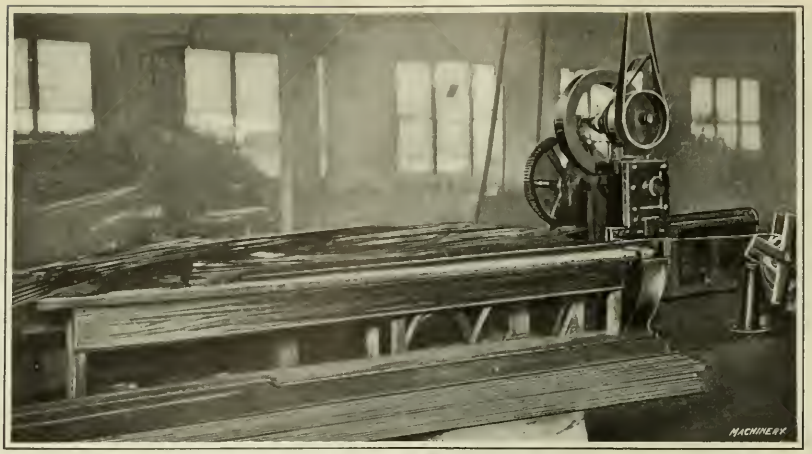

Fig. 9. Cutting Bench and Shear for cutting up Strip Steel into Stock Lengths

Pickling

The preceding description of the preliminary annealing process to which the steel is subjected refers to metal containing not less than 0.30 per cent of carbon, and after such steel has been annealed, it goes to the pickling department, where it is subjected to a treatment which removes all the oxide scale that was produced on the metal during the hot-rolling operations by which it was drawn out from the ingot into the form of ribbon stock. Steel with less than 30 points of carbon does not need a preliminary annealing, but goes direct to the pickling department. From this it will be evident that, after annealing, high-carbon steel is treated in the same way as steel with a low-carbon content, so that the following description applies to both classes of material.

The pickling process consists of immersing the rolls of steel in vats of sulphuric acid which acts upon the metal and causes the scale to be removed. This acid is contained in wooden vats which are furnished with steam pipes for heating the acid so that it will act more rapidly. The acid consists of a 5 per cent solution of sulphuric acid which has a density of 66 degrees Beaumé at a temperature of 60 degrees F. In pickling, the coils of steel must be loosened sufficiently so that the acid can easily find its way between the surfaces of the metal. The coils are supported on wooden frames which are lifted by a Yale & Towne electric hoist that runs on a track passing over the vats, the arrangement of the trolley and vats being shown in Fig. 5. These frames are dropped so that their ends are supported by the sides of the vat while the metal is immersed. In the case of low-carbon steel, the time that the metal is left in the vat is not important, as it may be immersed for as long as fifteen minutes without being damaged. With high-carbon steel, however, great care must be taken, as it requires about three or four minutes to remove the scale, while leaving the steel in the acid for a greater length of time will result in withdrawing carbon from the metal. The removal of the scale from the steel is the result of a combined chemical and mechanical action. The sulphuric acid reacts with the iron to liberate hydrogen gas which sets up a pressure between the steel and the scale and results in stripping off the scale. It is important for the stock to be uniformly covered with scale before pickling; otherwise, the pickled stock will have a "pitted" surface and, therefore, cannot be converted into good cold-rolled steel.

Fig. 10. Special Multiple Filing Machine for finishing Edges of Strip Steel

After the pickling operation has been completed, the steel must be washed immediately in order to remove the acid. This is done by lifting out the wooden frames from the acid vats and running them along on the hoist so that they may be dropped into similar vats filled with pure water which washes away the acid so that further action upon the steel is prevented. The removal of the acid would probably be effectually done by washing in water, but to make assurance doubly sure, the steel is removed from the water and plunged into a vat containing a dilute solution of lime water. The chemist has found that lime has the power to neutralize acid, but in the case of preparing steel for cold rolling, the use of lime water has a further advantage. This is due to the fact that when the steel is removed from the vats and given time to dry, it is coated with a film of lime which keeps both air and moisture from coming into contact with the metal, and so prevents it from rusting. It requires a "boss cleaner" and three helpers to look after a battery of two acid vats, one water tank and one lime water vat. The output is 2000 pounds of steel per hour.

Cold-rolling Operation

The cold rolling is done in mills built by the Rheinische Walzmaschinen Fabrik of Cöln-Ehrenfeld, Germany, shown in Figs. 6 and 7. Two sizes of mills are used which have rolls six and eight inches in diameter; and although both mills can be used for many sizes of stock, it is found economical to distribute the work among the mills according to its size. In cold rolling it is highly important to avoid chatter and vibration, as such a condition would be shown by irregularities in the surface of the product. This provision is well taken care of by having the power transmitted to the rolls through herringbone gears and shackle bars which serve as a double precaution against vibration and result in a very uniform transmission. The rolls are made of hardened chrome-vanadium steel containing a small percentage of tungsten, and are carefully ground to give them a very smooth finish. While in operation the rolls are water cooled by a continuous stream of water that flows through a pocket in the center of each roll. Those who are familiar with

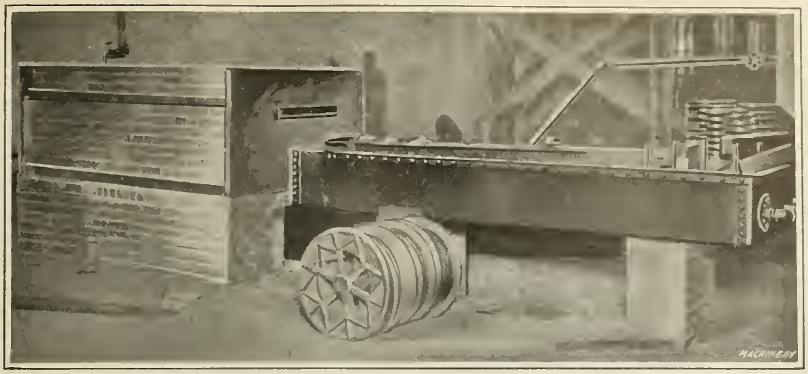

Fig. 11. Heating and Quenching Baths for hardening Strip Steel

cold-rolling mills will know that the position of the lower roll is fixed, while the upper roll may be adjusted to provide for the production of metal of various thicknesses. The chief roller becomes very proficient in setting the machines for rolling any gage of metal and is able to obtain very quickly the required adjustment. The setting is made by adjusting the rolls and testing the thickness of steel passed between them with a micrometer; then, if necessary, further adjustment is made until the desired result is obtained.

On the entering side of the mill there is a frame which supports an emery cloth wiper through which the steel runs in order to remove all foreign matter which might result in damaging the rolls. The mills are set to run in opposite directions, and arranged in series so that successive passes of the metal may be made through adjacent machines until the desired reduction has been obtained. The rolls are lubricated with a special grade of oil known as "Roll Oil," which is of about the same consistency as cylinder oil, but very carefully compounded to be sure that it is neither acid nor alkaline, as either condition would spoil the "bright" finish of the cold-rolled steel. After each two passes through the mill, the steel must be sent back to the annealing furnaces in order to remove strains which have been introduced through the mechanical working. In cases where the customer calls for steel which is "soft," it will be subjected to a final annealing operation after it has been rolled to the required thickness. Where "half hard" stock is called for, the steel receives one final pass through the rolls after being annealed. Other customers may order "hard" stock which has not been annealed, and their requirements will be fulfilled by subjecting the steel to two passes through the rolling mill after the last annealing operation has been performed.

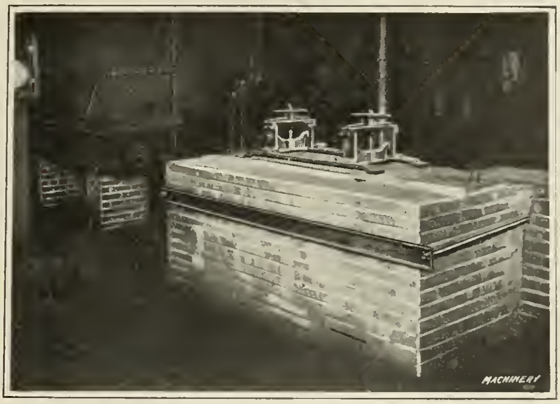

Fig. 12. Tempering Bath through which Steel is drawn after leaving Quenching Bath

The amount of reduction which can be obtained for each pass through the rolling mills depends upon the analysis of the steel; with low-carbon steel the reduction may be as great as 0.022 inch for each pass, and this will be gradually decreased until the final pass will only reduce the thickness of the metal about 0.005 inch. In the case of high-carbon stock, the reduction at each pass through the mill is much less; during the preliminary passes, this will amount to not more than 0.010 inch for each pass, while the reduction will be gradually decreased until the final pass reduces the thickness of the metal by only 0.003 inch. The degree of accuracy obtained in the gage of the metal is very great; in the thicker gages the variation will not exceed 0.0015 inch, while in the thinnest gages the limit of error is reduced to 0.00025 inch.

Trimming the Edges and Slitting Stock

After the rolling operation has been completed, the subsequent treatment of the cold-rolled steel will depend upon the use for which it is intended. For some purposes it is merely necessary to trim the edges so that the stock is of uniform width, while in other instances these edges must be finished in such a way that they are made quite smooth. Then for some uses, the steel must be hardened and tempered, while

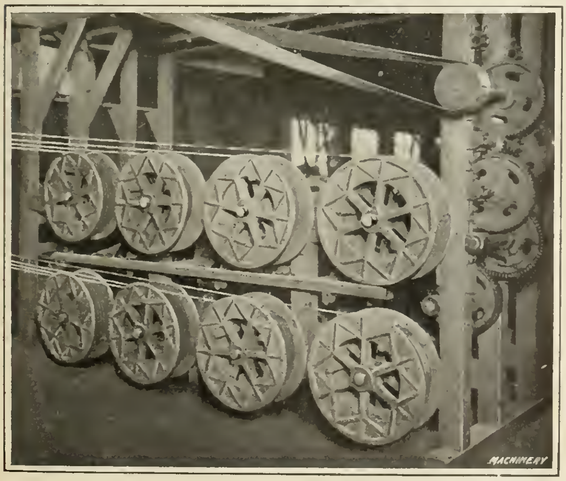

Fig. 13. Reels on which Strip Steel is wound after Heat-treating Operation is completed

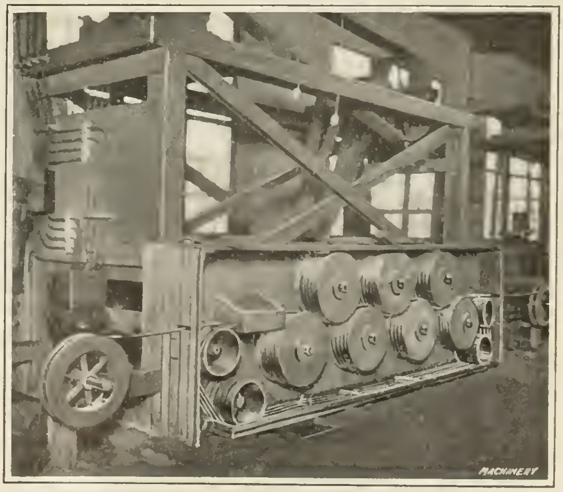

Fig. 14. Special Polishing Machine designed for applying High Finish to Strip Steel

other purchasers require it to be "dead soft." Some customers of the cold-rolled steel maker will also call for steel with a high polish, and still others are not particular about this point. As the production of all these features are important departments of cold-rolled steel manufacture, they will be described in the order in which the successive operations are performed.

For trimming the edges of the steel to reduce it to uniform width, use is made of a rolling mill fitted with rotary shear blades which are set at the required distance apart. The steel is passed through these blades from a reel on which the coil is supported; and after being reduced to standard width, it is rolled up on another reel at the opposite side of the mill. At the same time, a second reel winds up the trimming from the edges of the stock, and this scrap is pressed into bales and returned to the mill where the hot-rolled steel stock was produced. The same form of rotary shear is employed for slitting steel when it is desired to reduce stock of one width into two or more strips of lesser widths. The arrangement will be readily understood by referring to Fig. 8, which shows a mill set up for trimming the edges of the stock and slitting it into two narrow strips.

Finishing Edges of Stock

In those cases where it is required to have the edges of the strip steel brought to a smooth finish, use is made of a simple but ingenious multiple filing machine which provides for producing a smooth edge which may be either square or round. This machine is shown in Fig. 10, and consists of a table which supports a series of cross-slides made of wood that are grooved at both sides to receive tongues secured to the table. The ends of these slides are provided with short pieces of flat files, and the slides at opposite sides of the table are fitted with springs which tend to draw them together. In operation, the coil of strip steel, supported by a reel at one end of the table, is drawn between this series of files and then wound on a reel at the opposite end. It will be evident that in passing between the files, the edges of the steel are smoothed down; and by having all the files perpendicular to the plane of the steel a square edge is imparted, while arranging the files at a variety of different angles results in rounding the edges of the stock.

Cutting Strips Into Stock Lengths

After the edges of the cold-rolled steel have been trimmed—and finished in cases where the users' requirements make this operation necessary—some of the strip steel is cut up into standard stock lengths. For this purpose a measuring bench and shear are arranged as shown in Fig. 9; the coil of steel is mounted on a reel shown at the extreme right, and the steel is pulled between the shear blades so that a piece of the required length may be cut off, the length being indicated by a scale marked on the bench for that purpose. With this machine one man and a helper can very rapidly cut up steel into any lengths which may be required.

Hardening and Tempering

Purchasers of cold-rolled steel who use the material for making springs, and for various other purposes, call for steel which has been tempered; and for this purpose the cold-rolled steel maker must provide his mill with equipment for doing this work. One successful method of heat-treatment is applied as follows: The steel in the form of a coil is mounted on a reel and connected with a "leader" which provides for drawing it through the heating and quenching mediums at the proper speed. The steel is first run through a lead bath and its temperature raised to about 1450 degrees F., according to the analysis of the steel, after which it is quenched in oil; then the steel passes on through a second lead bath which provides for drawing the temperature at from 780 to 800 degrees F., after which the metal is wound on a second reel. A variable-speed motor is used for drawing the steel through the furnace, and this motor transmits power through a series of herring-bone reduction gears which provide for drawing the steel through at exactly the proper speed.

The lead bath is located in the furnace shown at the left in Fig. 11, and the oil bath in which the steel is quenched is contained in the metal tank at the right-hand side of this illustration. After passing through the oil bath, the steel is drawn through the tempering bath which is contained in the brick furnace shown in Fig. 12; this illustration also shows the hardening and quenching baths at the left-hand side. When the steel has been tempered, it passes onto the reels shown in Fig. 13, upon which the coils of steel are wound up. It will be evident from this illustration that provision is made for heat-treating eight coils of steel simultaneously; all the reels shown in Fig. 13 are driven from a single motor, power being transmitted through a train of high-reduction herring-bone gears which provide for drawing the steel through the hardening and tempering baths at the proper speed.

The preceding description applies to the method of heating the thicker gages of steel; in the case of the thinner gages, exactly the same method and form of equipment is employed, except that the metal is quenched in a lead bath which is kept just above the melting point, *i. e.*, at about 630 degrees F. This results in making the steel practically "glass hard"; but it is the plan to employ an alloy of lower melting temperature in order that it may be possible to have the steel even harder for those purchasers who demand such a condition. The object of quenching the thin steel in a lead bath is that it avoids the tendency to crack and become very crooked, which is a constant source of trouble where the steel is hardened in oil.

Polishing

For certain purposes there is a demand for cold-rolled steel with a high polish, and to meet the requirements of such users the steel is taken from the hardening and tempering department and subjected to a polishing treatment. This is done on machines provided with a series of rolls over which the steel runs, one of these machines being shown in Fig. 14. Upon entering, it passes through a box containing moist emery powder which must be extremely fine, powder from No. 80 to No. 100 being generally used. The steel carries away some of this emery with it, and in passing over the basswood rolls a rubbing action takes place which imparts a high polish to the steel. Upon leaving the machine, the metal passes between a series of wipers which effectually remove any emery which is left on the metal.

Conclusion

In referring to the desirable properties given to steel by the cold-rolling process, mention was made of the fact that cold-rolled steel is given a "bright" finish without any rust or oxide on the metal; but in order for the customer to secure the benefit of this high finish, great care must be exercised in packing the steel for shipment in order to prevent it from rusting while in transit. This is done by first wrapping the steel in oil paper and then covering the package with a thick layer of burlap. In the case of coils, the oil paper is wound around the steel and then the burlap is sewed around the entire coil; where the steel has been cut up into stock lengths, bundles of steel are wrapped in oil paper and burlap, and then the entire bundle is packed in a shipping box. In this way it is practically impossible for moisture to cause the steel to rust and lose its finish.

Cold-rolled strip steel is made by the Schwartz-Herrmann Steel Co. in widths ranging from 3/8 inch up to 4 3/16 inches; and the thickness of the product covers a range from 0.003 to 0.083 inch. On the thicker gages, the steel is guaranteed to come within 0.0015 inch of the specified thickness; and this limit of error is gradually reduced, so that it is possible to furnish the thinnest stock with a guarantee that the error in thickness does not amount to more than 0.00025 inch. To any experienced mechanic it will at once be apparent that the possibility of securing such a high degree of accuracy can only result through exercising absolute care in carrying out every step of the process of manufacture.

* * *

A novel use of the phonograph is made in weighing machines for speaking the weight. The weight is announced in a sonorous voice: "One hundred-and-fifty;" "two-hundred-and-three," etc.

INSPECTING LATHES*

WORK OF INSPECTION ENGINEER IN SEEING THAT SPECIFICATIONS ARE FULFILLED

BY JOHN J. RALPH†

THE purpose of this article is to explain the work of the inspection engineer who is employed by the purchaser of engine lathes to watch the process of manufacture and inspect the finished machines to see that all contract specifications are fulfilled. Three general topics are treated, *viz.*, the form of contract under which lathes are often purchased, the work of the inspector in investigating processes of manufacture, and current practice in inspecting finished lathes. Many shops that are having trouble with their lathe work because of the inaccuracy of the machines may find suggestions for overcoming the difficulty; and in this connection it cannot be too strongly emphasized that time and money spent in putting lathes into good working condition will pay large dividends in the form of an improvement in the quality of the work produced.

The Contract

The contract under which lathes are purchased usually specifies make of lathe, size, auxiliary equipment to be furnished, shipping dates, and penalty (if any) for nonfulfillment of any part of the contract. Specifications are also incorporated which call for the use of sound material, first-class workmanship, and inspection during the process of manufacture and before acceptance. It will be noted that these items are very indefinite—especially the one relating to the quality of workmanship. The design of the lathe is not subject to inspection; and ordinarily no mention is made of the maximum duty required of the lathe or the degree of accuracy of the work produced on it. In addition to seeing that all terms of the contract are fulfilled, the inspector is usually required to expedite delivery and to report the progress which is being made by the manufacturer toward completing the order.

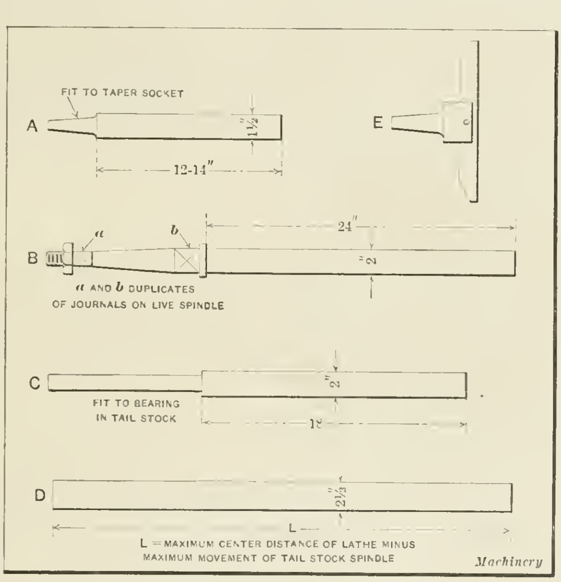

Fig. 1. Different Forms of Test Bars used in making Alignment Tests on Lathes

Relations between Inspector and Lathe Builder

In the machine tool trade, the employment of an inspection engineer to look out for the interests of the purchaser is a comparatively recent proposition, and the arrival of the inspector at the factory usually causes the employes to experience mixed emotions, none of which are likely to be pleasant even in the case of factories that build first-class tools. If he is tactless, inexperienced or dishonest, he is sure to cause trouble and expense, particularly in cases where the machine tool builder feels that his product does not need inspection. There is a deeper reason, however, for disputes arising through the employment of an inspection engineer: this is that there is often no recognized standard of accuracy in the shop; and as there is no maximum allowable error and no minimum limit of accuracy, it will be evident that there is plenty of room for an honest difference of opinion. "Good" and "first-class" workmanship are purely relative terms, and are subject to as wide a range of interpretation as the proverbial "hair" which varies from the eighth inch of the blacksmith to the fraction of a thousandth inch of the toolmaker. If the machine tool builder has no standard of reference, and his competitors have none, a dispute is likely to arise that is not adequately covered by the terms of the contract and in which, according to the terms, the purchaser's ruling is final.

The question of delivery is also likely to cause trouble, as the average shop is exceedingly lax in maintaining manufacturing schedules and has become accustomed to having the sales department make reductions in promised dates of delivery which were originally quite short. The presence of a purchaser's representative in the shop will be likely to assist the purchaser in gaining prompt deliveries, and this is one of the points which must be looked after by the inspector, although he should remember that the machine tool builder has many other customers who are also pressing him for deliveries, and he should avoid taking an unreasonable stand. Also, it should be borne in mind that extreme rapidity in manufacturing is likely to result in a proportional reduction in the quality of workmanship, so that the inspector should not make the error of over-emphasizing the importance of early delivery. Before leaving the question of the relations between the inspector and machine tool builder, attention should be called to the fact that the presence of an inspector in the factory is really a benefit to the builder of first-class machine tools, as it insures the fulfillment of all of the purchaser's requirements before shipment is made, and so avoids the possibility of subsequent trouble and expense. Furthermore, satisfactory reports from the inspector are often the best possible form of sales literature and bring repeat orders to the machine tool builder with no effort on his part beyond the submitting of quotations.

The Inspection

The inspection starts with the receipt of raw materials in the factory and includes a constant observation of the manufacture of all parts in order that defective workmanship may be promptly detected and rejected. Then, when the machine has been assembled, tests are made of the alignment of all working parts and correct operation of the mechanism. The inspector is expected to make a count of all items before shipment and to be sure that the method of packing is such that there will be no danger of damage in shipping.

Upon his arrival at the factory, the inspector's first step will be to make a complete study of the manufacturing operations involved in producing each machine in which he is interested. This is necessary so that he may know how the parts are made and whether there is possibility of trouble through the use of jigs which are likely to become inaccurate or operations that depend upon the workman's judgment. Particular attention should also be paid to the condition of all the machines used in the factory, in order that those that are liable to turn out defective work may be watched. There are often

* For other articles published in MACHINERY dealing with the subject of testing machine tools, see "Efficiency Test of a Stockbridge Shaper," May, 1914; "Milling Machine Dynamometer," November, 1913; "Inspection Tests for Cincinnati Gear Cutting Machines," October, 1913; "Lo-swing Lathe Test on Motor Armature Shafts," April, 1913; "Method of Testing Lathe Spindle Alignment," June, 1912; "The Testing of Spirit Levels," April, 1912; "Aligning the Spindles of a Multiple-spindle Drill Press," October, 1911; "Testing a Cylindrical Grinder," July, 1911; "Machine Tool Testing," February, 1911; and other articles there referred to.

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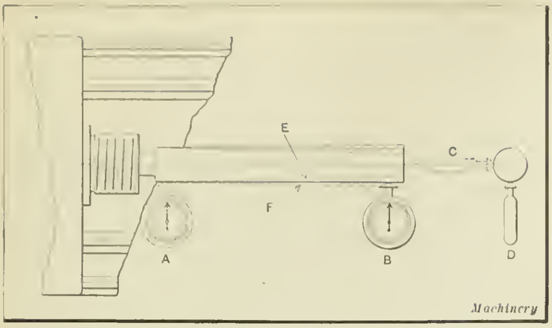

Fig. 2. Diagram showing Method of Procedure in testing Alignment of Lathe Spindle with Ways

places where partial inspections can be made, which will make it necessary to perform only an occasional final test of such parts in the assembled machine. Making a preliminary survey of manufacturing conditions in this way will often enable the inspector to predict accurately whether the order will be finished on time; and it will also enable him to form a general idea of the probable quality of the finished lathes, which could not be secured from an inspection after all parts have been assembled.

In testing the finished lathe, the following are the most important requirements that must be fulfilled: (1) All parts that move on the bed must travel in a line exactly parallel to the ways on the bed. (2) The axis of the spindle must be absolutely parallel with the ways, regardless of whether the machine is to be used for turning work between centers or machining pieces supported by a faceplate or chuck. (3) A line connecting the live and dead centers, for any position of the tailstock, should be parallel with the ways and should represent a continuation of the axis of the spindle. (4) The carriage bearings must be accurately scraped to fit the ways, and the carriage must move smoothly along the bed without any perceptible play. (5) If the carriage is fitted with a cross-slide, the slide must move in a line perpendicular to the axis of the spindle measured at a point horizontal to the center line of the spindle. (6) The power must be transmitted without vibration, and the speed change mechanism must operate easily. (7) The feed mechanism must operate easily.

The castings are inspected before machining operations are started and all those that show imperfections on working surfaces are rejected, as experience has shown that such defects cannot be satisfactorily remedied by ordinary shop methods. If defects are found in other parts of a casting, and these are of such a nature that they do not impair its strength, the casting may be passed by the inspector; but he will have to see that such defects are corrected before the part is sent to the assembling department. The ways on the bed are tested before the machine is assembled, a straightedge and master plate to which the ways are accurately scraped being used for this purpose. The accuracy of the carriage may best be determined by watching the workman as he scrapes its bearings to fit the ways on the bed, although tests made of the assembled machine will also expose any serious defects.

After the lathe has been assembled, and before any of the tests are made, it should be set up perfectly level, a sensitive spirit level being used to test both across and along the ways to see that this requirement has been fulfilled. Care should be

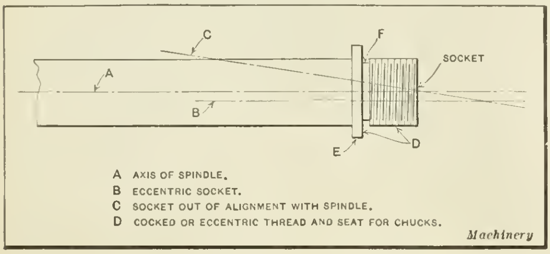

Fig. 3. Conditions that may be found in testing with Bar in Socket

taken to see that the legs are firmly supported and that all bearings have been properly adjusted. Then the fit of the centers in their sockets is tested with prussian blue to see that they seat themselves properly. After this has been done, the tailstock is moved back out of the way and bar *A*, Fig. 1, is inserted in the spindle in place of the center. Such a bar is very useful in making lathe tests, as it determines the accuracy of both the spindle and socket. After bar *A* has been put in place, an indicator is mounted in the toolpost and brought into contact with the bar, after which the spindle is slowly revolved and readings of the indicator are taken at both ends of the bar, as shown in Fig. 2. In making this test, no variation should be found at the spindle end of the bar, and at the outer end the variation should not exceed 0.00025 inch.

In cases where variation occurs, the high side of the bar is marked with chalk; and if the high sides coincide at both ends and the variations in the readings are equal, it shows that the socket is eccentric with the axis of the spindle; if different variations are found at opposite ends of the bar, it may show that the socket is out of alignment with the spindle. In Fig. 3, the condition of eccentricity of the hole is indicated by line *B*, and line *C* shows the condition where the error is in the alignment of the socket. If in making the tests at opposite ends of bar *A*, Fig. 1, the error shown by the indicator does not exceed the maximum allowable variation, the instrument is run along the bar from *A* to *B*, Fig. 2, first at the front of the bar and then at the top, as indicated at *C* and *D* in the end view; and in making this test the variation should

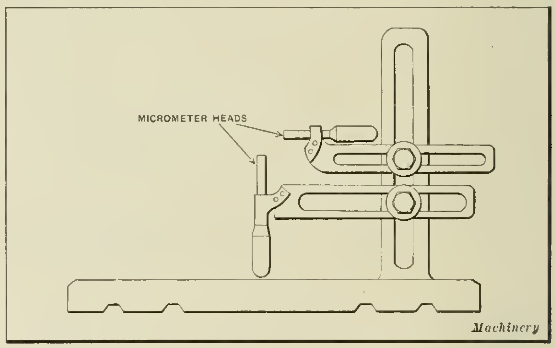

Fig. 4. Measuring Tool used with Bars B and C for testing Alignment of Headstock and Tailstock

not exceed 0.00025 inch. It is assumed that the test bar is perfectly accurate, but if there is any error in it, a suitable allowance should be made. All the bars shown in Fig. 1 are hardened and accurately ground to size, and the diameter should not vary over 0.0001 inch from end to end; the diameter is immaterial, but the bars should be tested for straightness at frequent intervals.

If the test conducted with a bar mounted in the lathe spindle shows satisfactory results, that is all that is desired; but when an error is discovered, it is difficult to tell where the inaccuracy is located. To determine the position of the error, bar *B*, Fig. 1, is used to test the accuracy of the alignment of the headstock with the ways. One end of this bar has bearings *a* and *b* of the same shape as those of the spindle, while the other end is a perfectly true cylinder. This bar is hardened and accurately ground to size so that it may be mounted in the headstock in place of the spindle. The alignment is then tested with an indicator, in the same way as with the bar mounted in the spindle, and if more than the allowable inaccuracy is discovered, the headstock is scraped until the error has been corrected as shown by indicator tests made at opposite ends of bar *B*. Fig. 4 shows a form of tool that will be found convenient in making a test with this bar; and after the headstock has been lined up in this way, the required degree of accuracy will be obtained.

When the test made on the bar mounted in the spindle bearings shows satisfactory results, the lathe spindle is replaced and the test repeated with the bar mounted in the spindle. In cases where the trouble is due to an error in the alignment

of the socket in the spindle, the following method of correction is employed: The high points on the bar are noted, together with the total variation of the indicator reading; and one-half of this difference indicates the true eccentricity of the socket with the axis of the spindle. This point is clearly brought out in Fig. 2, where it will be seen that the desired position for the bar lies midway between the high reading at E and the low reading at F. If the spindle is parallel with the ways (which has already been determined by the test made with the bar that fits in the spindle bearings, and by scraping to remove any existing error), it is possible to rebore and ream the socket to correct for the error in alignment or concentricity which was introduced the first time it was machined.

After the headstock tests have been made, the next point is to determine the accuracy of the tailstock, and on lathes where the tailstock is adjustable to provide for taper turning operations, it should first be set exactly at the zero point. The tailstock should then be moved along the bed until the centers in the headstock and tailstock touch when viewed from above. Fig. 5 shows an accurate method of observation, which consists of putting a sheet of white paper below the centers and using a magnifying glass from above. The tailstock center is usually 0.0005 to 0.0015 inch higher than the live center to provide compensation for wear, the amount depending upon the size of the lathe. This is a custom generally followed in the trade, but the increased use of hardened steel centers and the careful attention which is now paid to keeping them in good condition seem to indicate that it is not so necessary as was formerly the case.

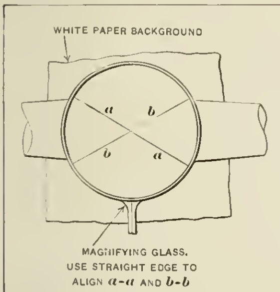

Fig. 5. Testing Alignment of Centers in Headstock and Tailstock

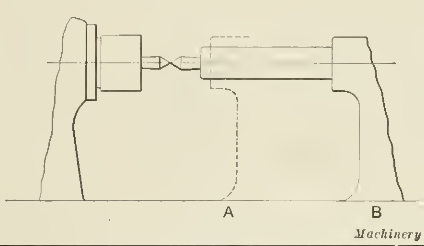

Fig. 6. Same Test as shown in Fig. 5, but with Tailstock Spindle fully extended

The tailstock is next moved back until the centers just touch with the tailstock spindle fully extended as shown in Fig. 6, after which the relative position of the centers is again viewed as shown in Fig. 5. This test serves as a check upon the alignment of the tailstock spindle with the ways, and after it has been completed the center is taken out of the tailstock spindle and replaced in another position in which the test is repeated to prove that the socket is in correct alignment with the tailstock spindle. In Fig. 7, line D indicates the effect of an error of alignment of the tailstock spindle, and if trouble of this kind is discovered it must be corrected by rescraping the tailstock bearings on the bed. If the tailstock spindle is parallel with the ways, but the socket is found to be eccentric with the spindle as indicated by line E, the centers may be brought into the required alignment by reboring and reaming the hole in the spindle. Such an error in a new lathe must not exceed very small limits.

The tailstock is next moved back to the end of the bed and bar D, Fig. 1, is set up between the centers, after which the indicator is mounted in the toolpost and readings are taken along the front and top of the bar as indicated in the end view, Fig. 2. The instrument must be carefully watched while making these observations, and the movement of the carriage must be slow and uniform, so that the effect of backlash will not be noticeable. After making the first test, the bar is turned through an angle of 90 degrees and a second series of readings is taken. If the results are satisfactory, it proves the accuracy of alignment of the outer ways with the line of

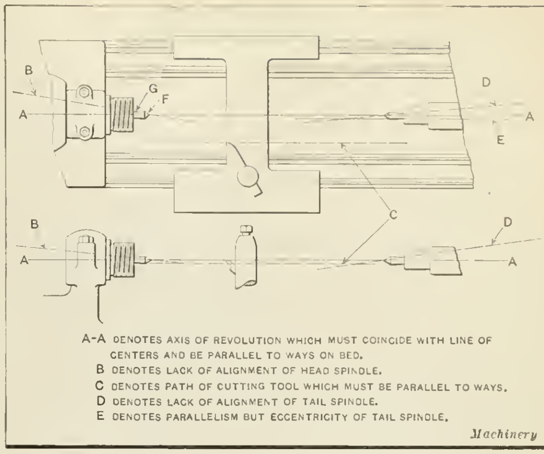

Fig. 7. Conditions of Alignment required between Headstock and Tailstock Spindles

centers. The tests are then repeated with the tailstock spindle fully extended to determine the actual error in alignment of the spindle. If the readings do not vary more than 0.00025 inch, the lathe may be passed, although the discovery of such an error means that, in turning, the maximum accuracy of the work can only approach that limit instead of true accuracy. It will, of course, be evident that in taking these readings allowance must be made for the difference in height between the head and tail centers, and for any variation that may exist in the size of the bar.

The lead of the screw is tested by closing the split nut on it and measuring the movement of the carriage along the bed with calipers. Care must be taken not to reverse the driving mechanism, as this would introduce apparent error due to the effect of backlash, making the results of the test inaccurate. It is hard to say what the limits of accuracy of the screw should be, but in a lathe of fair quality it does not seem unreasonable to specify a maximum total error of 0.010 inch over the entire length of the screw, with a maximum error of 0.0015 inch per inch of length.

The faceplate is next put on the spindle, and it should be a snug fit, although movable by hand. If the machine tools and jigs used were accurate, and if the live spindle were carefully centered, turned and ground, the faceplate should be almost exactly perpendicular to the axis of the spindle. To test this, the compound rest is set at zero and the indicator clamped at the center height, after which a reading is taken right across the faceplate. The spindle is then turned through a quarter revolution, and a second reading is taken across the faceplate. If the results of these two tests correspond, it shows that the faceplate is true; but if

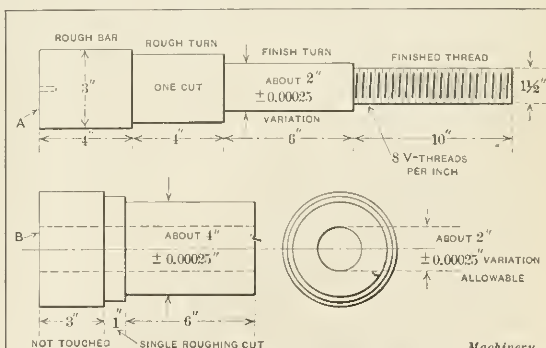

Fig. 8. Examples of Work turned on Centers, and Chuck Work done while conducting Running Test on Lathe

any discrepancy is discovered, the first step is to take off the faceplate and look for chips, sharp edges left by the turning tool or slight bruises.

If no such trouble is discovered, the faceplate is replaced on the spindle, taking particular care to see that it is accurately seated, after which the test is repeated; and if the two sets of readings still fail to agree, a cut must be taken across the faceplate. Many good mechanics claim that this should be done in all cases where great accuracy is expected of work done on the faceplate. Before taking this cut, the cross-slide setting should be tested; and this may be done by taking a cut across the face of a piece of stock held on the faceplate and testing this surface with a straightedge or surface plate. Another method is to make the test with an indicator held in the toolpost. If the cross-slide is accurate, the indicator reading obtained in traversing across the machined face should be uniform. Still another method is to use a testing square which is placed in the spindle with the blade in a horizontal position as shown at *E* in Fig. 1, after which an indicator reading is taken across the blade of the square. The square is then turned through 180 degrees and a second reading is taken. If the difference in readings is the same in both positions, it shows that the cross-slide is perpendicular to the ways. It will, of course, be evident that the use of this testing square is a substitute for the method of facing the piece of work mounted on the faceplate.

The next step is to test the thread of the spindle nose with a micrometer, using the three-wire method. The indicator is then applied to the spindle at points *D*, *E* and *F* in Fig. 3. This section of the spindle is usually machined at a different setting than that employed for grinding, and unless extreme care is taken it may be eccentric. If an error is discovered, it should be corrected by lapping. The chucks are tested by gripping a ground cylindrical bar and noting the difference in the indicator readings at opposite ends of the bar. The allowable error depends upon the size and quality of the chuck being tested; and in this connection it may be mentioned that the purchase of cheap and inaccurate chucks is false economy, as pieces machined in such chucks are likely to require a lot of subsequent hand fitting. The taper turning attachment is tested by mounting bar *D*, Fig. 1, between centers; the taper attachment is then set for some particular taper per foot, after which indicator readings are taken for each inch through a distance of 12 inches. If the taper attachment is accurate, it will be evident that the difference in readings will be 1/12 of the required taper per foot.

Working Tests

It may be possible for a lathe to pass all the preceding tests satisfactorily and still produce inaccurate work, so that after testing the alignment of all the machine members it is necessary to conduct a working test. For this purpose two pieces are usually machined—one held between centers and one in the chuck or faceplate. In making this test the operation of all parts of the mechanism should be carefully watched. The bearings should be oiled and carefully watched during the test to see that the lubricant is circulated properly. Particular attention should be paid to operating the lathe under each of the available combinations of speed and feed, taking care to see that the clutches and gears operate smoothly. Fig. 8 shows examples of the type of pieces employed for making the two working tests. For testing the operation of the lathe on work held between centers, piece *A* is first roughed out for its full length, a sufficiently heavy cut being taken to show the power of the lathe. After this has been done, finish cuts are taken to prove the accuracy of work produced on the machine.

Piece *B* is next chucked and turned. As in the case of work mounted on centers, the roughing cut should be very heavy to test the power of the lathe, while the finishing cuts should be made with a view of determining the accuracy of work which can be produced. In performing the boring operations, the final cut should first be taken by running the tool from the outer to the inner edge of the work; and then, without stopping the lathe, the tool should be fed in for a distance corresponding to the depth of the cut just taken. A similar boring cut is then taken while traversing the tool to the outer end of the hole. This method equalizes the error due to the wear on the cutting edge and deflection of the unsupported end of the tool. The inspector should be thoroughly familiar with the limits of accuracy required in handling lathe work on different sizes and types of machines, and he should not demand greater accuracy than is actually required. The final point to be looked after in conducting a working test is to look over the machine carefully to see that the bolts and fastenings are properly tightened, that all gear guards and other auxiliary parts are in place, and that all members of the mechanism operate satisfactorily.

Packing

After the machine has been inspected and accepted, it is marked, and all the equipment that goes with it is sent to the shipping room with the lathe. Here all parts of the machine that would be likely to become damaged if shipped in place are removed and packed separately. The machine is thoroughly cleaned and all bright parts are "slushed" over with a rust-resisting compound, after which the machine is carefully crated and marked for shipment.

* * *

TRANSLATOR'S PIGEON ENGLISH

Catalogues and leaflets describing machine tools are frequently published in several languages to facilitate sales in foreign countries. The translations are made by men who may be linguists of more or less ability, but who are seldom remarkable for their mechanical knowledge and a correct understanding of mechanical terms. Hence the language is sometimes rather strange, and although it may express the meaning, the wording leaves something to be desired. An example of this kind is given in the following, which is a translation from a catalogue published in three languages and referring to certain types of machine tools.

Terms of Delivery

Prices.—They are understood according to special written offer without packing loco neuses.

Payment.—All invoices are understood with 2 per cent cash discount. Long credit according to agreement. References should be given.

Packing.—Unless spezial instructions are given, the packing is done carefully according to our best judgment.

Despatch.—The goods are despatched in all cases for risk and account of the consignee. In the case of free delivery according to special agreement, the amount of the freight will be credited on the invoice on presentation of the bill of lading or forwarding note.

Term of Delivery.—The agreed term of delivery will be observed as far as possible. Defective material or breakdowns in the factory prolong the term of delivery. Mobilisation, war and events beyond the control of man, disengage me from the obligation of delivery.

Claims.—They are only acknowledged if made within eight days from the arrival of the goods at their destination.

Guarantee.—Defects which have proved to be due to faulty construction, workmanship or material, are remedied free of charge in my factory within one year. The replaced parts are my property. Other claims are not acknowledged. The parts to be repaired or replaced should be forwarded to my factory, carriage paid.

Illustration.—They are unbinding because improvements can give rise to slight deviation.

* * *

Motor cars are becoming so numerous in many American cities that finding sufficient parking space in the "downtown" sections is a serious problem. During business hours thousands of cars are parked along the principal business streets of Detroit. Fortunately, many of the streets are of sufficient width to permit cars to be driven in to the curb at an angle that permits any car to be readily backed out though other cars are closely parked alongside. In other cities having narrower streets, traffic space is so narrow that motor cars must be drawn up closely paralleling the curb. In Milwaukee it has become necessary to take a section off around some of the parks in order to provide space for cars. In time, it seems that it will be necessary for cities to provide large central areas for the storage of motor cars, and where space is at a premium these places may be two- or three-story open side structures, with ramps that permit easy access to the upper floors.

MANUFACTURE OF CIRCULAR METAL SAWS*

SELECTION OF STEEL, STAMPING OUT BLANKS, CUTTING TEETH, HEAT-TREATMENT AND ETCHING

BY FRANK M. SHAW†

Many of the contracts for shrapnel and high-explosive shells which have been placed in this country during the past eighteen months provided for the payment of bonuses as a reward for early completion, and this led to the speeding up of every operation as far as possible. Those who are at all familiar with the manufacture of shells know that there is a large amount of cutting off to be done, and as the material is a tough grade of steel, it will be evident that the strain on the saws used for this purpose is quite severe. This has created an unusual demand for circular saw blades, and more particularly for those made of high-speed steel, which are adapted for severe service conditions. Circular saws are made from a number of different grades of steel, and each of these will be referred to separately.

Carbon steel is seldom used in the manufacture of circular saws over 12 inches in diameter—so seldom, in fact, that the use of this material does not warrant discussion. Low tungsten steels are made from a variety of different alloys, all of which possess special merits in the manufacture of saws; but a very good saw—and one which is preferred by many users—is made from a vanadium steel that does not contain any tungsten. Some of the alloys contain a greater percentage of tungsten than others, and the trade names by which they are known usually designate the constituent of the alloy which predominates or the presence of which must be considered in heat-treating. Thus, there are manganese-tungsten steels, chrome-vanadium steels, etc. Each of these alloys requires a different method of heat-treatment, and great care must be exercised to see that the temperature of the metal is raised to exactly the required degree before quenching. If the temperature is raised too high the steel will be damaged, and subjecting it to a subsequent heat-treatment will not always result in obtaining results as good as those which might have been secured by applying the correct heat-treatment in the first place.

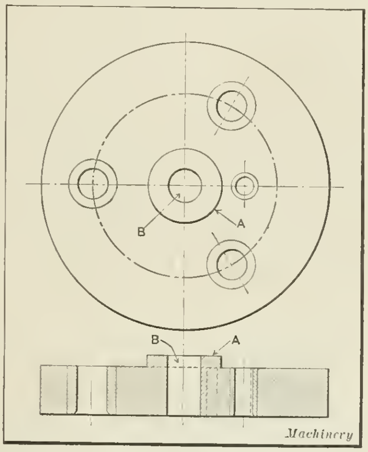

Fig. 3. Jig for drilling Holes

High-speed steel is being used to a greater extent every year in the manufacture of circular saws. This steel contains from 8 to 18 per cent of tungsten or its equivalent of molybdenum, and comes in various alloys; but tungsten is a constituent of most high-

* For additional information on this subject, see "Making Saws," published in MACHINERY, March, 1909.

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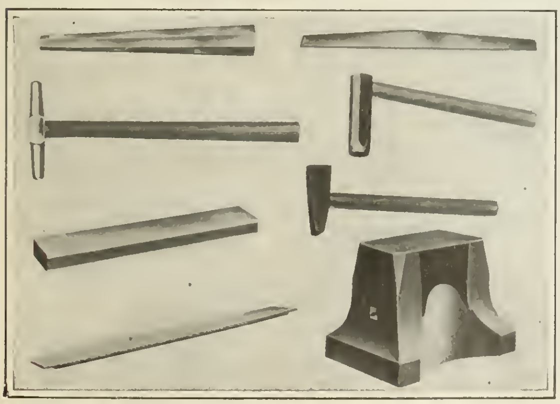
Fig. 1. Anvil, Hammers and Surface Plates used by Sawsmiths in Straightening Plates from which Circular Saw Blades are made

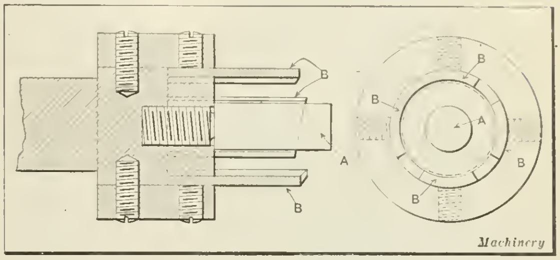

Fig. 2. Tool used for boring Arbor Hole in Circular Saw Blades

speed steels used in the manufacture of circular saws. Some of the high-speed steels used for this purpose are of the type which must be hardened by quenching in oil, while others are of the so-called self-hardening variety. The writer's experience has been that steels hardened in oil make tougher saws than those of the so-called self-hardening type.

When the plates of steel are received in the factory, they are in the form of round disks, and the first step is to measure them for thickness and diameter, after which they are placed in racks ready for subsequent use. The plates of low tungsten steel are 0.015 inch above the required thickness, while high-speed steel plates are 0.032 inch too thick. This allowance is provided to enable the saws to be ground to exactly the required thickness. Owing to the higher temperature which it is necessary to employ in hardening high-speed steel, it is necessary to have the blanks thicker than in the case of the low tungsten steels, because provision must be made for grinding away a greater amount of metal after the hardening operation has been completed. The diameters of plates of both of these classes of steel are ⅛ inch over size when delivered to the factory.

The first operation involved in the fabrication of these round plates into circular saws consists of flattening them, as their shape is likely to be very irregular. This is done on a special anvil, and use is made of a variety of hammers ranging in weight from 3 to 7 pounds. These hammers are of special shapes which experience has shown to be best suited for the requirements of the work, several of which are illustrated in Fig. 1. This flattening or straightening operation calls for peculiar skill that can only be gained through experience; the men employed in this work are known as sawsmiths. It is an axiom of circular saw manufacture that the less hammering done on the hardened saw the better; in fact, nothing but a peening hammer should be used.

In order to cut the arbor hole in the saws a ½-inch pilot hole is first drilled, after which the special tool shown in Fig. 2. is employed to cut the arbor hole, provided the size of this hole does not exceed 2 inches in diameter. As most saws under 30 inches in diameter have a smaller arbor hole than this, there is not enough boring to warrant making special tools for larger sized holes, and so standard boring tools are used. In the special tool shown in Fig. 2, A is the pilot which enters the ½-inch hole; and B are the cutters, each of which is 3/32 inch thick by 5/8 inch wide, and ground 0.016 inch under the hole size. Holes exceeding 2 inches in diameter are machined with a boring tool driven by a drill press. In the case of saws which have driving holes, these are drilled by setting up the blade in a jig which locates the holes in the

desired positions. This jig, which is shown in Fig. 3, is of simple construction and easily handled; it is made of a plate 1 inch thick by 6 inches in diameter, with a boss *A* about 1/4 inch high which fits into the arbor hole in the saw blade. A 5/8-inch hole *B* through the center provides for passing through a bolt by which the saw is fastened to the jig. The usual form of hardened bushings is furnished for locating the holes in the work. In the case of saws which are sprocket-driven, the holes for the sprocket teeth are punched after the arbor hole has been machined in order to insure concentricity, and the driving sides of these holes are then filed around to allow them to mesh properly with the sprocket. If the corner is simply filed off, the metal around the hole is likely to chip or break away.

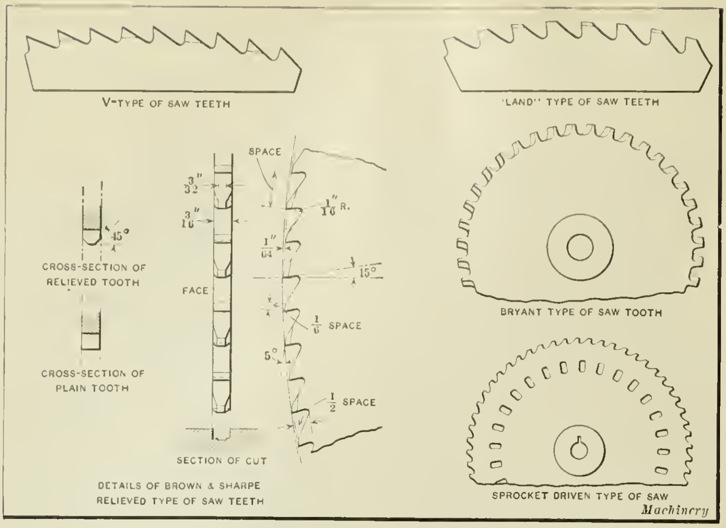

Fig. 4. Different Types of Teeth commonly used on Circular Saws

As the rim of the steel plates is very irregular and it is inadvisable to grind them round, owing to the danger of burning the metal, recourse is sometimes had to the use of stamping dies for trimming the blanks to size under a power press. A more satisfactory method is to trim them up on a gear-cutting machine which is made to trim the plate and cut the saw teeth at the same setting of the work. A number of different shaped teeth are employed, the following being those most commonly used: (1) The V-shaped tooth which is cut to a sharp point or edge and has its front face either radial or under-cut. (2) The type of tooth which has a land at the top instead of being cut to a sharp point; this style of tooth may also have its front face radial or under-cut, the under-cutting varying from 10 to 15 degrees and the width of the land varying according to the pitch of the tooth. (3) The Brown & Sharpe patent relieved tooth which is the same shape as the others except that alternate teeth are cut away on both sides at the top to one-half the width of the other teeth, and made 1/64 inch higher. This type of saw makes three small chips instead of one large one. (4) The Bryant type of tooth, which is used on saws of very heavy pitch, the saw being driven by a sprocket which engages the backs of the teeth. This type of tooth is ground about 1/32 inch thinner at the back than at the front, the purpose being to provide clearance for any burr which may be raised by the sprocket teeth. Examples of these different types of saw teeth are shown in Fig. 4.

The practice of cutting saw teeth on the gear-cutter is far superior to punching them, as the former method does not introduce any strains in the metal and insures the production of teeth of absolutely uniform pitch. In cutting the teeth of circular saws on a gear-cutting machine, the cutters are generally made of high-speed steel, 3½ inches diameter, thickness varying with pitch. The saw blanks are mounted upon an arbor and located in the proper relation to the cutter by means of an inside caliper. To explain this location of the work, suppose it is required to cut the teeth of a 14-inch circular saw with an arbor hole 1½ inch in diameter; the arbor on which the work is mounted would be located at $\frac{14 - 1\frac{1}{2}}{2} = 6\frac{1}{4}$ inches from the periphery of the cutter. The same method is used to determine the setting which will give the proper depth of tooth. In cutting teeth in high-speed steel saw blades, it is necessary to have a supporting plate at the back of the work to prevent the metal from breaking out at the back of the teeth; this plate has teeth cut in it similar to the teeth that are to be cut in the saw blade. After cutting the teeth, any burr which may remain on the saws is removed, and the saws are ready to be hardened.

Specially constructed heat-treating furnaces are used, and in conducting the heat-treating operation great care must be taken to see that the work is brought to a uniform temperature. Oil is the best fuel to use in the heating furnace, although gas can be employed with satisfactory results for temperatures up to 1800 degrees F. Saws made of low tungsten steel require a temperature varying from 1450 to 1800 degrees F. according to the character of the alloy and the nature of the quenching bath that is employed. High-speed steel saws are heated to from 1950 to 2250 degrees F. There are a number of different grades of quenching oils capable of giving satisfactory results; and where whale oil is used, beeswax, rosin and tallow are sometimes added to the contents of the quenching bath. Oil of degras, commonly known as "No. 2 soluble quenching oil," gives very good results, enabling the saws to hold their original shape very well. In hardening saws made of self-hardening steel, it is merely necessary to heat the blades to the required temperature and then clamp them between two heavy plates to prevent distortion while the metal is cooling. These plates are mounted on a hydraulic press and held together by a pressure of sixty pounds per square inch. The plates are water-cooled. Low tungsten steel saws are tempered in oil at from 350 to 475 degrees F.,

Fig. 5. Nutter & Barnes Machine for Grinding V-type Circular Saw Teeth

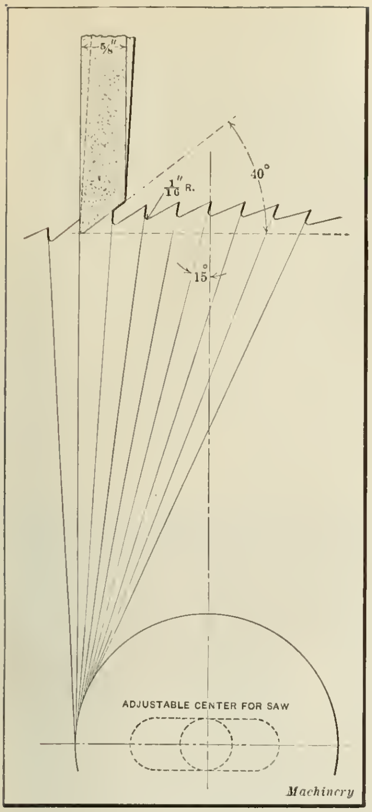

Fig. 6. Diagram showing Work done, Fig. 5

according to the nature of the alloy; and high-speed steel saws are drawn at temperatures ranging from 450 to 1200 degrees F. The idea of drawing the temper at 1200 degrees F. may frighten some people, but in the case of certain steels it will result in producing a tougher saw and one which is quite as hard as it would have been if the temperature had been drawn at 600 degrees F.

After tempering, the saws are again given to the sawsmith to be straightened, the work being done while the metal is still hot. It is very important for the saws to be fairly flat at the time that they leave the tempering furnace, as the work of straightening necessarily results in the introduction of strains in the metal. As already mentioned, a peening hammer is used in straightening the saw; this hammer is quite similar in shape to the hammer used for the previous straightening operation except that it has a sharper edge. It weighs $3\frac{1}{2}$ pounds. After straightening, the arbor hole is ground to the correct size, a special vertical-spindle machine being used for this purpose; and hardened and ground gage plugs are used to determine the accuracy of its size. After the saw has been set up on the machine, the wheel-head is raised to bring the wheel into the working position; and an eccentric device governs the position of the wheel to provide for grinding the hole to the required size. Great annoyance and inconvenience have often been caused by not having the arbor hole true to size; if the hole is under size, it cannot be ground, and requires a great deal of time to "stone" it up to the required diameter. The exercise of some care in grinding will obviate much annoyance and the loss of a considerable amount of time in this way.

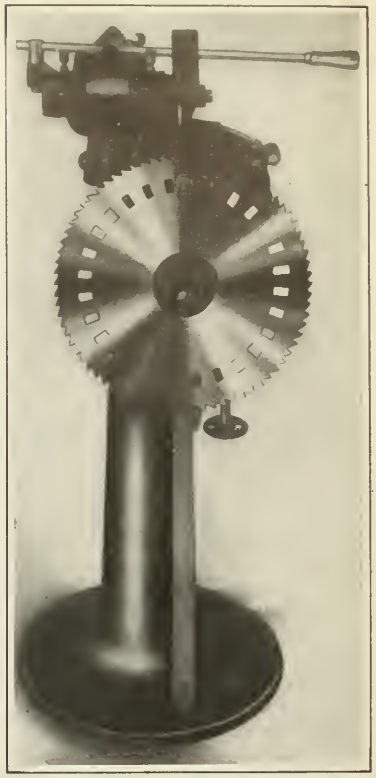

Fig. 7. Hunter Grinding Machine for "Land" Type of Circular Saw Teeth

The operation of so-called "straight" grinding, which consists of grinding the saw down to the required thickness, is done on a special double-wheel machine which provides for grinding both sides of the saw at the same time. The saw revolves on an arbor and is rotated by two driving wheels directly opposite the grinding wheels which travel in opposite directions, one grinding up and the other down. After being once more inspected by the sawsmiths, the saw blades are ready to be "taper" or hollow ground. The taper or clearance should be 0.025 to 0.035 inch for the first 2 inches in from the edge, and straight from that point to the collar. The saw is now mounted on a test mandrel and rotated to determine its true running qualities, after which it is ready to be sharpened. This is done on automatic machines equipped with very soft wheels, as the steel may easily be damaged by burning.

Sharpening circular saws with V-type teeth is a relatively simple matter. The saw blade is mounted on an arbor and the machine is furnished with a suitable index wheel for accurately spacing the teeth. A machine built by the Nutter & Barnes Co., Hinsdale, N. H., for doing this work is illustrated in Fig. 5, and Fig. 6 shows in diagrammatic form the conditions which must be fulfilled in grinding saw teeth of this type. It will be noticed that the position of the mandrel upon which the saw is mounted is adjustable to provide for obtaining the required under-cut for the face of the teeth. Fig. 7 illustrates a machine built by the Hunter Saw & Machine Co., Pittsburg, Pa., for grinding the tops of saw teeth of the "land" type; this is a hand-operated machine and its operation will be apparent to the reader after studying the illustration.

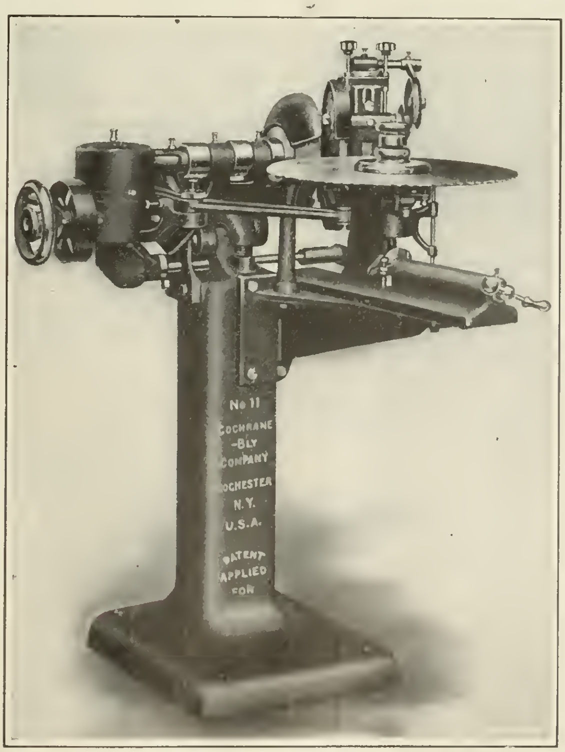

Fig. 8. Cochrane-Bly Grinder for sharpening B. & S. Relieved Type of Circular Saw Teeth

It will be obvious that the grinding of circular saws with the Brown & Sharpe relieved type of teeth calls for a more complicated form of machine than is needed for grinding the two types of teeth to which reference has been made. Fig. 8 shows a machine built for this purpose by the Cochrane-Bly Co., Rochester, N. Y. It is provided with three wheels and is automatic in its operation.

One wheel works in two directions, i. e., forward and sideways; during the forward motion it grinds the front face of a tooth to an under-cut angle of 15 degrees, and during the side stroke it backs off the land at the top of the tooth to an angle of 5 degrees, leaving alternate teeth 1/64 inch higher than the teeth adjacent to them. This wheel is 8 inches in diameter and 40 grain, grade K; the forward and sidewise movements are controlled by cams.

The other two wheels on the machine are carried by a head that is mounted on a perpendicular slide. While the other wheel is grinding the faces and lands of two teeth, these wheels work on the under side of one tooth and the top of the next tooth but one, in order to reduce the thickness of alternate teeth to one-half the thickness of the full-width teeth. It is these narrow teeth which are left 1/64 inch higher than the full-width teeth. The wheels used for this work are about 4 inches in diameter, and 40 grain, grade O.

Fig. 9 shows in diagrammatical form the work done by the machine for grinding the Brown & Sharpe relieved type of saw teeth. It will be noticed that alternate teeth have either a full line or a dotted line across them, and these lines indicate the work done by the two wheels carried on the head mounted on a vertical slide; one of these wheels grinds the relief at the top of a tooth as indicated by the full line, and when the other wheel comes into action it grinds the relief at the bottom of the next alternate tooth that is shown by the dotted line. This idea will be understood by referring to the Brown & Sharpe relieved type of saw tooth shown in Fig. 4. Both wheels work on each alternate tooth in order to grind the relief at both sides, but the wheels do not work on the same tooth simultaneously. On the Cochrane & Bly machine the wheels grind on the same tooth at once, first the lower wheel and then the upper one.

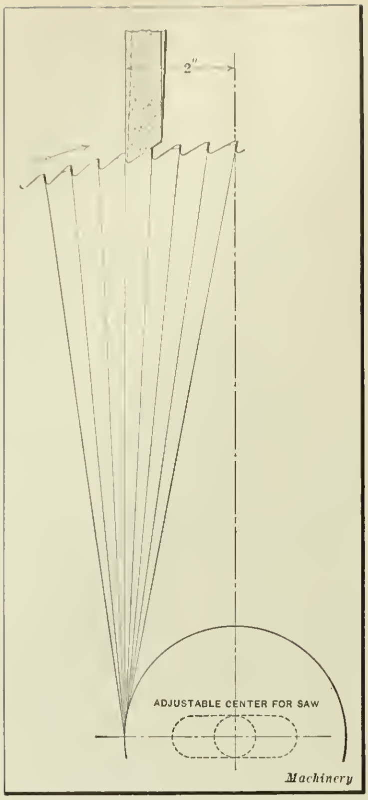

Fig. 9. Diagram showing Work done by Saw Tooth Grinder shown in Fig. 8

Polishing and etching are the last operations, the polishing being done with No. 40 Turkish emery. The etching requires considerable skill to secure satisfactory results, and although this does not affect the cutting qualities of the saw, it does have a great deal to do with the appearance of the product. The quickest and easiest method of etching saw blades is to use a rubber stamp covered with a thin film of acid, which is applied to the saw blade and allowed to remain for a sufficient length of time to eat into the metal. The trouble with this method is that it is difficult to secure clean-cut edges on the etched design, particularly when working on high-speed steel; and the acid also destroys the rubber stamps very rapidly. A more satisfactory method is to make a master plate in which is cut the legend and design that it is desired to etch on the saw blade. Transfers are made from this plate by first covering the plate with a paste made by boiling 3 pounds of beeswax and ½ cup of Venus turpentine, with sufficient spirits of turpentine to give the required thickness and enough lampblack to make the paste quite visible when it is spread on the master plate. After spreading it over the master plate, the surplus paste is wiped off, and a piece of tissue paper is then put over the plate and rolled down with a rubber roller. The tissue paper transfer is then lifted off and placed upon the saw in the position where the etching is to be done, and the paper is removed by moistening it with water. This leaves a coating of paste which forms the "resist" that protects the metal surrounding the design from the action of the acid used for etching. Shellac is also spread around the transfer to protect the saw from the acid. Nitric acid mixed with an equal volume of water is then applied over the transfer so that it will attack the portions of the steel which are exposed; and after being given a sufficient time to etch the metal, the surplus acid is neutralized by adding caustic potash solution. By this method very good results will be obtained. In etching high-speed steel it is desirable to add salt to the 50 per cent nitric acid solution. The saw is then entered on a record card system, of the form shown in Fig. 10, and sent to the shipping room. Heavy corrugated cardboards are placed between the saws when they are packed for shipment, to guard against the possibility of damage before they reach the customer's factory.

* * *

A manufacturer of mechanical specialties has devised a unique business card for representatives of the company in the form of a small two-sheet card folder, measuring 2 by 3 inches. This card, of medium weight stock, is of soft gray color and printed in a brown of harmonizing tone; it is arranged for use with the larger dimension vertically. The front sheet is cut with a circular opening near the top just the size of a cent, and an actual penny is affixed to the next sheet to show through; only the bright, new cent is used. Directly below, on the front sheet, is printed, "It's Worth A Penny To Know." On the second page, or reverse side of the front sheet, arrangement is made for indicating the name of the representative, while on the third page the company name, address, etc., is printed; this latter comes below the penny attached to this sheet and is covered by the front page of the card folder. The fourth, or outside back page, carries the company's trademark. This clever card arouses a natural interest and curiosity, and has been the means of obtaining many important interviews for the representatives, otherwise difficult to procure.

Our order No. 11476 Date: Oct. 16, 1915

Customer's order No. 6793

Name: John Adams

Address: Cincinnati, Ohio

Order received: Oct 13, 1915 Shipped: Oct. 17, 1915

Diameter: Inches	Thickness: Inch	No. of Teeth	Shape of Teeth	Type of Machine	Hardening Temperature, Degrees F.	Temper Drawn at Degrees F.	Steel	To Cut	No. of Saws Ordered	Remarks:
24	3/16	86	Undercut "land"	C.-B.	2250	1200	High speed	Machine steel bars 6 inches in diameter.	12	Cutting speed 40 feet per minute.

Machinery

Fig. 10. Form of Card used for keeping Record of Circular Saws

TUNGSTEN PRODUCTION IN THE UNITED STATES

The tungsten production in the United States during the first six months of 1916 was about 3290 short tons of concentrates carrying 60 per cent tungsten trioxide, according to a report made by the United States Geological Survey. The output of Colorado was 1505 tons, valued at $3,638,000, of which the Boulder field furnished 1494 tons. The tremendous rise of prices caused by the need of high-speed steel used in making war munitions ordered by the European governments caused the great increase in production. Ores carrying 60 per cent tungsten trioxide brought about $66 a unit at the beginning of the year. At first the sudden demand created by the orders for war steel was far ahead of the productive capacity of the country. The rapid rise in price starting last fall at a time when tungsten mining was at low ebb culminated in the undreamed maximum price mentioned. As a result, the production increased faster than the consumption, and soon overran the demand. By the end of June the price per unit of tungsten trioxide had fallen to $25. The normal price is between $6 and $7. The American production and imports of tungsten amount roughly to 5100 tons of 60 per cent concentrates, valued at $3,278,000. Allowing 20 per cent of the metal losses in various operations, it is estimated that between 11,000 and 12,000 tons of high-speed steels were made during the first six months of 1916, in addition to the steel made from tungsten saved from scrap.

Fig. 1. Shelby Steel Tubing after Bulging

* * *

BULGING SEAMLESS STEEL TUBING

A fine example of the manipulation which seamless steel tubing will stand without heating is illustrated in the accompanying halftone, Fig. 1. This shows a piece of Shelby steel tubing, the original diameter of which was 6 inches, and the walls ¼ inch in thickness. The dimensions of the bulged end are 6 inches in width by 9 inches in length, and the total amount of the bulging was done from one side of the tube.

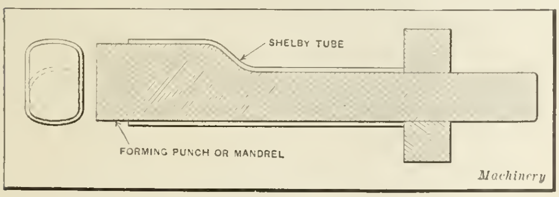

Fig. 2. Shelby Steel Tubing with Bulging Mandrel in Place

The manipulation of this tubing was done by James M. McClellon, of Everett, Mass., in connection with some experimental locomotive boilers he was building.

The work was done in a hydraulic wheel press such as is used in railroad shops for forcing wheels on the axles. Eighty-five-ton pressure was required. Aside from the fact that the tube was not heated for the operation, a remarkable feature of the operation was that the bulging was done without the use of a die. An inside form or punch of steel was made that started with a pilot 5½ inches diameter, and was formed exactly to the shape it was desired that the bulged tube should receive. This form was carefully smoothed up, coated with white lead, and forced into the tube, leaving it just as is shown in the photograph. C. L. L.

* * *

THE ITEM OF WORKMANSHIP

The Bowman-Blackman Machine Tool Co., St. Louis, Mo., dealer in machine tools, steam hammers, electric cranes, etc., has issued a circular letter on the importance of workmanship, from which the following is taken:

To many people it is not clear why more money should be paid for one machine than for another that appears to have an equally meritorious design. Yet it is a fact that the builders who get the lion's share of the open, competitive machine tool business are the ones who make the high-priced tools. It is a fact that the steady buyers of tools almost invariably settle down to using the high priced lines, and one reason, as we see it, why the expensive makes give enough better satisfaction to warrant paying their extra cost is that they are better on the score of workmanship.

In our judgment, there is nothing that so much affects the performance of a tool, whether it be for fine tool-room work or for heavy, gruelling manufacturing operations, as the workmanship or the perfection of the fits. With two lathes, for instance, of exactly the same design, of which one was carefully fitted and the other carelessly, the difference in the performance would surprise one who had not had this feature previously impressed on him.

There is a great difference between a bearing that is merely snug and one that is a real fit. The former may touch in but a few spots and have but, say, a tenth of the full area of contact. It will thus wear out of alignment about ten times as quickly. It will pull harder, owing to the unequal oil film. It will chatter, because between the points of contact its members are unsupported or "overhanging." It will heat from the pressure from heavy cuts. From the standpoints of durability, power consumption, quality of output and amount of output, it will be seen that the point of workmanship in a machine is vital.

The final fitting is one of the most important items of expense in building high-grade tools. To illustrate its costliness, we mention that a prominent manufacturer of tool-room fixtures makes a difference in the price of surface plates, between those merely planed to a finish and those that are scraped to a fit, of almost double. In other words, the single final operation of perfecting the fit in this instance costs almost as much as the material and all the preliminary machine work combined.

* * *

MACHINE SHOP PRACTICE SESSION A.S.M.E.

H. K. Hathaway, chairman of the Committee on Machine Shop Practice, has prepared the following programme for the machine shop practice section of the American Society of Mechanical Engineers at the annual meeting in New York, December 5 to 8:

"Notes on the Standardization of Machine Tools," by Carl G. Barth;

"The Undoing of Established Mistakes," by Wilfred Lewis;

"A Classification of Machine Shop Practice and a Proposed Plan of Action for this Committee," by H. K. Hathaway.

Two sessions of the machine shop section will be held and an extended discussion of the papers is hoped for. The subject of machine tool standardization is most important, and it is expected that formal written discussions will be received from a number of well-known machine tool builders.

* * *

An unexpected result of workmen's compensation laws enacted in the various states has been the promotion of temperance. These laws are so drastic that the employer has often no defence in cases of gross negligence where the employe is solely to blame for getting hurt. Under these conditions no employer can take the risk of employing men addicted to drink, and many manufacturers in states having compensation laws have been active in promoting "no license." They also refuse to hire men who drink and discharge drinking men. The large steel mills have made it known that men can retain employment only on condition that they abstain from drinking anything stronger than "Adam's ale."

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EXPERIMENTAL ENGINEERING

While much has been said about the adverse influence of large corporations on the economic life and industrial development of the nation, it must be admitted that they have many redeeming features, one of which is the development of experimental engineering, possible only in a large organization. The development of any industry from an engineering standpoint will be comparatively slow and insignificant as long as the industry is carried on by organizations too small to maintain a costly experimental department; but when through combination or otherwise, a large industrial unit has been developed, it can afford the cost of a well-equipped experimental department, where a rapid development may take place. As an example may be mentioned the electrical industry in the United States, where remarkably rapid strides have been made in the development of new apparatus, new methods, and the discovery of new principles, mainly because the leading concerns in this field have been strong enough to spend large sums yearly on experimental work. One of them, for example, maintains a staff of hundreds of high-priced men, and has a large building of imposing dimensions set aside for nothing but experimental work. As a result of this work many new discoveries have been made, and new industries have been founded on the basis of these discoveries. While it is well known to engineers that in certain instances large corporations have retarded engineering progress by buying the patent rights and suppressing new inventions which have too seriously interfered with an industry they have already developed, it must be admitted that these instances are, in the case of some corporations, at least, more than compensated for by the opportunities for research and development made possible by their resources and facilities for experimental work.

* * *

INTENSIVE PRODUCTION

The scarcity of labor, high wages and high prices of materials will result in the adoption of much more efficient methods of production than now generally prevail. Machine tool making has been largely "building" rather than manufacturing. Lathes, planers, shapers, drilling machines and milling machines have been put through the shops in comparatively small lots and in a variety of sizes. There could be little of intensive methods of production employed, and costs were high. The big orders from Europe have made possible the manufacture exclusively of one size and kind of lathe, for instance, and some remarkable records have been made. One concern turned out 400 heavy simple turret lathes for projectile work, each weighing 10,000 pounds, in less than five months while carrying on its regular machine tool manufacture. But a separate plant was used for the special product and the most advanced methods of production were employed. Tools, jigs and fixtures were provided before starting work and every part was manufactured—not built.

Another "builder" of lathes has devoted his comparatively small plant exclusively to the manufacture of one size of engine lathe with astonishing increase of efficiency and capacity. When he was building several sizes of lathes and putting them through in lots, delays were common, due to some castings proving defective. A lot might be held up because two or three cone pulleys had developed blow holes when machined. Time was required to get replacements from the foundry. But when building one size only, a few defective castings do not necessarily delay shipments, as the castings are ordered on a weekly supply basis and some of the incoming supply can be taken to fill out and the replacements used later.

* * *

MODERN FIXTURE DESIGN

The general conception of a jig is a holding means for guiding a drill when drilling machine parts so that every part will be drilled alike and no laying out will be necessary. A drill jig is necessarily light when designed for small parts, because it must be lifted and handled with the contained piece by the operator.

This general conception of the relation of a jig to the part has been mistakenly applied to work-holding fixtures for planers and milling machines. There is no need for lightness in a fixture for holding castings on a planer; instead there is need for great strength and rigidity. The parts must be adequately supported and firmly held if heavy cuts are to be taken. The same conditions apply with much greater force in milling. The pressure of hogging milling cutters is much greater than that of hogging planer tools. Fixtures used in the most progressive motor car plants for holding work on heavy milling machines are remarkable for weight and rigidity. A string of fixtures filling the length of the platen will in some cases weigh nearly as much as the platen itself.

The design of the fixtures is such that each casting is supported on compensating plugs, and while firmly gripped at a number of points, there is no distortion; the chucking is quickly accomplished without leveling up and the use of blocks, wedges, jacks and other common chucking accessories.

* * *

THE NEED OF SKILLED MEN

Never has there been so great a demand for machinists, machine operators and toolmakers as during the past and present year. The supply is far short of the demand, and manufacturers have been obliged to take in farmers, street-car conductors, bar-tenders, laborers and other likely men, and train them to become operators. This has been a costly and unsatisfactory process. Out of ten picked up from various other occupations, two or three may be found to have the natural skill and aptitude for mechanical work. The others have to be dismissed after they have received costly instruction and have spoiled much work. One concern estimates that it has cost from $200 to $300 per man to get one that was worth keeping.

The big makers of motor cars depend on the small concerns to train their help. They pay operators big wages during the season of heavy production and lay them off when business slackens. Such methods discourage the maintenance of apprentice systems by the concerns that realize the need of training skilled men. They cannot afford to train boys and have them taken away in the third or fourth years of their time when they are just beginning to repay some of the cost of the mechanical instruction given.

The evil has been serious for years, and seems to be getting worse instead of better. It is a big problem to be solved.

EDUCATIONAL PREPAREDNESS VS. INDUSTRIAL PROGRESS

W. H. DOOLING*

The vast armies and navies of Europe at the present day, together with their enormous equipments and resources, are leading to campaigns of military preparedness on the part of this nation. The conclusion has been reached that if we are to keep pace with the rest of the mighty world powers, we must be prepared to meet them on a military as well as on a peace basis. Army and navy experts are urging larger expenditures of money for greater fighting forces and equipment. The enormous sums spent in waging war are not productive of any wealth to the country. If such large sums of money could be obtained and expended in the furtherance of industrial education, the wealth and prosperity of the nation would be materially increased. The National Association of Manufacturers, in 1912, estimated the annual national loss in human resources, due to 50 per cent of the children leaving school in the elementary grades, at $250,000,000. A consideration of these figures leads us to the conclusion that a campaign of educational preparedness should be waged no less vigorously than one of military preparedness, in order that these losses may be made up and the wealth and prosperity of the nation increased.

Of late years education and industry have been forced to recognize their close relation to each other. The phenomenal progress of industry has clearly outstripped the feeble efforts that education has put forth to meet it, and, as a result, we have such losses as cited above. It is interesting to note the slow progress of education in contrast to that of industry. Not so many years ago the secondary schools of our country had but one aim in view—to prepare students for higher institutions where they would take up one of the professions, law, medicine or the ministry. Of the small percentage of grammar school graduates who entered high school, a still smaller percentage were annually graduated. Only a select few could then enter college, and there they pursued still further their classical studies leading to one of the recognized professions.

Meanwhile the rise of modern industry had begun. The old apprenticeship system had fallen into disuse. Times had changed since the shoemaker made the entire shoe and cloth was manufactured in the home. The invention of shoemaking machinery, the power-loom, the cotton gin, power-harvester, etc., called for a division of labor, and a great industrial change took place. Large concerns grew up; large numbers of employes were needed; a great demand for managers and superintendents arose; and these people needed an education. Young men were needed in the shops, yet the employers had no time, nor could they afford to teach them the trade thoroughly, but simply gave them one certain thing to do. In other words, these boys became mere cogs in the wheels of industry. Here again education in the schools ought to have been able to teach these young men the theory and practice of the trades, and make them more valuable to their employers.

But education was unprepared; it went ahead with its classical curricula, ignoring the needs of its communities, training the smaller proportion of the pupils to the exclusion of the larger. After a long search for competent men on the part of employers, they thought that possibly in the large amount of material scrapped annually from the schools there might be some which under proper treatment would prove valuable. Many pupils who had no ability for book learning were found to have considerable manual dexterity, coupled with a certain ability to think and think well about mechanical subjects. After much opposition, a few courses relating to the trades were adopted by some high schools. Later, high schools and schools devoted exclusively to technical education were founded. At present we have the manual training, technical and trade schools, offering a variety of courses to meet the needs of this class of pupils. In some schools part-time courses are in use, whereby the pupil is enabled to spend part of his time in the shop and part of his time in school, thus combining theory with actual shop practice. A gratifying percentage of the scrap heap has been reclaimed. These pupils are doing good work for their employers and for themselves.

* Address: 38 Cane St., Fitchburg, Mass.

But there is still a great deal to be done. In order that education may be prepared and that the schools may be as efficient as possible in their teaching of technical subjects, it is of utmost importance that they have the hearty cooperation of the manufacturers and employers themselves. Their good will is not enough; there must be active participation of some sort in order that the best results may be obtained. The boys in school are very likely to think that there is a wide gulf separating them from the actual industry they contemplate entering. This does not mean that a man must break up his shop organization. If he could spare an hour or two once in awhile to give a talk at the school, it would do wonders toward bridging this gulf. He might present to them the problems that are coming up daily in his line of work. This would help to keep both instructor and pupil in touch with everyday conditions and also stimulate their inventiveness. Or, if a manufacturer is unable to spare the time, he might encourage visits to his shop or factory on the part of the pupils, and delegate a subordinate to point out and explain the different processes and machines. When he is sending out catalogues, he might remember to address a few to the school of his community, for these catalogues are of prime interest to the trade student. These few suggestions may, of course, be supplemented by others which will occur to the employer, if he endeavors to help along the school of his community.

In this way he will be helping himself by building up better material from which to choose his subordinates, and helping the great mass of children who up to this time have been handicapped in the struggle for existence by a lack of training. Hearty and active cooperation of manufacturers and schools will aid education to prepare for its proper work—to realize its highest ideals, namely, the preparation of *all* children for earning an honest livelihood in the trade for which they are by nature and training best fitted.

* * *

CENSUS OF MANUFACTURES IN THE UNITED STATES

A preliminary statement of the general results of the census of manufactures for the United States, issued by Director Sam. L. Rogers of the Bureau of the Census, consists of a summary comparing the figures for 1909 and 1914, by totals. The figures are preliminary and subject to such change and correction as may be found necessary from a further examination of the original reports. The census of 1914 excluded the hand trades, the building trades, and the neighborhood industries, and took account only of establishments conducted under the factory system. Statistics were not collected for establishments having products valued at less than $500.

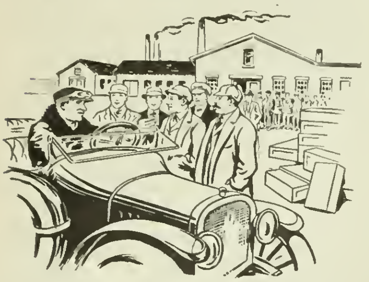
Compared with the manufactures census of 1909, the capital invested increased 23.7 per cent, or from $18,428,270,000 to $22,790,880,000. The number of establishments increased from 268,491 to 275,793, or 2.7 per cent; the average capital per establishment increased from $69,000 to $83,000. The value of the products increased 17.3 per cent, or from $20,672,052,000 to $24,246,323,000; the average value per establishment was $88,000, an increase of $11,000. The number of persons engaged in manufactures increased 7.6 per cent, or from 7,678,578 to 8,265,426, but the number of proprietors and firm members decreased 3.1 per cent, or from 273,265 to 264,872. The number of salaried employes, however, increased 22 per cent, or from 790,267 to 964,217. The amount paid in salaries increased 37.2 per cent, or from $938,575,000 to $1,287,917,000; an average increase of about $150 a year to each employe. The number of wage earners increased from 6,615,046 to 7,036,337, or 6.4 per cent. The amount paid in wages increased from $3,427,038,000 to $4,079,332,000, an average increase of about $70 a year to each one. In 1914, the greatest number were employed during March and April, and the smallest number in December and November; in 1909 the greatest number were employed in November and December, and the smallest number in January and February. The primary horsepower used, in 1914, increased 20.7 per cent, or from 18,675,376, in 1909, to 22,537,129, and the value added by the manufacture (the value of the products less the cost of materials) increased 15.8 per cent, or from $8,529,261,000 to $9,878,234,000.

SNAPSHOTS ON THE ROAD

ONE WAY TO HIRE MEN—WHEN LUBRICATION WORKED TOO WELL—SOME COMPETITION—CURING THE LATHE THAT WOULDN'T TURN STRAIGHT—A DIFFICULT MILLING JOB—THE UNKNOWN PLANT

BY THE FIELD EDITOR

"SIT down here a minute, Mr. Field Editor, I want to show you the most exacting inquiry that ever came into this office," said the manager of a gear-cutting shop. And as I settled into my chair, the manager went through his files and pulled out an inquiry from a person in Central Pennsylvania. The inquirer stated that he was in the market for gears for special apparatus that he was designing, and he desired gears cut that would turn two cylinders, one large and one small, at such rates that their peripheral travel would be coincident. So far the inquiry was ordinary, but this critical inventor went on to state that the diameter of the large cylinder, *as nearly as he could measure it*, was 1.765633739 inch and the circumference was 5.5469 inches. The small cylinder, he wrote, was 0.5625 inch in diameter, and 1.767175 inch in circumference.



"And asked how many fellows wanted jobs at $5 a day"

"Say," chuckled the manager, "it's mighty lucky for us that that chap couldn't measure any closer!"

One Way to Hire Men

In traveling around the country you hear of all kinds of methods of hiring skilled mechanics, especially in these times when men are scarcer than the proverbial hen's teeth; but I had a "new one" called to my attention by the superintendent of a shop in Southern Connecticut that is near a mammoth arms plant noted for its aggressiveness in securing men.

"It sure was funny," said the superintendent. "That big octopus plant has been scouring the country for men and getting some good ones, too, by paying the highest wages. The employment director got a brilliant idea. He thought that some of the toolmakers he had pulled from country shops and who went back to their homes every week-end could be induced to bring down more of their former shopmates. So that Saturday morning he tried his plan on a man whom he had purloined from a shop in Western Massachusetts."

"And how did the stunt work?"

"Oh, the stunt worked all right," chuckled the superintendent. "The toolmaker came back Monday morning and reported that he had six of his former shopmates down in the employment line waiting their turn to fill out the blanks. But the morning passed away without the men arriving in the shop, and the employment manager questioned the 'procurer,' who was dumbfounded to think that his friends had not shown up, because he had personally placed them in the line. Well, that night the man went to his boarding house and found his former shopmates all sitting there as unconcerned as could be. The explanation was simple. 'We were standing in the line waiting our turn,' one of the men explained, 'when an automobile stopped in front of the line and a dandy looking chap with a fur overcoat stepped out and asked how many fellows wanted jobs at $5 a day. We six chaps were sticking together, so we immediately jumped into his machine, and he took us down to his shop, and we landed some fine jobs, too.'"

It was certainly a new way to get men and, though questionable, was more direct than the equally questionable method that the big company had employed to get its men.

When Lubrication Worked Too Well

"Say," said the superintendent, "did you ever hear of a lubricant that did its job too well?"

"No," said I, settling back in the visitor's chair beside the superintendent's desk; "I certainly didn't suppose there was such a thing as over-lubrication."

"Well, just turn around and look at the job on that big horizontal boring mill out there, and you'll understand my story better."

Following the superintendent's glance, I saw the horizontal boring mill, and two laborers were tugging at a big fixture on the table, presumably to turn it so as to line it up for some particular hole to be bored.

"That fixture," said the superintendent, "weighs 2000 pounds, and the casting weighs another 800 pounds. You can appreciate that it is a real man's job—or rather two men's job—to turn that fixture every time it is necessary to reset it for boring a new set of holes. You'll notice that it's a box fixture, so that perfect alignment is not necessary, as a universal joint connects the machine spindle with the boring-bar, but nevertheless it must be turned after every pair of holes.

"I sat here one afternoon looking out, just as we are now, watching those two laborers turn that fixture, and it occurred to me that a little graphite and oil smeared on the base would make it turn a whole lot easier, so we tried it out, and sure enough it could be turned by one man very easily. I came back and sat down and congratulated myself that there was another job well taken care of, but I had no more than got comfortably started on a long report on "Why the Shop Overhead Has Increased" when Tom, the boring mill hand, came into the office with the funniest look on his face and said, 'I can't make that darned fixture stay put anywhere, even when I set those clamps up with all my strength. That fixture just seems to slip and slide all over the lot when the cut starts.'

"And Tom was right. I went out there and he hadn't overstated the case at all. That graphite had done its work so well that it was impossible to get any adhesion between the fixture and the boring mill bed, and nothing remained for us to do but clean off the graphite and use the fixture in the same old way. It's a strange thing, but this seems to be a case where elbow grease works better than graphite."

Some Competition

The problems encountered in a job machine shop often form the subjects of interesting discussions. I was visiting a shop in a fair sized country town, and the job shop man was telling how he had lost a contract for turning shafts.

"The other fellow beat me to it on price by about 50 per cent, and naturally he got the job," said the shop man.

"But something is wrong. Why such a great discrepancy in the two bids?"

"That's easy; my competitor runs a little two-man shop out on the edge of the woods where there is no such thing as rent; and it really isn't a two-man shop at all, because he is one of the men and his wife is the other."

"You mean his wife runs a machine in the shop?"

"Exactly that. On this shaft job she centers the work in a drill press and drills a few cross holes in the finished work and he runs a lathe. So, everything considered, you can see how he can figure pretty close."

"That's sure unfair competition"

"That's sure unfair competition," I said, rising to leave; but that chap's going to lose out

"All of which goes to show what a little misplaced matter will do"

somehow and sometime just as sure as I'm a foot high—because he has the wrong business viewpoint.

Curing the Lathe that Wouldn't Turn Straight

Many a good story comes from the chair of a hotel lobby long after factory wheels have stopped turning. There was a good lesson in the one told by old George Watson, the veteran salesman for a large lathe manufacturing company.

"It happened down in the oil country where I was setting up half a dozen lathes in one of those old Pennsylvania shops that were built before the war. I had one lathe set up and the operator was doing nicely, so I started out to line up another. About the middle of the afternoon the operator of the first machine came to me and said, 'Would you believe it, Mr. Watson, my lathe that you lined up so nicely has been turning as straight as a die up to fifteen minutes ago, but now I can't get a straight cut off the darned thing. Come over and see what's the matter.'

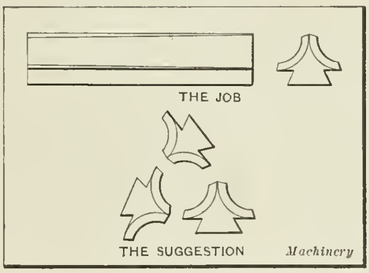
"I went over, and sure enough you couldn't make that lathe cut straight to save your life, but I *knew* it had been right all the morning, so I stood off to one side and looked for the answer. And I found it. Over at the back of that lathe near one corner was a truck loaded with as many rough iron shafts as could be piled on it. The helper had left this standing there a half hour ago, and the load was too much for that old floor, so when it sagged, the corner of the lathe went with it. I told them to pull that truck out of 'speaking' distance, and the lathe came back into line and turned just as prettily as you could expect any well behaved lathe to do."

All of which goes to show what a little misplaced matter will do.

A Difficult Milling Job

"I have asked every mechanical man who has been here in the last two weeks what his ideas would be about tackling a milling job that I have on the slate," said the master mechanic, after having finished a circuit of the shop. "You see, the proposition is this. I have these machine steel forgings furnished me and they must be milled all over," and he rapidly drew a little sketch on his pad.

"It would be a nice little job except for the fact that the radius of the milled section tapers from one end to the other. And this prevents me from making the two cuts with a pair of straddle-milling cutters. After asking everyone I can think of, I have decided to make a cutter the full length of the work, with bearings as large and long as possible, and feed the work broadside into the cutter. Then I'm going to skip over to the other side and make the same cut, and finish that side also. I don't like the idea of running that small diameter cutter up there broadside, but I don't see any other way, do you?"



"It seems to me I'd tackle that job something like this"

"It seems to me," said I, taking out my pencil, "I'd tackle that job something like this: I'd have a pair of fixtures and load three of the parts around each fixture so that the parts to be milled would be around a circle of the right diameter. Then with a cutter on the lines of a taper reamer, having a long piloted bearing, I'd take a cut endwise right through the work up to a stop, and get three pieces for every pass of the cutter instead of one. I haven't attempted to draw up the fixture, but you can see how the work should be spaced, and any of your men can get up a suitable fixture."

"By George," said the master mechanic, "I never thought of that; and I'll tell you right now that if the fixtures that are partly made don't work, I'm going to try out your idea. Come in again where you're along this way. We'll always be glad to see you."

"Quality First"

"See that sign," said the president of one of the best known precision tool companies of the country. "Look around the shop and you'll see these 'Quality First' signs posted everywhere. It's a motto we want to instill in the minds of every man connected with this organization, from the sweeper up. The first requirement in our work is quality. Quantity always comes second, and only by hammering this home in every way we can think of can we keep our men in the right frame of mind for accurate work."

And the manager was right. Whether it was in the grinding room, the lathe department, the planning department or the shipping room, there was a sign reading "Quality First."

The Unknown Plant

Lying close to a railroad track in a Middle Western town is a plant of a prominent manufacturer making a special line of machinery. The machinery is well-known, but the visitor could not find the factory without inquiring of practically everyone he met on the street. No name adorns this prominent plant, and after chasing through a number of back yards, over fences, railroad tracks, through kitchens, etc., you finally land in front of an unpretentious building called the office. Even the shape of the building does not indicate that it is used for a manufacturing office. But upon opening the door a safe is detected and the name of the manufacturer is at last learned.

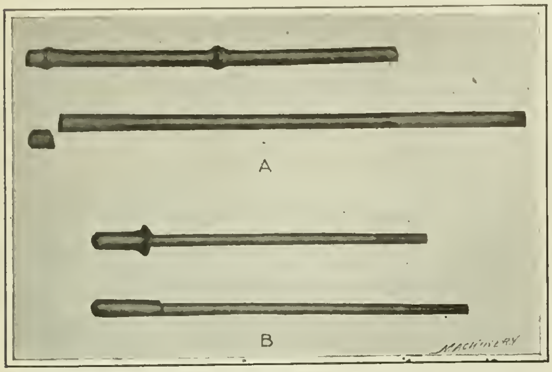
The first impression of carelessness holds good; when you once find the office, you are shown the manager, who has to take great care in rising from his chair in order not to disturb two years' correspondence packed on his desk. One corner of his desk is piled a foot high with telegrams—some of them at least three years old. Letters, pieces of machinery—parts long since forgotten—and ink-wells of all sizes and descriptions clutter the remaining space. The pigeon holes in the desk are also filled to overflowing, and look as though they had not been cleaned out since the incumbent started in business.

Again first impressions are borne out when you are shown into the shop. How a manufacturer can turn out accurate machinery in such a plant is almost inconceivable. The plant probably has grown. Yes, it has. It has been in business for at least twelve to twenty years, and in that time surely should have grown some. But in growing it has taken in existing buildings and made use of kitchens, sheds, bed-rooms, etc. No care has been taken to see that the floors of the various rooms have been leveled up or that the partitions have been torn down. For instance, you will find a boring machine having its cutting end working in the "dining-room" and its driving end in the "bed-room." The operator has to go around a partition to change his gears! Such conditions make anything but a favorable impression upon the visitor to this shop. But then—if it suits the owner, I suppose it is his business to run his plant as he sees fit; but is it *good* business?

"You will find a boring machine with its cutting end working in the dining-room and its driving end in the bed-room"

UNUSUAL ELECTRIC BUTT-WELDING

At *A* in the illustration is shown a ½-inch diameter steel rod which is approximately sixteen inches long and a short ½-inch diameter brass rod which is about one inch long. Above this is shown the pin completely welded. This is known



Interesting Examples of Butt-welding

as a "kicking-pin" which is used in a textile drying machine. To complete one of these kicking-pins, two operations are necessary.

The first operation consists in grasping the center of the ½-inch steel rod in the clamping electrodes of a Thomson electric welder. The electrodes are clamped on this rod a predetermined distance apart, and the current is turned on. After the central portion of the rod is heated by electrical resistance to a white heat, the electrodes are moved toward each other a certain distance which forms in the middle of the rod a very symmetrical shoulder as shown. A second operation on this piece consists of welding the short brass rod to the end of the long steel rod. This operation is accomplished without any difficulty, although not without a large burr being thrown up all around. This burr is subsequently ground off, revealing a very good joint between the brass and steel rods.

At *B* are shown two rods before and after being welded together. The unusual thing about this operation is that the two rods are of such different diameters. The shorter one which is approximately ½ inch in diameter is made of tool steel, and the longer one which is about 9/32 inch in diameter is made of cold-rolled steel. Each of these rods is held in an electrode clamp, and upon being brought together they get very hot, the smaller rod heating much faster than the larger rod because of its smaller cross-section. Owing to its tendency to heat faster, the small rod, when pressure is brought to bear upon it, quickly flattens out on the end to such an extent that the flattened portion has as large a cross-section as the short rod. When this stage has been reached the rods are separated for a short time, and immediately the temperature of the smaller rod drops to very nearly that of the larger one. When these rods have reached the same temperature, they are again brought together and, because of the fact that the cross-sections are now approximately the same on the ends of both rods, the tendency is for both rods to heat uniformly, thereby causing a perfectly good electric weld. This operation also throws up a large burr which is removed by grinding.

* * *

A few years ago there was a strong feeling in this country that the most important element in any enterprise was the financial element, and that if there was only money enough available nothing else mattered much. This idea has not held good, for we are beginning to realize that there is an end to the largest bank account, and are rapidly coming to the conclusion that neither money nor organization will permanently insure success without proper direction. It is therefore imperative for us to study leadership and to find the laws on which successful administration is based.—*H. L. Gantt, in Industrial Leadership.*

CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. SCREW MACHINE*

BY WILLIAM W. JOHNSON†

When a large number of circular forming tools are to be designed, a great deal of labor is involved in computing the different diameters separately. The usual method is as follows (see diagram):

First, find the value of *W* in the right angle triangle *ACD*.

$$W = \sqrt{r^2 - h^2}$$

in which

r = radius of largest diameter of circular tool;

h = distance to which the center of the tool is set, either above or below the center line of the work.

Now, find the value of r in the right angle triangle *ACD*.

$$r = \sqrt{(W - c)^2 + h^2}$$

in which

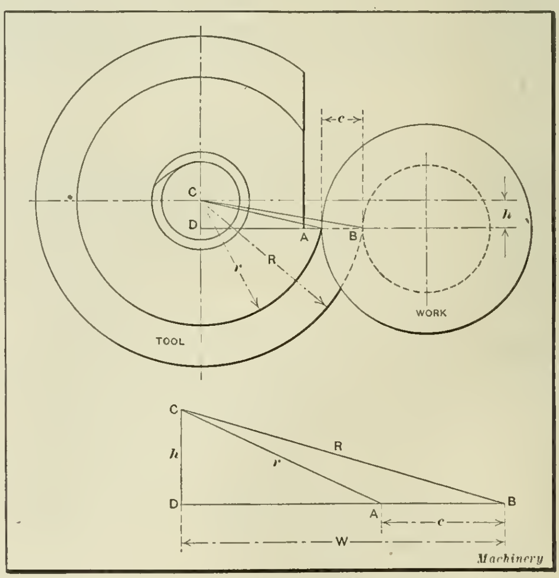
c = one-half the distance between the required diameters of the work;

r = the required radius of the circular tool.

This method is quite long and cannot be materially shortened by using a table of squares. Therefore, anything that can be done to aid in computing the different diameters of circular forming tools will be of interest. This article will give a series of tables which have been computed for the diameters of circular tools, corresponding to variations of one-thousandth inch in the radius of the work. These tables are applicable to the new No. 6 Brown & Sharpe automatic screw machine, the general dimensions of which are given below.

Maximum Diameter of Tool—*D*	= 4
Center of Tool Above Center of Work—*h*	= 5/16
Tap, Left-hand	= 3/4 — 12 pitch
W	= 3/8

The maximum diameter *D* of forming tools for this machine should be 4 inches. To find the other diameters of the tool for any piece to be formed, proceed as follows: Subtract the smallest diameter of the work from the diameter of the work which is to be formed by the required tool diameter; divide the remainder by two; locate the quotient obtained in the column headed "Length c on Tool," and opposite the figure thus located and in the adjacent column read off directly



Notation used in Formulas for Forming Tool Calculations

the diameter to which the tool is to be made. The quotient obtained which is located in the column headed "Length c on Tool," is the length c as shown.

* For previous articles relating to circular forming tools, published in MACHINERY, see also "Calculation of Circular Forming Tools," March, 1911; "Circular Form and Cut-off Tools," March and April, 1910; "Formulas for Circular Forming Tools," January, 1908; "Charts for Forming Tools," October, 1904; "Straight and Circular Forming Tools," June, 1904.

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DIMENSIONS OF CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. AUTOMATIC SCREW MACHINE

Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool
0.001	3.9980	0.081	3.8401	0.162	3.6803	0.242	3.5228	0.323	3.3635	0.404	3.2045	0.484	3.0477
0.002	3.9960	0.082	3.8381	0.163	3.6784	0.243	3.5208	0.324	3.3615	0.405	3.2025	31/64	3.0470
0.003	3.9940	0.083	3.8361	0.164	3.6764	0.244	3.5188	0.325	3.3596	0.406	3.2006	0.485	3.0457
0.004	3.9921	0.084	3.8342	0.165	3.6744	0.245	3.5169	0.326	3.3576	13/32	3.2001	0.486	3.0438
0.005	3.9901	0.085	3.8322	0.166	3.6724	0.246	3.5149	0.327	3.3556	0.407	3.1986	0.487	3.0418
0.006	3.9881	0.086	3.8302	0.167	3.6705	0.247	3.5129	0.328	3.3537	0.408	3.1966	0.488	3.0398
0.007	3.9862	0.087	3.8282	0.168	3.6685	0.248	3.5110	21/64	3.3534	0.409	3.1947	0.489	3.0379
0.008	3.9842	0.088	3.8263	0.169	3.6665	0.249	3.5090	0.329	3.3517	0.410	3.1927	0.490	3.0359
0.009	3.9822	0.089	3.8243	0.170	3.6646	0.250	3.5070	0.330	3.3498	0.411	3.1908	0.491	3.0340
0.010	3.9802	0.090	3.8223	0.171	3.6626	0.251	3.5051	0.331	3.3478	0.412	3.1888	0.492	3.0320
0.011	3.9783	0.091	3.8203	11/64	3.6609	0.252	3.5031	0.332	3.3458	0.413	3.1868	0.493	3.0300
0.012	3.9763	0.092	3.8184	0.172	3.6606	0.253	3.5011	0.333	3.3439	0.414	3.1849	0.494	3.0281
0.013	3.9743	0.093	3.8164	0.173	3.6586	0.254	3.4992	0.334	3.3419	0.415	3.1829	0.495	3.0261
0.014	3.9723	3/32	3.8149	0.174	3.6567	0.255	3.4972	0.335	3.3399	0.416	3.1810	0.496	3.0242
0.015	3.9704	0.094	3.8144	0.175	3.6547	0.256	3.4952	0.336	3.3380	0.417	3.1790	0.497	3.0222
1/64	3.9692	0.095	3.8124	0.176	3.6527	0.257	3.4933	0.337	3.3360	0.418	3.1770	0.498	3.0202
0.016	3.9684	0.096	3.8105	0.177	3.6508	0.258	3.4913	0.338	3.3341	0.419	3.1751	0.499	3.0183
0.017	3.9664	0.097	3.8085	0.178	3.6488	0.259	3.4893	0.339	3.3321	0.420	3.1731	0.500	3.0163
0.018	3.9644	0.098	3.8065	0.179	3.6468	0.260	3.4874	0.340	3.3301	0.421	3.1712	0.501	3.0143
0.019	3.9625	0.099	3.8045	0.180	3.6449	0.261	3.4854	0.341	3.3282	27/64	3.1695	0.502	3.0124
0.020	3.9605	0.100	3.8026	0.181	3.6429	0.262	3.4834	0.342	3.3262	0.422	3.1692	0.503	3.0104
0.021	3.9585	0.101	3.8006	0.182	3.6409	0.263	3.4814	0.343	3.3242	0.423	3.1672	0.504	3.0085
0.022	3.9565	0.102	3.7986	0.183	3.6389	0.264	3.4795	11/32	3.3227	0.424	3.1653	0.505	3.0065
0.023	3.9546	0.103	3.7966	0.184	3.6370	0.265	3.4775	0.344	3.3223	0.425	3.1633	0.506	3.0046
0.024	3.9526	0.104	3.7946	0.185	3.6350	17/64	3.4763	0.345	3.3203	0.426	3.1614	0.507	3.0026
0.025	3.9506	0.105	3.7927	0.186	3.6330	0.266	3.4755	0.346	3.3184	0.427	3.1594	0.508	3.0006
0.026	3.9486	0.106	3.7907	0.187	3.6311	0.267	3.4736	0.347	3.3164	0.428	3.1574	0.509	2.9987
0.027	3.9467	0.107	3.7887	3/16	3.6301	0.268	3.4716	0.348	3.3144	0.429	3.1555	0.510	2.9967
0.028	3.9447	0.108	3.7868	0.188	3.6291	0.269	3.4696	0.349	3.3125	0.430	3.1535	0.511	2.9948
0.029	3.9427	0.109	3.7848	0.189	3.6271	0.270	3.4677	0.350	3.3105	0.431	3.1516	0.512	2.9928
0.030	3.9408	7/64	3.7841	0.190	3.6251	0.271	3.4657	0.351	3.3085	0.432	3.1496	0.513	2.9909
0.031	3.9388	0.110	3.7828	0.191	3.6232	0.272	3.4637	0.352	3.3066	0.433	3.1476	0.514	2.9889
1/32	3.9383	0.111	3.7808	0.192	3.6212	0.273	3.4618	0.353	3.3046	0.434	3.1457	0.515	2.9870
0.032	3.9368	0.112	3.7789	0.193	3.6192	0.274	3.4598	0.354	3.3026	0.435	3.1437	33/64	2.9858
0.033	3.9348	0.113	3.7769	0.194	3.6173	0.275	3.4578	0.355	3.3007	0.436	3.1418	0.516	2.9850
0.034	3.9329	0.114	3.7749	0.195	3.6153	0.276	3.4559	0.356	3.2987	0.437	3.1398	0.517	2.9831
0.035	3.9309	0.115	3.7730	0.196	3.6133	0.277	3.4539	0.357	3.2968	7/16	3.1388	0.518	2.9811
0.036	3.9289	0.116	3.7710	0.197	3.6113	0.278	3.4519	0.358	3.2948	0.438	3.1378	0.519	2.9792
0.037	3.9269	0.117	3.7690	0.198	3.6094	0.279	3.4500	0.359	3.2928	0.439	3.1359	0.520	2.9772
0.038	3.9250	0.118	3.7671	0.199	3.6074	0.280	3.4480	23/64	3.2921	0.440	3.1339	0.521	2.9753
0.039	3.9230	0.119	3.7651	0.200	3.6054	0.281	3.4460	0.360	3.2909	0.441	3.1320	0.522	2.9733
0.040	3.9210	0.120	3.7631	0.201	3.6035	9/32	3.4455	0.361	3.2889	0.442	3.1300	0.523	2.9714
0.041	3.9190	0.121	3.7611	0.202	3.6015	0.282	3.4441	0.362	3.2869	0.443	3.1280	0.524	2.9694
0.042	3.9171	0.122	3.7592	0.203	3.5995	0.283	3.4421	0.363	3.2850	0.444	3.1261	0.525	2.9674
0.043	3.9151	0.123	3.7572	13/64	3.5993	0.284	3.4401	0.364	3.2830	0.445	3.1241	0.526	2.9655
0.044	3.9131	0.124	3.7552	0.204	3.5976	0.285	3.4382	0.365	3.2811	0.446	3.1222	0.527	2.9635
0.045	3.9111	0.125	3.7533	0.205	3.5956	0.286	3.4362	0.366	3.2791	0.447	3.1202	0.528	2.9616
0.046	3.9092	0.126	3.7513	0.206	3.5936	0.287	3.4342	0.367	3.2771	0.448	3.1182	0.529	2.9596
3/64	3.9075	0.127	3.1493	0.207	3.5917	0.288	3.4322	0.368	3.2752	0.449	3.1163	0.530	2.9577
0.047	3.9072	0.128	3.7473	0.208	3.5897	0.289	3.4303	0.369	3.2732	0.450	3.1143	0.531	2.9557
0.048	3.9052	0.129	3.7454	0.209	3.5877	0.290	3.4283	0.370	3.2712	0.451	3.1124	17/32	2.9552
0.049	3.9032	0.130	3.7434	0.210	3.5858	0.291	3.4263	0.371	2.2693	0.452	3.1104	0.532	2.9538
0.050	3.9013	0.131	3.7414	0.211	3.5838	0.292	3.4244	0.372	3.2673	0.453	3.1084	0.533	2.9518
0.051	3.8993	0.132	3.7395	0.212	3.5818	0.293	3.4224	0.373	3.2654	29/64	3.1081	0.534	2.9499
0.052	3.8973	0.133	3.7375	0.213	3.5798	0.294	3.4204	0,374	3.2634	0.454	3.1065	0.535	2.9479
0.053	3.8953	0.134	3.7355	0.214	3.5779	0.295	3.4185	0.375	3.2614	0.455	3.1045	0.536	2.9460
0.054	3.8934	0.135	3.7335	0.215	3.5759	0.296	3.4165	0.376	3.2595	0.456	3.1026	0.537	2.9440
0.055	3.8914	0.136	3.7316	0.216	3.5739	19/64	3.4148	0.377	3.2575	0.457	3.1006	0.538	2.9421
0.056	3.8894	0.137	3.7296	0.217	3.5720	0.297	3.4145	0.378	3.2555	0.458	3.0986	0.539	2.9401
0.057	3.8875	0.138	3.7276	0.218	3.5700	0.298	3.4126	0.379	3.2536	0.459	3.0967	0.540	2.9382
0.058	3.8855	0.139	3.7257	7/32	3.5685	0.299	3.4106	0.380	3.2516	0.460	3.0947	0.541	2.9362
0.059	3.8835	0.140	3.7237	0.219	3.5680	0.300	3.4086	0.381	3.2496	0.461	3.0928	0.542	2.9342
0.060	3.8815	9/64	3.7225	0.220	3.5661	0.301	3.4067	0.382	3.2477	0.462	3.0908	0.543	2.9323
0.061	3.8796	0.141	3.7217	0.221	3.5641	0.302	3.4047	0.383	3.2457	0.463	3.0888	0.544	2.9303
0.062	3.8776	0.142	3.7197	0.222	3.5621	0.303	3.4028	0.384	3.2438	0.464	3.0869	0.545	2.9284
1/16	3.8767	0.143	3.7178	0.223	3.5602	0.304	3.4008	0.385	3.2418	0.465	3.0849	0.546	2.9264
0.063	3.8756	0.144	3.7158	0.224	3.5582	0.305	3.3988	0.386	3.2398	0.466	3.0830	35/64	2.9247
0.064	3.8736	0.145	3.7138	0.225	3.5562	0.306	3.3969	0.387	3.2379	0.467	3.0810	0.547	2.9245
0.065	3.8717	0.146	3.7119	0.226	3.5543	0.307	3.3949	0.388	3.2359	0.468	3.0790	0.548	2.9225
0.066	3.8697	0.147	3.7099	0.227	3.5523	0.308	3.3929	0.389	3.2339	15/32	3.0773	0.549	2.9206
0.067	3.8677	0.148	3.7079	0.228	3.5503	0.309	3.3910	0.390	3.2320	0.469	3.0771	0.550	2.9186
0.068	3.8657	0.149	3.7060	0.229	3.5484	0.310	3.3890	25/64	3.2308	0.470	3.0751	0.551	2.9167
0.069	3.8638	0.150	3.7040	0.230	3.5464	0.311	3.3871	0.391	3.2300	0.471	3.0732	0.552	2.9147
0.070	3.8618	0.151	3.7020	0.231	3.5444	0.312	3.3851	0.392	3.2281	0.472	3.0712	0.553	2.9128
0.071	3.8598	0.152	3.7000	0.232	3.5425	5/16	3.3841	0.393	3.2261	0.473	3.0692	0.554	2.9108
0.072	3.8578	0.153	3.6981	0.233	3.5405	0.313	3.3831	0.394	3.2241	0.474	3.0673	0.555	2.9089
0.073	3.8559	0.154	3.6961	0.234	3.5385	0.314	3.3812	0.395	3.2222	0.475	3.0653	0.556	2.9069
0.074	3.8539	0.155	3.6941	15/64	3.5378	0.315	3.3792	0.396	3.2202	0.476	3.0634	0.557	2.9050
0.075	3.8519	0.156	3.6922	0.235	3.5366	0.316	3.3772	0.397	3.2182	0.477	3.0614	0.558	2.9030
0.076	3.8499	5/32	3.6917	0.236	3.4346	0.317	3.3753	0.398	3.2163	0.478	3.0594	0.559	2.9010
0.077	3.8480	0.157	3.6902	0.237	3.5326	0.318	3.3733	0.399	3.2143	0.479	3.0575	0.560	2.8991
0.078	3.8460	0.158	3.6882	0.238	3.5306	0.319	3.3714	0.400	3.2124	0.480	3.0555	0.561	2.8971
5/64	3.8457	0.159	3.6862	0.239	3.5287	0.320	3.3694	0.401	3.2104	0.481	3.0536	0.562	2.8952
0.079	3.8440	0.160	3.6843	0.240	3.5267	0.321	3.3674	0.402	3.2084	0.482	3.0516	9/16	2.8942
0.080	3.8421	0.161	3.6823	0.241	3.5247	0.322	3.3655	0.403	3.2064	0.483	3.0496	0.563	2.8932

Machinery

DIMENSIONS OF CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. AUTOMATIC SCREW MACHINE—Continued

Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool
0.564	2.8913	0.645	2.7334	0.725	2.5779	0.806	2.4209	0.887	2.2648	0.967	2.1115	1.047	1.9592
0.565	2.8893	0.646	2.7314	0.726	2.5759	0.807	2.4190	0.888	2.2629	0.968	2.1096	1.048	1.9573
0.566	2.8874	0.647	2.7295	0.727	2.5740	0.808	2.4171	0.889	2.2610	31/32	2.1082	1.049	1.9554
0.567	2.8854	0.648	2.7276	0.728	2.5721	0.809	2.4151	0.890	2.2590	0.969	2.1077	1.050	1.9535
0.568	2.8835	0.649	2.7256	0.729	2.5701	0.810	2.4132	57/64	2.2578	0.970	2.1058	1.051	1.9516
0.569	2.8815	0.650	2.7237	0.730	2.5682	0.811	2.4113	0.891	2.2571	0.971	2.1039	1.052	1.9497
0.570	2.8796	0.651	2.7217	0.731	2.5662	0.812	2.4093	0.892	2.2552	0.972	2.1020	1.053	1.9479
0.571	2.8776	0.652	2.7198	0.732	2.5643	13/16	2.4083	0.893	2.2533	0.973	2.1001	1.054	1.9460
0.572	2.8757	0.653	2.7178	0.733	2.5624	0.813	2.4074	0.894	2.2514	0.974	2.0981	1.055	1.9441
0.573	2.8737	0.654	2.7159	0.734	2.5604	0.814	2.4055	0.895	2.2494	0.975	2.0962	1.056	1.9422
0.574	2.8717	0.655	2.7139	47/64	2.5597	0.815	2.4035	0.896	2.2475	0.976	2.0944	1.057	1.9403
0.575	2.8698	0.656	2.7120	0.735	2.5585	0.816	2.4016	0.897	2.2456	0.977	2.0925	1.058	1.9384
0.576	2.8678	21/32	2.7115	0.736	2.5565	0.817	2.3997	0.898	2.2437	0.978	2.0906	1.059	1.9365
0.577	2.8659	0.657	2.7100	0.737	2.5546	0.818	2.3977	0.899	2.2418	0.979	2.0886	1.060	1.9346
0.578	2.8639	0.658	2.7081	0.738	2.5527	0.819	2.3958	0.900	2.2398	0.980	2.0867	1.061	1.9327
37/64	2.8636	0.659	2.7061	0.739	2.5507	0.820	2.3939	0.901	2.2379	0.981	2.0848	1.062	1.9308
0.579	2.8620	0.660	2.7042	0.740	2.5488	0.821	2.3920	0.902	2.2360	0.982	2.0829	1 1/16	1.9298
0.580	2.8600	0.661	2.7022	0.741	2.5469	0.822	2.3900	0.903	2.2341	0.983	2.0810	1.063	1.9289
0.581	2.8581	0.662	2.7003	0.742	2.5449	0.823	2.3881	0.904	2.2321	0.984	2.0791	1.064	1.9270
0.582	2.8561	0.663	2.6983	0.743	2.5430	0.824	2.3862	0.905	2.2302	63/64	2.0784	1.065	1.9252
0.583	2.8542	0.664	2.6964	0.744	2.5410	0.825	2.3842	0.906	2.2283	0.985	2.0772	1.066	1.9233
0.584	2.8522	0.665	2.6945	0.745	2.5391	0.826	2.3823	29/32	2.2278	0.986	2.0753	1.067	1.9214
0.585	2.8503	0.666	2.6925	0.746	2.5372	0.827	2.3804	0.907	2.2264	0.987	2.0734	1.068	1.9195
0.586	2.8483	0.667	2.6906	0.747	2.5352	0.828	2.3785	0.908	2.2245	0.988	2.0715	1.069	1.9176
0.587	2.8464	0.668	2.6886	0.748	2.5333	53/64	2.3782	0.909	2.2226	0.989	2.0695	1.070	1.9157
0.588	2.8444	0.669	2.6867	0.749	2.5313	0.829	2.3765	0.910	2.2206	0.990	2.0676	1.071	1.9138
0.589	2.8425	0.670	2.6847	0.750	2.5294	0.830	2.3746	0.911	2.2187	0.991	2.0657	1.072	1.9119
0.590	2.8405	0.671	2.6828	0.751	2.5275	0.831	2.3727	0.912	2.2168	0.992	2.0638	1.073	1.9100
0.591	2.8385	43/64	2.6811	0.752	2.5255	0.832	2.3708	0.913	2.2149	0.993	2.0619	1.074	1.9081
0.592	2.8366	0.672	2.6808	0.753	2.5236	0.833	2.3688	0.914	2.2130	0.994	2.0600	1.075	1.9062
0.593	2.8346	0.673	2.6789	0.754	2.5217	0.834	2.3669	0.915	2.2111	0.995	2.0581	1.076	1.9044
19/32	2.8332	0.674	2.6769	0.755	2.5197	0.835	2.3650	0.916	2.2091	0.996	2.0562	1.077	1.9025
0.594	2.8327	0.675	2.6750	0.756	2.5178	0.836	2.3630	0.917	2.2072	0.997	2.0543	1.078	1.9007
0.595	2.8307	0.676	2.6730	0.757	2.5158	0.837	2.3611	0.918	2.2053	0.998	2.0524	1 5/64	1.9005
0.596	2.8288	0.677	2.6711	0 758	2.5139	0.838	2.3592	0.919	2.2034	0.999	2.0504	1.079	1.8988
0.597	2.8268	0.678	2.6691	0.759	2.5120	0.839	2.3572	0.920	2.2015	1.000	2.0485	1.080	1.8969
0.598	2.8249	0.679	2.6672	0.760	2.5100	0.840	2.3553	0.921	2.1995	1.001	2.0466	1.081	1.8950
0.599	2.8229	0.680	2.6653	0.761	2.5081	0.841	2.3534	59/64	2.1978	1.002	2.0447	1.082	1.8931
0.600	2.8210	0.681	2.6633	0.762	2.5062	0.842	2.3515	0.922	2.1976	1.003	2.0428	1.083	1.8912
0.601	2.8191	0.682	2.6614	0.763	2.5042	0.843	2.3495	0.923	2.1957	1.004	2.0409	1.084	1.8893
0.602	2.8171	0.683	2.6594	0.764	2.5023	27/32	2.3480	0.924	2.1938	1.005	2.0390	1.085	1.8874
0.603	2.8152	0.684	2.6575	0.765	2.5003	0.844	2.3476	0.925	2.1919	1.006	2.0371	1.086	1.8855
0.604	2.8132	0.685	2.6555	49/64	2.4991	0.845	2.3457	0.926	2.1900	1.007	2.0352	1.087	1.8836
0.605	2.8113	0.686	2.6536	0.766	2.4984	0.846	2.3437	0.927	2.1880	1.008	2.0333	1.088	1.8818
0.606	2.8093	0.687	2.6516	0.767	2.4965	0.847	2.3418	0.928	2.1861	1.009	2.0314	1.089	1.8799
0.607	2.8074	11/16	2.6506	0.768	2.4945	0.848	2.3399	0.929	2.1842	1.010	2.0295	1.090	1.8780
0.608	2.8054	0.688	2.6497	0.769	2.4926	0.849	2.3379	0.930	2.1823	1.011	2.0276	1.091	1.8761
0.609	2.8035	0.689	2.6477	0.770	2.4907	0.850	2.3360	0.931	2.1804	1.012	2.0257	1.092	1.8742
39/64	2.8028	0.690	2.6458	0.771	2.4887	0.851	2.3340	0.932	2.1785	1.013	2.0238	1.093	1.8723
0.610	2.8015	0.691	2.6438	0.772	2.4868	0.852	2.3321	0.933	2.1765	1.014	2.0219	1 3/32	1.8709
0.611	2.7996	0.692	2.6419	0.773	2.4848	0.853	2.3301	0.934	2.1746	1.015	2.0200	1.094	1.8704
0.612	2.7976	0.693	2.6399	0.774	2.4829	0.854	2.3282	0.935	2.1727	1 1/64	2.0188	1.095	1.8685
0.613	2.7957	0.694	2.6380	0.775	2.4810	0.855	2.3263	0.936	2.1708	1.016	2.0181	1.096	1.8666
0.614	2.7938	0.695	2.6360	0.776	2.4790	0.856	2.3244	0.937	2.1689	1.017	2.0162	1.097	1.8647
0.615	2.7918	0.696	2.6341	0.777	2.4771	0.857	2.3225	15/16	2.1679	1.018	2.0143	1.098	1.8629
0.616	2.7899	0.697	2.6322	0.778	2.4751	0.858	2.3205	0.938	2.1670	1.019	2.0124	1.099	1.8610
0.617	2.7879	0.698	2.6302	0.779	2.4732	0.859	2.3186	0.939	2.1650	1.020	2.0105	1.100	1.8591
0.618	2.7860	0.699	2.6283	0.780	2.4713	55/64	2.3179	0.940	2.1631	1.021	2.0086	1.101	1.8572
0.619	2.7840	0.700	2.6263	0.781	2.4693	0.860	2.3167	0.941	2.1612	1.022	2.0067	1.102	1.8553
0.620	2.7821	0.701	2.6244	25/32	2.4688	0.861	2.3148	0.942	2.1593	1.023	2.0048	1.103	1.8534
0.621	2.7801	0.702	2.6224	0.782	2.4674	0.862	2.3129	0.943	2.1574	1.024	2.0029	1.104	1.8515
0.622	2.7782	0.703	2.6205	0.783	2.4655	0.863	2.3109	0.944	2.1555	1.025	2.0010	1.105	1.8497
0.623	2.7762	45/64	2.6202	0.784	2.4635	0.864	2.3090	0.945	2.1536	1.026	1.9991	1.106	1.8478
0.624	2.7743	0.704	2.6186	0.785	2.4616	0.865	2.3071	0.946	2.1516	1.027	1.9972	1.107	1.8459
0.625	2.7723	0.705	2.6166	0.786	2.4596	0.866	2.3052	0.947	2.1497	1.028	1.9953	1.108	1.8440
0.626	2.7704	0.706	2.6147	0.787	2.4577	0.867	2.3033	0.948	2.1478	1.029	1.9934	1.109	1.8421
0.627	2.7684	0.707	2.6127	0.788	2.4558	0.868	2.3013	0.949	2.1459	1.030	1.9915	1 7/64	1.8414
0.628	2.7665	0.708	2.6108	0.789	2.4538	0.869	2.2994	0.950	2.1440	1.031	1.9896	1.110	1.8403
0.629	2.7645	0.709	2.6089	0.790	2.4519	0.870	2.2975	0.951	2.1421	1 1/32	1.9891	1.111	1.8384
0.630	2.7626	0.710	2.6069	0.791	2.4500	0.871	2.2956	0.952	2.1402	1.032	1.9877	1.112	1.8365
0.631	2.7607	0.711	2.6050	0.792	2.4480	0.872	2.2937	0.953	2.1383	1.033	1.9858	1.113	1.8346
0.632	2.7587	0.712	2.6031	0.793	2.4461	0.873	2.2917	61/64	2.1381	1.034	1.9839	1.114	1.8327
0.633	2.7568	0.713	2.6011	0.794	2.4441	0.874	2.2898	0.954	2.1363	1.035	1.9820	1.115	1.8309
0.634	2.7548	0.714	2.5992	0.795	2.4422	0.875	2.2879	0.955	2.1344	1.036	1.9801	1.116	1.8290
0.635	2.7529	0.715	2.5972	0.796	2.4403	0.876	2.2859	0.956	2.1325	1.037	1.9782	1.117	1.8271
0.636	2.7509	0.716	2.5953	51/64	2.4386	0.877	2.2840	0.957	2.1306	1.038	1.9763	1.118	1.8252
0.637	2.7490	0.717	2.5934	0.797	2.4383	0.878	2.2821	0.958	2.1287	1.039	1.9744	1.119	1.8233
0.638	2.7470	0.718	2.5914	0.798	2.4364	0.879	2.2802	0.959	2.1268	1.040	1.9725	1.120	1.8215
0.639	2.7451	23/32	2.5899	0.799	2.4344	0.880	2.2782	0.960	2.1249	1.041	1.9706	1.121	1.8196
0.640	2.7431	0.719	2.5895	0.800	2.4325	0.881	2.2763	0.961	2.1230	1.042	1.9687	1.122	1.8177
41/64	2.7419	0.720	2.5876	0.801	2.4306	0.882	2.2744	0.962	2.1211	1.043	1.9668	1.123	1.8158
0.641	2.7412	0.721	2.5856	0.802	2.4286	0.883	2.2725	0.963	2.1192	1.044	1.9649	1.124	1.8139
0.642	2.7392	0.722	2.5837	0.803	2.4267	0.884	2.2706	0.964	2.1172	1.045	1.9630	1.125	1.8121
0.643	2.7373	0.723	2.5817	0.804	2.4248	0.885	2.2686	0.965	2.1153	1.046	1.9611	1.126	1.8102
0.644	2.7353	0.724	2.5798	0.805	2.4229	0.886	2.2667	0.966	2.1134	1 3/64	1.9594	1.127	1.8083

Machinery

DIMENSIONS OF CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. AUTOMATIC SCREW MACHINE—Continued

Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool
1.128	1.8064	1.147	1.7709	1.166	1.7354	1.185	1.7000
1.129	1.8046	1.148	1.7690	1.167	1.7335	1.186	1.6981
1.130	1.8027	1.149	1.7672	1.168	1.7316	1.187	1.6963
1.131	1.8008	1.150	1.7653	1.169	1.7298	$1\frac{3}{16}$	1.6954
1.132	1.7989	1.151	1.7634	1.170	1.7279	1.188	1.6944
1.133	1.7971	1.152	1.7615	1.171	1.7260	1.189	1.6925
1.134	1.7952	1.153	1.7597	$1\frac{11}{64}$	1.7244	1.190	1.6907
1.135	1.7933	1.154	1.7578	1.172	1.7241	1.191	1.6888
1.136	1.7915	1.155	1.7559	1.173	1.7223	1.192	1.6870
1.137	1.7896	1.156	1.7541	1.174	1.7204	1.193	1.6851
1.138	1.7877	$1\frac{5}{32}$	1.7536	1.175	1.7185	1.194	1.6832
1.139	1.7859	1.157	1.7522	1.176	1.7167	1.195	1.6814
1.140	1.7840	1.158	1.7503	1.177	1.7149	1.196	1.6795
$1\frac{9}{64}$	1.7828	1.159	1.7485	1.178	1.7130	1.197	1.6777
1.141	1.7821	1.160	1.7466	1.179	1.7111	1.198	1.6758
1.142	1.7802	1.161	1.7447	1.180	1.7093	1.199	1.6739
1.143	1.7784	1.162	1.7428	1.181	1.7074	1.200	1.6721
1.144	1.7765	1.163	1.7410	1.182	1.7056	.....	......
1.145	1.7746	1.164	1.7391	1.183	1.7037	.....	......
1.146	1.7728	1.165	1.7372	1.184	1.7018	.....	......

Machinery

* * *

MACHINING A BALL AND SOCKET JOINT

BY CHESTER S. RICKER*

On Paige-Detroit motor cars there is a ball and socket joint which has to be machined very carefully, as it has heavy duty to perform. This joint is located at the forward end of the torque tube which is attached to the rear axle. It serves a double purpose, *i. e.*, to transmit the driving action and to resist the torque or tendency of the rear axle to rotate about the axis of the wheels. At the same time, it must be free to move about its center as the rear axle rises and falls, due to spring action. Furthermore, the center of the ball and socket must be coincident with a universal joint which the ball encloses. The methods of making these two pieces on a Bullard vertical turret lathe are shown in the accompanying illustrations. About fifty per hour is the rate of production on both pieces, although output on the socket usually runs slightly less because of the additional work required in facing off the flange in addition to machining the socket.

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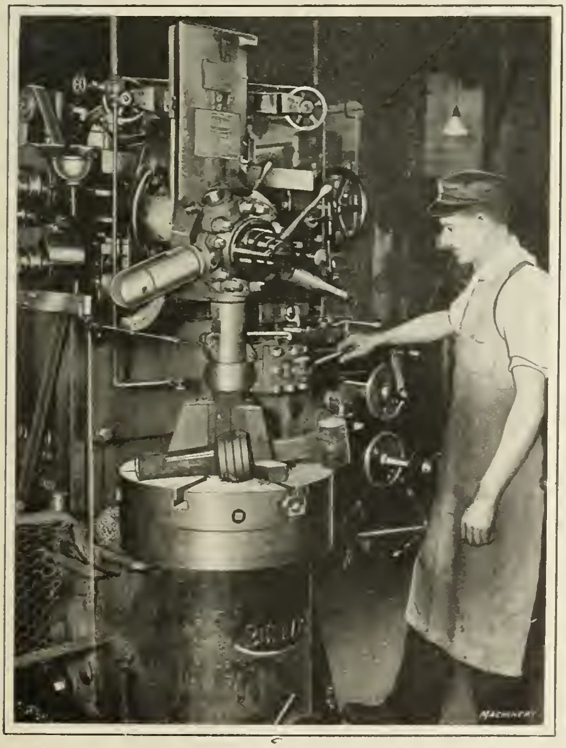

Fig. 1. Bullard Vertical Turret Lathe tooled up for turning Ball of a Ball and Socket Joint

Both tools are designed on the same principle. Heavy cylindrical bars are mounted in the turret, the end of these bars being slotted to carry the tools. The tool for machining the socket, Fig. 2, is a circular disk of slightly smaller diameter than the socket and of suitable thickness to just fit in the slot in the bar. A weight and cord are used to keep the tool out of engagement with the work. The cord is secured in place by a hook, so that it only requires a second to release it when the turret has to be rotated to the next position. The same is true of the feeding device which is hooked to the tool and to the transverse tool-holder. When the tool has been lowered into the work until the center is coincident with the center of the socket, the cross-feed is started, the work having already been started rotating.

The method of attaching the weight and the feed-bar is most clearly shown in the illustration of the ball, Fig. 1, which also shows a piece of work unfinished, one that is semi-finished, and one in the chuck that is completely finished. The "semi-finishing" tool is shown at the left side of the turret in the first position above the tool which is at work. It shows very clearly the design of the tool-holder and the rotary piece carrying the cutter. Both pieces are made from malleable iron.

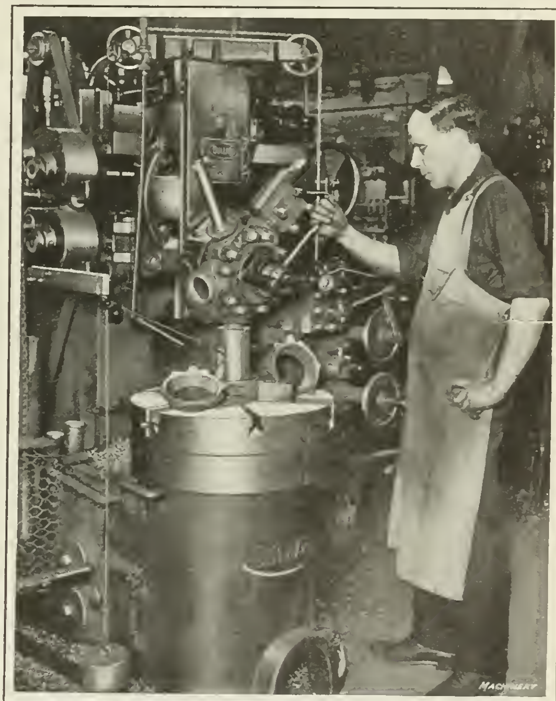

Fig. 2. Bullard Vertical Turret Lathe tooled up for turning Socket of a Ball and Socket Joint

* * *

POLISHING STRAP SPEEDS

Several modifications of belt type polishing machines are in use, but they all consist essentially of two flanged pulleys, carrying a canvas belt coated with glue and abrasives on the outer side. They are often called strapping or strap buffing machines. The straps or polishing belts run at speeds of from 2000 to 2500 feet per minute generally, and are effective for finishing irregular surfaces, especially on brass work. They have found a considerable field of usefulness in polishing surfaces that are inaccessible with the polishing wheel. Experience has shown that the finer woven belts hold the abrasive materials better than those that are coarser woven.—*Grits and Grinds.*

ELECTRIC SPOT-WELDING PRACTICE—2*

APPLICATION OF ELECTRIC SPOT-WELDING MACHINES TO VARIOUS WELDING PROCESSES

BY DOUGLAS T. HAMILTON†

While the operation of an electric spot-welding machine is comparatively simple, there are a number of points in connection with it, as well as the preparation of the material, that should receive careful attention. As has been previously explained in the article which appeared in the August number of MACHINERY, it is necessary to vary the pressure, current and time, depending on the thickness of the stock and the character of the material being spot-welded. Another point is the cleaning of the material and the preparation of it when other than the regular spot-welding operations are being performed. These points, together with a description of some of the more practical applications of a spot-welding machine to various welding processes, will be covered in the following.

Fig. 1. Results of an Endeavor to separate Two Pieces of Sheet Steel that have been spot-welded—Note how Metal around Welded Spot is tearing away and Welded Spot remains Intact, forming one Sheet with the Lower Piece

Preparation of Work for Spot-welding

In welding sheet metal, the best results can be obtained when the stock is clean and free from scale, rust or dirt. The cleaner and better the stock the easier it is to weld, and the less current it takes to accomplish the work. It will also be found that when the metal is clean and free from scale the electrodes will wear much longer than when the stock is dirty. Electrodes should be kept clean and firmly held in their holders. If dirt is allowed to gather around the sockets that hold the electrodes, good contact cannot be made. Dirt and grease as well as scale are non-conductors of electric current, and with the low voltage employed in electric spot-welding machines, it takes very little dirt, grease or scale to make poor contact and obtain poor results. In fact, the entire machine should be kept clean, and if there is undue heating at any point, it is a clear indication that there is poor contact, and this should be remedied without delay. Loose joints in the machine mean that there is poor contact and resultant heating with a decrease in power. Care should be taken to see that the bolts fastening the copper leads or secondary circuit to the transformer and the copper blocks holding the electrodes are tightened.

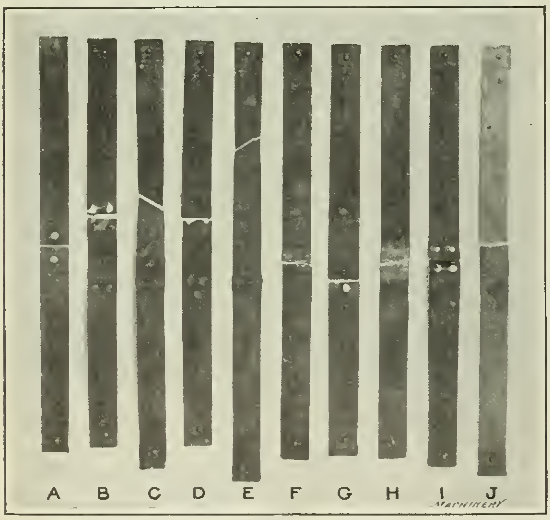

Fig. 2. Results of Tests made to show Comparative Strength of Spot-welded and Riveted Joints

Other electric welding processes which can be accomplished on a spot-welding machine require in most cases a previous mechanical preparation of the stock. Some of these processes are known as point-welding, bridge-welding, T-welding, etc. The methods used in preparing the stock for accomplishing these various processes will be described in the following.

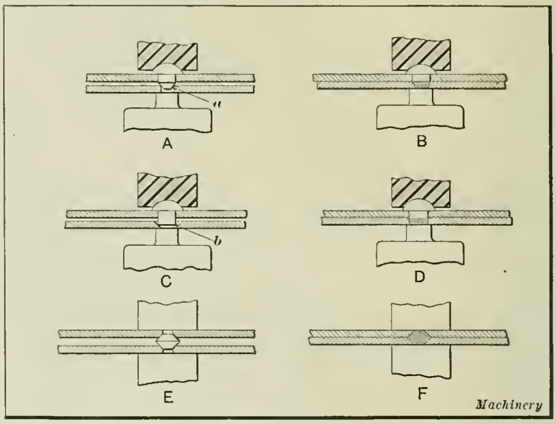

Fig. 3. Diagram illustrating Various Processes of accomplishing Electric Riveting on a Spot-welding Machine

TABLE OF TIME AND POWER REQUIRED AND COST OF SPOT-WELDING SHEET STEEL AND IRON

No. of Sheet Steel Gage U. S. Standard	Thickness in Fractions of an Inch	Decimal Equivalent in Inches	Approximate K. W. Required	H. P. at Dynamo	Time in Seconds to Make a Weld	Cost of 1000 Welds at 1 cent per K. W. Hour
28	1/64	0.0156	4.0	5.7	0.25	$0.00278
26	3/160	0.0187	5.5	7.9	0.30	0.00458
24	1/40	0.0250	7.0	10.0	0.40	0.00774
22	1/32	0.0312	8.0	11.4	0.50	0.01110
20	3/80	0.0375	9.0	12.9	0.55	0.01375
18	1/20	0.0500	10.0	14.3	0.70	0.01945
16	1/16	0.0625	12.0	17.1	0.85	0.02840
14	5/64	0.0781	13.5	19.3	1.00	0.03750
12	7/64	0.1093	16.5	23.6	1.30	0.05950
10	9/64	0.1406	19.0	27.2	1.70	0.08950
9	5/32	0.1562	20.0	28.6	1.80	0.10000
8	11/64	0.1718	21.5	30.7	2.00	0.11950
7	3/16	0.1875	22.5	32.1	2.10	0.13100
6	13/64	0.2031	23.5	33.6	2.20	0.14350
5	7/32	0.2187	24.5	35.0	2.35	0.16000
4	15/64	0.2343	25.5	36.4	2.45	0.17300
3	1/4	0.2500	26.5	37.8	2.60	0.19100
1	9/32	0.2812	28.5	40.7	2.80	0.22200
0	5/16	0.3125	29.5	42.0	2.95	0.24100
000	3/8	0.3750	33.5	47.8	3.50	0.30800
00000	7/16	0.4375	36.5	52.0	4.00	0.40500
0000000	1/2	0.5000	39.5	56.4	4.45	0.48800
....	9/16	0.5625	42.2	60.3	4.90	0.57400
....	5/8	0.6250	45.0	64.3	5.40	0.67600
....	11/16	0.6875	47.7	68.2	5.84	0.77300
....	3/4	0.7500	50.7	72.5	6.30	0.88800
....	13/16	0.8125	53.5	76.5	6.80	1.01000
....	7/8	0.8750	56.3	80.5	7.25	1.13500
....	1	1.0000	62.0	88.6	8.20	1.41300

* For information on electric welding previously published in MACHINERY, see "Electric Spot Welding," August, 1916, and other articles there referred to.
† Associate Editor of MACHINERY.

Power and Time Required for Electric Spot-welding

The power required for operating an electric welding machine depends on the size of the machine, character and thickness of the material being welded, and the time taken to make the weld. In operating all electric welding machines of the resistance type, alternating current should be used of either 220 or 440 volts, 60 cycles. Where the frequency varies from 60, for instance 25, a special transformer adapted to this lower frequency is necessary. Voltages higher than 450—up to 550 or 600—are more dangerous to handle, and it is advisable to use a remote control switch mounted on the wall at some distance from the machine. This prevents any possibility of the operator coming in contact with this dangerous current when operating the welding machine. Where two or three phase current is available, only one phase of the multi-phase system should be used. Inside the welding machine and

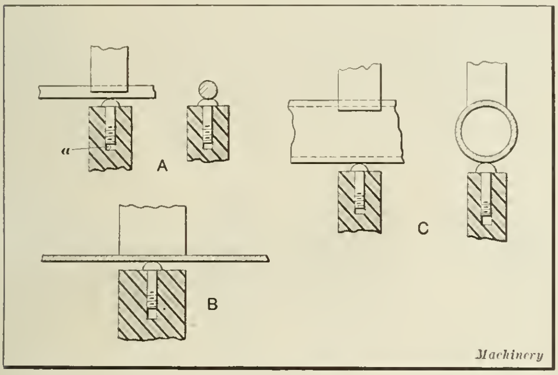

Fig. 4. Diagram illustrating Processes of welding Screws to Sheet Tubing, etc.

forming a part of it is a transformer which transforms the voltage from 220 to 440 down to three to five volts, which is the pressure used in all "stock" machines for making the average weld in sheet metal. This voltage is so low that it cannot be felt by the bare hands, and explains why it is absolutely safe for the operator.

The accompanying table gives the approximate amount of power required for welding a given thickness of sheet steel in a given time. This can be varied at will, as the time can be shortened by increasing the power, or the amount of power can be decreased by taking a longer time to do the work. In both cases the cost of the current will be the same. In this table the cost for current is based on one thousand welds at a cost of one cent per kilowatt-hour. To obtain the approximate

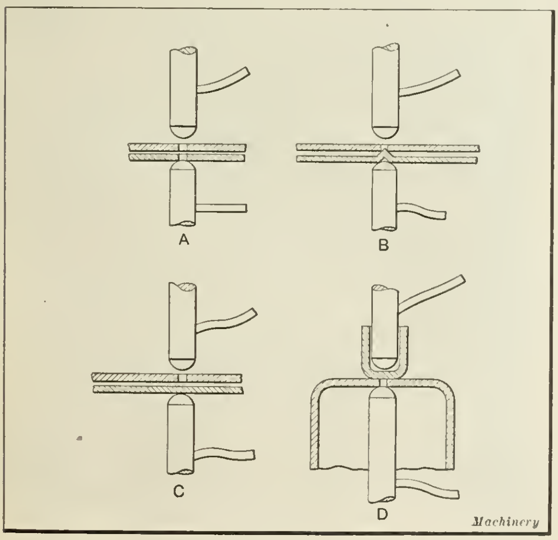

Fig. 5. Diagram illustrating Processes used in spot-welding Large Articles

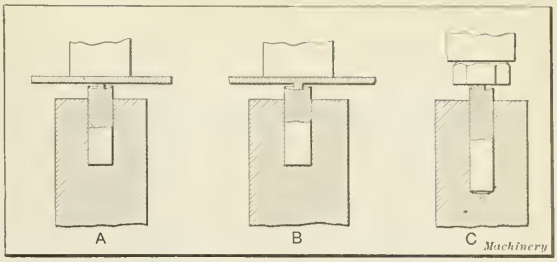

Fig. 6. Diagram illustrating Process of uniting Sheets to Studs and Bolt Bodies to Heads

cost for welding various thicknesses of stock, multiply the price given in the last column by the rate per kilowatt charged by the local electric light company, which will give the cost per one thousand welds. For example, suppose the material being welded is 1/16-inch sheet steel. The power required would be 12 kilowatts, time 0.85 second, and the cost per one thousand welds, figuring on a basis of eight cents per kilowatt-hour, would be 22.7 cents.

Strength of Spot-welded Joints

One of the chief advantages of electric spot-welding is that it takes the place of riveting on many classes of work, and not only does the work more rapidly, but also more effectively.

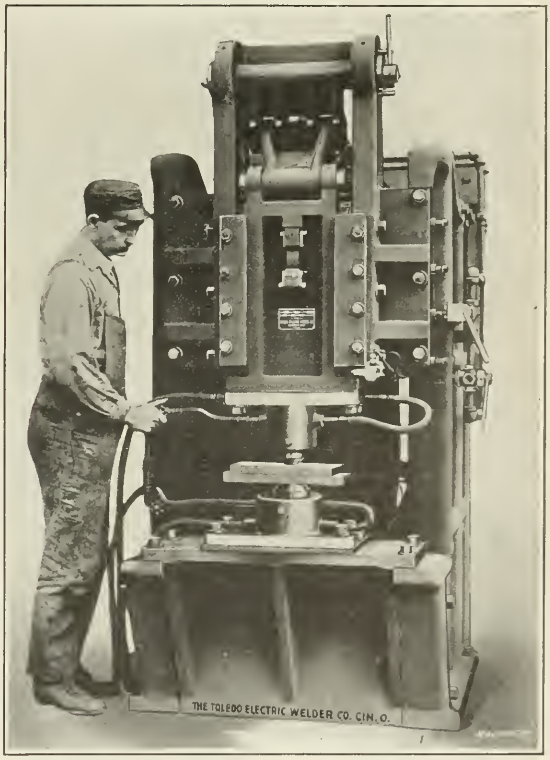

Fig. 7. Special Toledo Electric Spot-welder having a Capacity to weld Two Plates each $1\frac{1}{4}$ inch Thick and applying Hydraulic Pressure for operating the Upper Electrode

For instance, an electric spot-welded joint is stronger than a riveted joint. The examples shown in Fig. 2 give some idea as to the efficiency of a welded joint as compared with one that is riveted. The data pertaining to these tests are as follows: The strip *A* was spot-welded in one place and broke at the weld when a tensile pull of 1625 pounds was exerted on it. The strip *B* was spot-welded in two places and also riveted in two places. It broke at the riveted joint when a pull of 1555 pounds was reached. The strip *C* was spot-welded in three places and broke outside the weld when a pull of 2715 pounds was exerted. It should be noticed in this case that

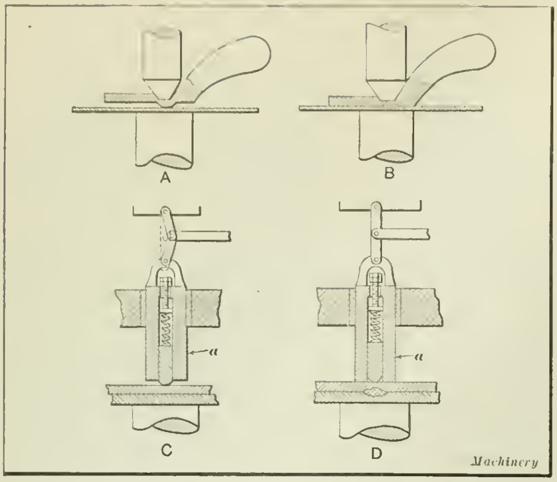

Fig. 8. Diagram illustrating Principles of welding Thick to Thin Metal and welding Thick Sheets of Metal

Electric Riveting on a Spot-welding Machine

There are certain classes of work where a rivet is desired, and previous to the adoption of the electric welding machine, of course, the rivet was upset by a riveting machine. An electric welding machine can be used to good advantage on this work, however, because the rivet, instead of being closed over in a cold state, is heated by the electrodes of the machine, and hence makes a much better joint that if it were riveted over cold. Fig. 3 shows several different methods of performing electric riveting operations. At *A* is shown one method. Here it will be noticed that two plates are to be joined by a rivet. The top plate is provided with a larger hole than the bottom plate, and the rivet is pointed. Using a combination of this sort makes a very strong joint because the heat is localized at the point *a* which, when the plates are pressed together, acts as a junction point. The result of a weld of this character is shown at *B*.

Still another application of electric riveting is shown at *C*. In this case the lower plate is provided with a taper hole and the rivet with square corners. Again the heat is localized in the lower plate at the point *b*, and a satisfactory weld can be accomplished, as shown diagrammatically at *D*.

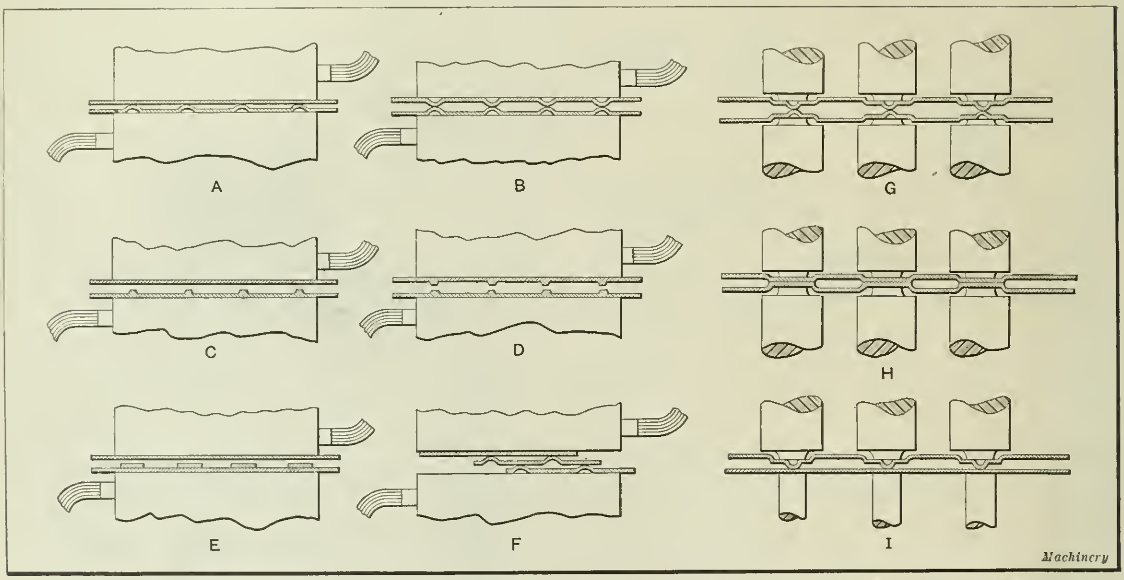

Fig. 9. Diagram illustrating Various Processes of accomplishing Multiple Point- or Projection-welding and Multiple Electrode welding

the metal was elongated considerably at the point where the break took place. The strip *D* was spot-welded in three places and also had three rivets. It broke at the riveted joint when a pull of 2055 pounds was exerted. The strip *E* was lap-welded and broke outside the weld when a tensile pull of 2720 pounds was reached on the indicator. Strip *F* was butt-welded and broke at the weld when a tensile pull of 2555 pounds was reached. Strip *G* was spot-welded and riveted in one place. It broke at the rivet with a pull of 990 pounds. The strip *H* was lap-welded and broke at the weld when a tensile pull of 2425 pounds was reached. Strip *I* was spot-welded in two places and broke at the weld when a pull of 2275 pounds was reached. Strip *J* is a plain piece of hoop iron, which was not welded, and broke when a pull of 2690 pounds was reached. By looking over these tests it will be noticed that in all cases the electrically welded joints were stronger than the riveted ones.

Another example which illustrates the effectiveness of a spot-welded joint is shown in Fig. 1. In this case two pieces of sheet steel of the same thickness have been spot-welded at one point. In endeavoring to separate these two pieces it will be noticed that the welded joint still held and that the metal around the weld gave way. This is a different test from those previously illustrated in that no tensile pull on the joint has been made.

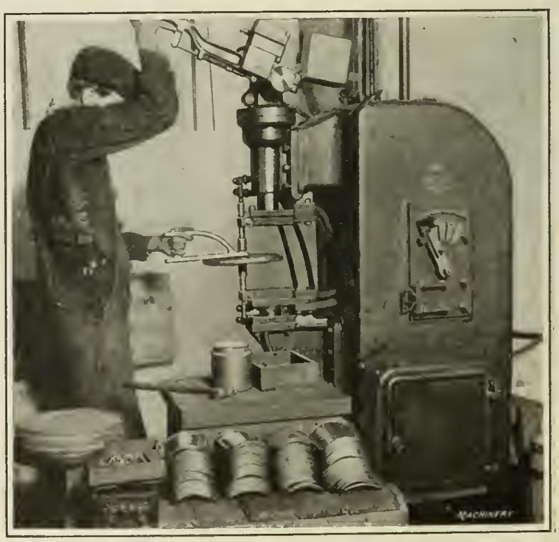

Fig. 10. Electric Riveting of Cream Separator handled on a Toledo Electric Welder

When it is desirable to have both surfaces of the plates smooth, the method shown at *E* can be adopted. Here a double cone rivet is interposed between the two plates, which as illustrated, are provided with holes equal in diameter to about the smallest diameter of the cone-shaped rivet. When the current is turned on and pressure applied, the rivet is "fused" and forms a perfect junction between the two plates, as illustrated at *F*.

A practical application of electric welding is shown in Fig. 10. Here the machine is used for welding a bracket to a cream separator pail shell. The operator first places the rivet in the bracket and shell, then places them on the electrode of the machine, as shown, turns on the current, and applies pressure. As soon as the rivet reaches a bright red heat it upsets considerably, but owing to the large size rivets used the electrodes are not depended upon to completely upset the rivet, as this would cause excessive wear of the electrodes. The work is, therefore, removed from the machine as soon as the rivet is thoroughly heated and smashed down with a hammer on the block shown. One operator by this method can turn out 900 riveted shells in nine hours.

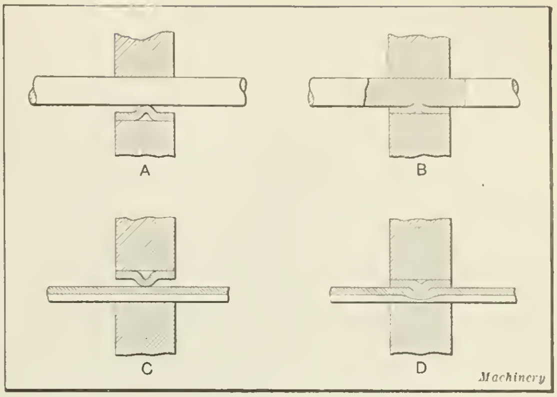

Fig. 13. Diagram illustrating Process known as "Ridge-welding"

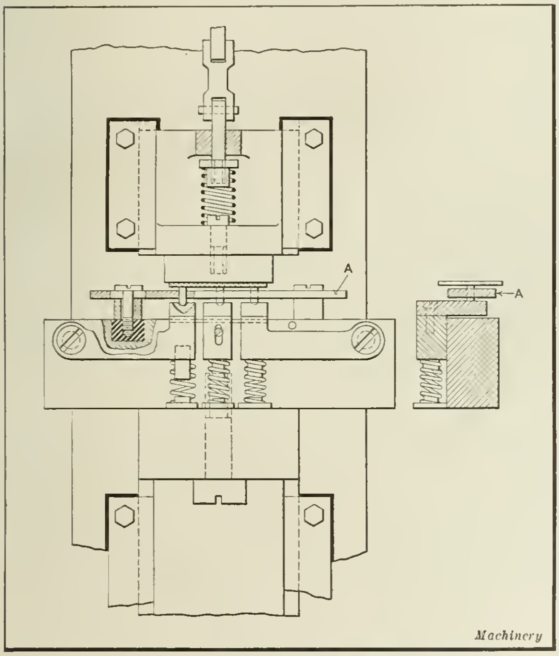

Fig. 11. Diagram illustrating Principle of Machine employing Three Electrodes for welding Pins to Sheet Steel—Compensation is made for Variation in Length of Pins

Butt-welding on an Electric Spot-welding Machine

As has been previously stated, the electric spot-welding machine can be used for performing welding operations by a variety of processes. One process which resembles butt-welding is shown in Fig. 6. At *A* is shown one method of welding a rod to a sheet. In order to localize the current at a point, the rod is prepared with a teat and a cup-shaped top. The teat first comes in contact with the sheet, and as this is broken down by the pressure of the electrode the ring around the rod then comes in contact, making a second connection, and greatly intensifies the resistance to the flow of the current so that the rod can be welded to the sheet without leaving practically any burr. Another modification of this principle is shown at *B*. In this case the sheet instead of the rod is prepared with a teat, and the rod is made with a concave or cupped end. *C* in this same illustration shows still another method which is applied in this case to a hexagon bolt. This application is almost identical with that shown at *A*, except that a bolt head instead of a thin sheet of metal is being welded. This method of making cap-screws economizes in material and at the same time makes a strong cap-screw.

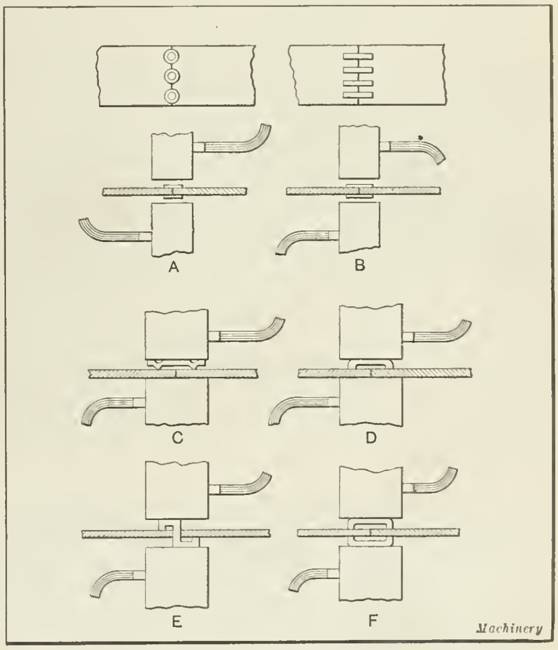

Fig. 14. Diagram illustrating Principle employed in accomplishing Process known as "Bridge- or Tie-welding," permitting the joining of Narrow Strips without decreasing Length

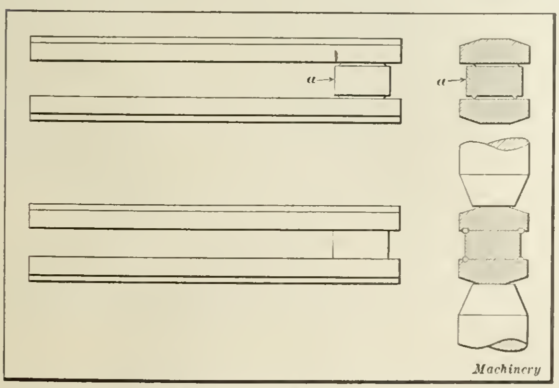

Fig. 12. Diagram illustrating Principle applied in the spot-welding of Telephone Transmitter Magnet Bars without drawing the Temper

Fig. 4 shows some additional examples of butt-welding accomplished on a spot-welding machine. At *A* is shown a method of welding a screw to a rod. This can be done very

satisfactorily on the spot-welding machine, provided that a clearance is left at the bottom of the screw or at the point *a* so that the electrode contacts only with the rim or head of the screw. This enables the welding to be done rapidly and decreases the amount of current used. A somewhat similar method of welding is shown at *B*. Here a screw is being welded to a sheet. The process in this case is identical with that shown at *A*, with the exception of a slight change in the shape of the upper electrode.

Another modification of this principle is shown at *C*. In this case the screw is being welded to a tube. There are two points in connection with this method that should be closely observed. In the first place, the screw must be located in relation to the tube so that the axis of the screw is in line with the axis of the screw and the upper electrode. If this is not the case, there will be a slight deflective movement and a satisfactory weld will not be accomplished. Another thing is that the welding must be done very rapidly to prevent "scattering" the electric current. In fact, the quicker the welding is done the better the results obtained.

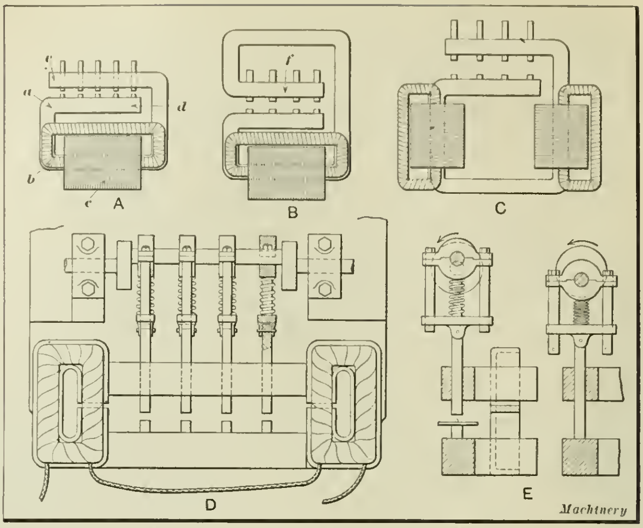

Fig. 16. Diagram illustrating Principle of Design of Multiple Electrode Welding Machines

Spot-welding Large Articles

When it is desired to electrically weld large articles at a very small point, several different processes, as shown in Fig. 5, can be adopted. One process which is shown at *A* consists in drilling two small holes through the pieces of the metal to be welded. When the electric current is applied and the electrodes are brought in contact with the two sheets, the current is localized around the hole and does not spread out into the material, as is the case when electrodes are simply brought down in contact with the surface of the material. It also requires much less power and a shorter time to make the weld. Still another modification of this method is shown at *B*. Here one piece has a hole drilled in it and the other is provided with a projection. This still further decreases the amount of power required to make the weld. The method shown at *C* is similar to that at *A* with the exception that only one piece is provided with a hole. The method shown at *D* illustrates the method of welding a small cup to a larger one. In this case it will be noticed that the large cup is provided with a hole for localizing the current.

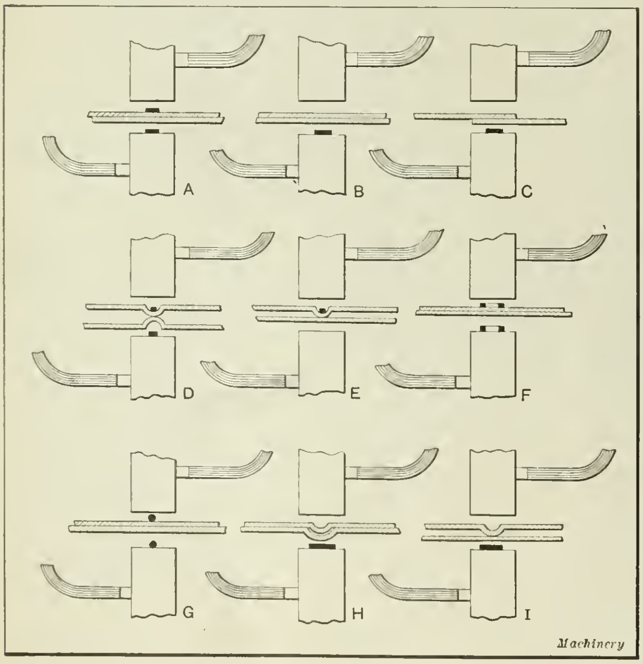

Fig. 15. Diagram illustrating Various Processes employed in welding Two Sheets of Steel by means of Buttons

Welding Thick to Thin Metal

Little difficulty is experienced in welding two pieces of sheet steel of the same thickness, but when the thicknesses of the two parts to be welded are unequal, difficulty is sometimes encountered in obtaining a perfect junction. The reason for this is that the thin sheet heats up much quicker than the thicker one and is burned before the thick sheet reaches a welding temperature. One method of satisfactorily welding a thick sheet to a thin one is shown at *A* and *B* in Fig. 8. In order to prepare the thicker piece to be welded to the thinner one, a point or projection is formed on the lower surface of the thick piece. This localizes the current, and both pieces—thick and thin—heat up at the same time, so that when pressure is applied a perfect junction can be made.

Welding Thick Work

As has been previously stated, the limit of spot-welding practice is reached when the pressure necessary to bring the sheets of metal into intimate contact is such that upsetting of the copper electrodes takes place. *C* and *D* in Fig. 8 show a method of applying mechanical means for effecting a contact between the two sheets to be welded. The hardened steel sleeve *a* is connected up by a toggle mechanism to a hydraulic or air cylinder. To effect the weld, the pressure is then applied and the hardened steel sleeve is brought down in contact with the surface of the sheets, pressing them against a lower electrode which preferably should be made from either a large block of copper or a similar mechanism to the upper electrode. When the sheets have been brought down into intimate contact, the current is turned on, and as the electrode is held in contact with the sheet by means of a very stiff spring, the pressure exerted by the electrode is sufficient to fuse the sheets together when they reach the proper temperature.

A practical application of this principle in which the steel dies are dispensed with is shown in Fig. 7. In this case large copper electrodes—the upper one 2½ and the lower one 3 inches diameter—are used to both heat and press the metal together. This machine which has a capacity for welding two strips 1¼ inch thick exerts 50 tons, and is operated hydraulically. The slide carrying the upper electrode is operated through a toggle-joint, receiving power from a hydraulic ram. The maximum capacity is 100 kilowatts.

Point- or Projection-welding

There are numerous applications of point- or projection-welding which can be accomplished on an

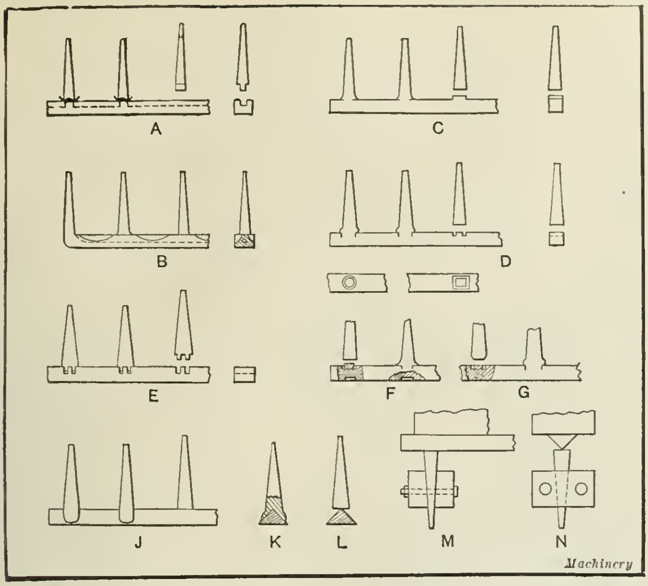

Fig. 17. Diagram illustrating Principles used in employing Process known as "T-welding" with Special Application to the Manufacture of Garden Rakes

electric spot-welding machine. The example shown at *A* in Fig 8 illustrates one of the simplest processes employed. Fig. 12 shows a process which is not as well known, and which has remarkable possibilities. By the ordinary method of performing electric spot-welding operations, it is impossible to join two hardened pieces without drawing the temper. There are cases, however, where it is desirable to secure a good weld without drawing the temper, the magnet bars used in a telephone receiver being an example in point.

Those familiar with this work know that magnet bars in telephone transmitters should be as permanent as possible, and for this reason a special material known as magnet steel is used; this is hardened to a glass hardness. Formerly difficulty was encountered in joining the two bars of the magnet, because of the extreme hardness of the pieces. The method generally employed was to drill holes through each end of the magnet and through the spacing keeper and then rivet the members together. This method had the serious objection that in riveting the pieces together it was difficult to avoid breaking the magnets owing to their extreme hardness, so that a considerable percentage of magnets were spoiled during the final riveting operation.

Electric welding has greatly simplified this problem by uniting the three pieces rigidly without drawing the temper of the magnets. The manner in which this is accomplished is interesting. The spacing bar as shown at *a* in Fig. 12 is provided with knife-shaped circular ridges about 1/64 inch high. The pieces are then assembled in a fixture to hold them in the proper position and placed between the electrodes of a spot-welding machine especially fitted up to provide an amperage of about 2000 amperes. The electrodes are then brought in contact with the work, the current turned on and the weld made in a fraction of a second. So rapidly is the weld made that the metal is not annealed; it does not have time to heat up except at the knife edge point where the weld is actually made. Practically no flash is formed and the pieces are rigidly united.

Multiple Point- or Projection-welding

In electric welding comparatively large pieces of thin metal where it is desirable to have the pieces lie in close proximity to each other, the multiple point or projection method of welding can be employed with success. Some of the processes employed for this purpose are illustrated in Fig. 9. *A* shows a case where one sheet only is provided with projections; *B* where two sheets are provided with projections; *C* where projections are formed into the sheet by milling it away; *D* where projections are formed in both sheets in a similar manner; *E* where the button method is employed; and *F* where three sheets are being united. The disadvantages of the button method are that it is difficult to locate the buttons in the correct position to each other, and it is much slower than the other processes. Of course, it requires no special preparation of the material previous to welding.

A modification of the principle illustrated at the left-hand side of Fig. 9 is shown on the right-hand side of the same illustration. In this case, instead of using long, flat electrodes, a series of electrodes are employed. This process applies particularly to the manufacture of sheet steel radiators. *G* shows how the metal is prepared with points for welding and *H* shows the result of the weld. *I* is a modification of the process in which only one sheet is provided with projections.

Multiple Electrode Welding

In Fig. 11 is an application of what might be called multiple point- or projection-welding. In this case it is desirable to weld a number of pins to a sheet, and as these pins generally vary in length, provision must be made for taking care of this discrepancy so that all pins will contact at the same time. The diagram illustrates the principle of the machine designed for this purpose. The pins are located in a plate *A* which acts as a cooling agent for conducting away the heat, and is supported and insulated, as shown. The pins rest in small cup-shaped grooves in the lower electrodes which, as will be seen, are spring mounted so as to take care of any variation in the thickness of the metal and the length of the pins. It will be noticed that the two side electrodes are swung from a fulcrum point, whereas the center electrode as shown in the sectional view to the right is in the form of a slide.

The diagram shown in Fig. 16 illustrates several methods of supplying current from the same transformer secondary to several pieces engaging electrodes in such a manner that the same heating effect is produced in all the pieces on which the electrodes contact. In the case shown at *A* the secondary of the transformer is composed of a heavy copper casting *a*, whereas *b* is the primary and *c* the laminated iron core. The

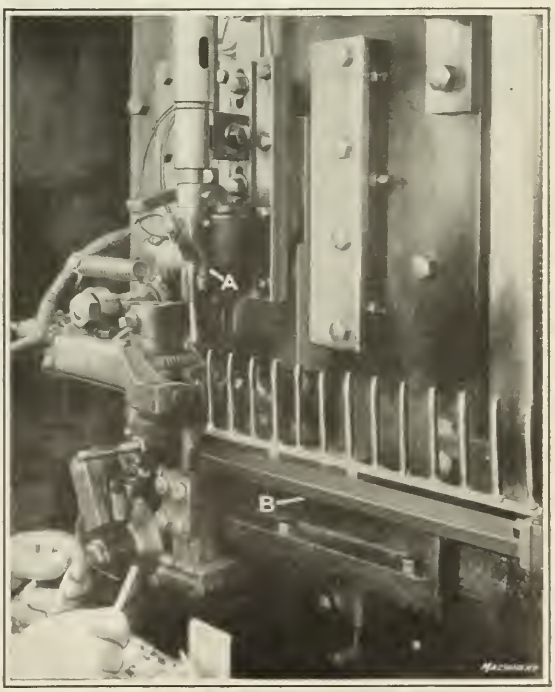

Fig. 18. Semi-automatic Machine built by the National Electric Welder Co. for welding Garden Rakes

terminals d and c of the secondary extend in opposite directions, so that the difference of potential across any pair of electrodes is the same. This will be made more clear by referring to the diagram shown at B. Here the terminal bars extend in the same direction, and one of them f forms the terminal of a secondary circuit which is partially returned upon itself. In such a construction, a difference of potential exists across each pair of electrodes.

The diagram shown at C illustrates the application of two primaries or sets of primary coils which act upon the same secondary bar or casting in such a manner as to give an increased potential across the bars due to the fact that the electro-motive forces set up in the secondary by the primary act in series to reinforce one another. In this case two laminated cores can also be used to advantage. By arranging the current carrying the secondary bars in this manner, an equal potential force is obtained, so that a satisfactory weld can be made by each of the individual electrodes. D and E show a diagram of an automatic welding machine incorporating the multi-electrode principle shown at C.

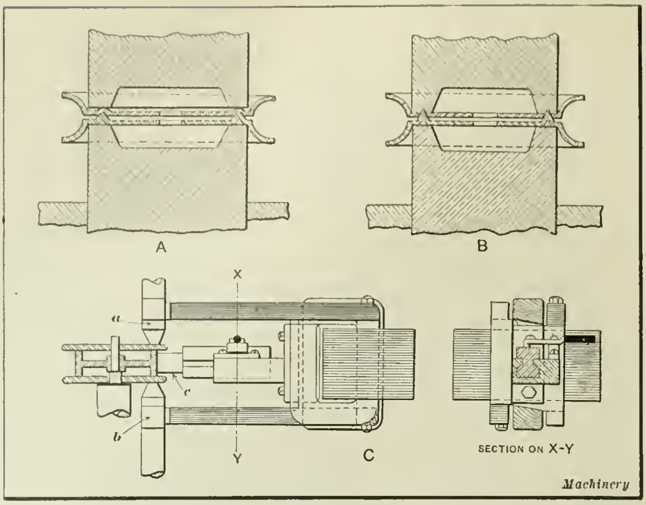

Fig. 19. Diagram illustrating Various Processes employed in the Manufacture of Sheaves or Pulleys

Ridge-welding

Ridge-welding is that process of electric welding which makes use of the principle of forming ridges on the work and then generally placing these ridges at right angles to each other, forming a cross at the point where the weld is made. This junction of the two pieces localizes the heat directly in line with the axis of the electrodes, and makes rapid welding possible. Two examples of this class of work are shown in Fig. 13. Example A shows a rod being welded to a narrow strip provided with a ridge in the center. In this case the circumference or arc on the rod acts in the same manner as a ridge, and by turning on the current and applying pressure these two pieces can be homogeneously united, as shown at B. Another method which makes use of two strips, both of which are provided with ridges, is shown at C. The action of welding these two pieces together is almost similar to that previously described, the finished weld being shown at D.

Button-welding

Another welding process which has been used with satisfactory results is that known as button-welding. In addition to many other uses, this can be applied to the welding of very thick work which it would be impossible to spot-weld because of the fact that the metal could not be brought into close contact without applying enormous pressure. By this method a button of metal of the same material as that being welded is placed on the top or bottom electrode or on both, as the case may be; then the two pieces to be welded are placed between these buttons and pressure is applied on top of the button. The current is then turned on and the buttons localize the current, resulting in the metal being fused at the point where the buttons are located, and when pressure is applied the partially molten buttons are then forced through the already molten metal and a perfect junction is made. Several process applications are shown in Fig. 15: A shows one method where two buttons are used; B, one button; C, a case where one button is used to perform a lap-weld; D, a combination of button- and point-welding; this is a special process and is seldom used; E, a case where a point and one button is used; and F, buttons in the form of rings. The example shown at G is one in which pieces of wire are employed in the place of flat buttons; H is a case where the two pieces are provided with projections fitting in each other and a button used in addition; I represents a somewhat similar case to that shown at H. All of these processes have not been used in practice, but represent possibilities of electric welding.

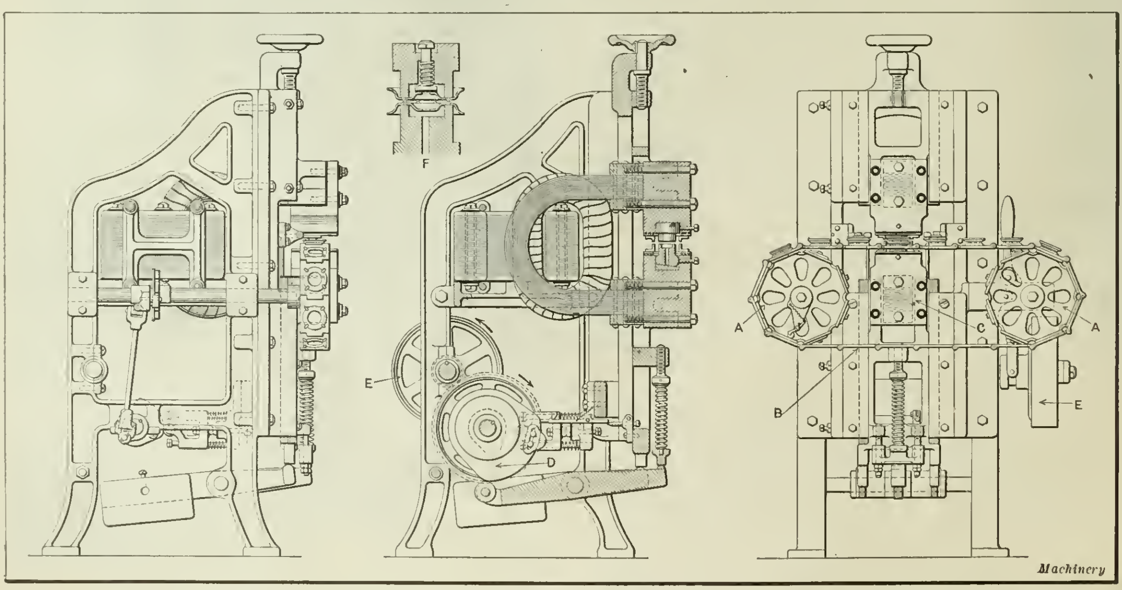

Fig. 20. Diagram illustrating Principle of Construction of a Semi-automatic Machine for Electric welding Sheaves for Window Frames

Bridge- or Tie-welding

When it is desired to unite two narrow strips so that their ends abutt without overlapping, this can be accomplished by the process known as bridge- or tie-welding. Several applications of this process are illustrated in Fig. 14. One process illustrated at *A* consists in using a number of small flat washers, all of which lie in the same plane and are superimposed on the plates to be welded, making contact therewith. When the current is turned on and pressure applied, these pieces are fused, and make a junction point between the two strips of metal, leaving practically little or no burr. *B* shows a slight modification of this process, using solid strips instead of washers; *C* is a combination of bridge- and point-welding, the bridge being provided with projections which localize the current and effect quick heating. This process does not give as solid a junction as those previously described. A similar process is shown at *D* which has the same objection. *E* is still another process which, while it effects a junction between the two pieces, does not give a strong joint. *F* is a somewhat similar process to *D*, employing two bridges instead of one, which has the same objection as the processes illustrated at *C* and *D*.

T-welding

A process of electric welding which has a wide application in the agricultural field is known as T-welding. This process is used to special advantage in the manufacture of garden rakes and, as shown in Fig. 17, has many modifications. At *A* is shown one method of effecting a weld. The top part of the rake is provided with a slot running its entire length, and the tangs which are welded to it are provided with projections fitting in this slot. These tangs are then satisfactorily welded to the frame under a spot-welding machine. Still another method is shown at *B*. In this case the current is localized by providing points by milling away the sides of the top of the rake. *C* shows still another method. Here the outside of the rake is provided with projections of an area equal to the lower end of the tang, so as to equalize the heating effect of the current on the parts welded.

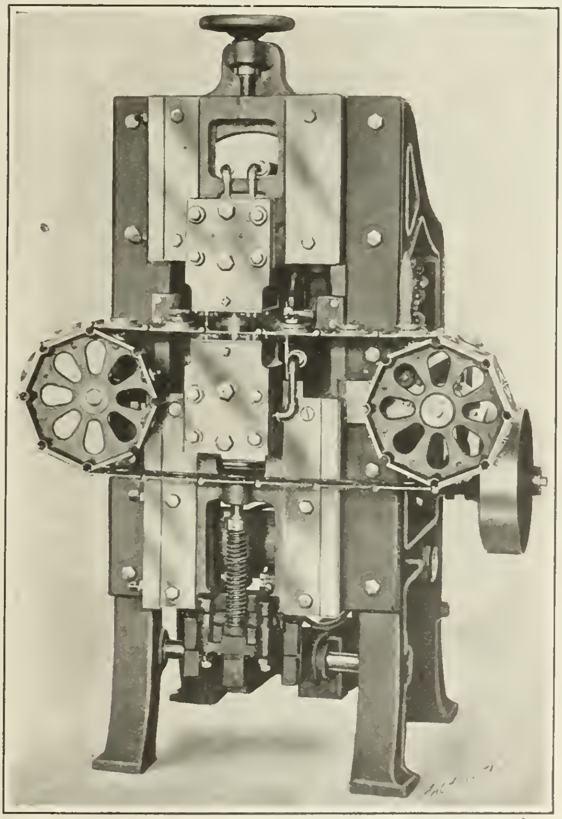

Fig. 21. Special Electric Seam Welding Machine built by the Universal Electric Welder Co.

The method shown at *D* is somewhat similar with the exception that the projection is formed by milling two small slots across the face of the top part of the rake. A method which is just the reverse of that shown at *D* is shown at *E*. Here both pieces are provided with projections, forming a matched joint. *F* and *G* show still other methods which are limited in their application because of the difficulty of making the required projections. The methods shown at *J*, *K* and *L* illustrate the preparation of the work for welding and the finished welded work, *L* showing how the weld is started and *J* and *K* the form of the weld. *M* and *N* show two views illustrating how the electrodes are applied to the work to perform a weld as shown at *J*, *K* and *L*, respectively.

A practical application of this process of welding is shown in Fig. 18. In this case the tangs of the rake are made from 1/4-inch round steel rods, which are welded to a triangular back 1/4 by 7/16 inch. There are fourteen teeth in each rake and one operator produces 375 rakes in nine hours, or in other words, he makes 5250 welds in this time. In operating this machine, the tangs are placed in the solenoid *A* and the back is placed on slide *B*; the machine then automatically spaces the tangs, sets and welds them to the back at the rate previously mentioned.

Sheave Welding

A class of work in which the point or projection method of electric welding is used to good advantage is the manufacture of sheaves for window sashes. Two methods of applying this process are illustrated diagrammatically at *A* and *B* in Fig. 19. In the example shown at *A*, the two halves of the sheaves are prepared with projections which fit into each other, whereas in the case shown at *B* one piece or half is provided with a projection and the other with a hole to receive it. Usually this work is carried on in a semi-automatic manner, and a special machine has been designed for this work as illustrated in Figs. 20 and 21. Referring to Fig. 20, it will be noticed that the machine is provided with two drums *A* on which an endless chain *B* is carried. These drums are rotated through suitable mechanism, being indexed around to bring the pair of sheaves to be welded in line with the welding electrodes. The sheaves remain in line with the welding electrodes for a sufficient length of time for the weld to be effected. The various timing mechanisms on the machine as well as the movement of the lower electrode slide *C* is controlled by cam *D* driven by gears from a main driving pulley *E*. A different electrode mechanism from that shown attached to the machine is shown in the same illustration at *F*. In this case it will be noticed that the upper electrode is provided with a spring-operated pad having a non-conductive surface. This is used to prevent the work from bulging in the center when the pressure is being applied to effect a weld. The production of the machine shown in Figs. 20 and 21 is 15,000 sheaves in ten hours.

The diagram shown at *C* in Fig. 19 illustrates a method of welding sheaves or small pulleys employing three contacting electrodes. This employs a single transformer which permits of making more than one weld simultaneously and in which there is an even distribution of current to each weld. The secondary consists of three terminals, *a*, *b* and *c*, one of which c is common to the other two and disposed equidistantly between them, so that there will be at all times an equal distribution of the electric current through the secondary to the welding terminals. A third terminal may be connected to the turns at the connection between them, so that there is a turn between the terminals at both ends of the secondary, and the third terminal in this case will have two volts between this and the other two. By using an apparatus of this kind, it is possible, as is clearly seen, to confine the heating to the contacting surfaces of the work. The upper edges of the interposed electrodes, of course, conduct the current to the junction of the plate and the center of the sheave in such a manner that the core or center is not heated except on its contacting surfaces with the plate. In this way a satisfactory weld can be easily effected.

LAYING OUT SKEW BEVEL GEARS*

THE TWO PRINCIPAL TYPES OF SKEW BEVEL GEARS, THEORY OF THEIR DESIGN AND METHODS OF CUTTING TEETH

BY REGINALD TRAUTSCHOLD†

One excellent type of gear—the skew bevel—has been generally avoided by both designers and machinists: by the former on account of the difficulty experienced in laying it out, and by the latter because of a fancied intricacy in the method of cutting. The development of bevel gear generators, as well as greater familiarity on the part of the machinist with processes of milling and planing gear teeth, have gone a long way toward removing his antipathy for the skew bevel gear. There remains, however, the dislike of the designer as an explanation of the continued unpopularity of this gear, which is also due in part to a slightly greater cost of manufacture than that of the ordinary bevel gear.

The shaft axes of skew bevel gears do not lie in a common plane, and the various face and cutting angles do not converge to a common apex; in place of a single apex, there is a circle of apexes, so that accurate mathematical calculations of the various angles are complicated and involved. This constitutes the basis for the dislike of skew bevel gears on the part of the designer. However, very close approximations of the true angles and diameters can be arrived at by the use of simple formulas, and these approximations are as reliable from the practical working point of view of the shop as if the exact measurements were actually furnished, which would indeed involve complicated calculations. The conditions governing the obliquity of skew bevel gear teeth and the various diameters and angles are, in reality, quite simple; and when the basic principles have once been grasped by the designer, the lay-out of a skew bevel gear combination presents little more difficulty than that of an ordinary bevel gear.

There are two general types of skew bevel gears, which, for the sake of brevity, may be referred to as Types A and B. In the former a pinion of the ordinary bevel gear type is employed, the oblique teeth being confined to the gear, and in the latter the teeth are oblique in both pinion and gear. In each type, the pitch surface of the pinion is the frustum of a figure generated by the revolution of a straight line about the axis of the figure, the generating line lying in a plane parallel to a plane through the axis, and being neither parallel nor at right angles to the axis, *i. e.*, the figure is a hyperboloid of revolution.

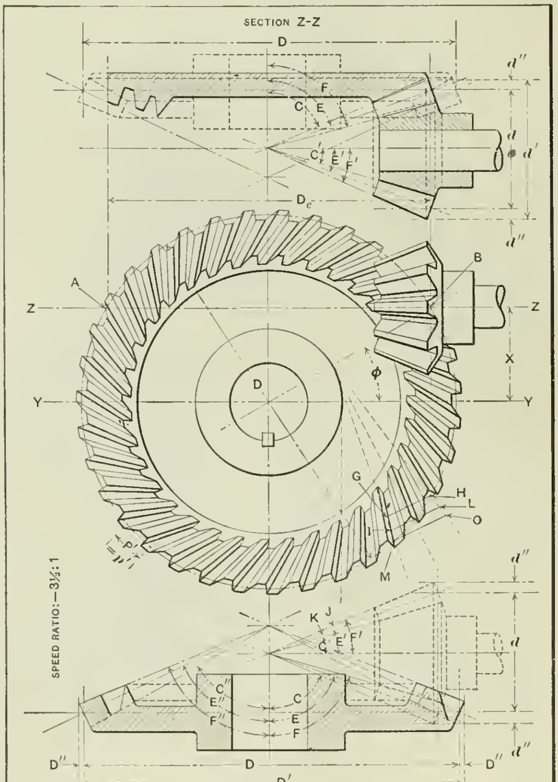

Fig. 1. Diagram showing Principles involved in Lay-out of Type A Skew Bevel Gears, in which Ordinary Bevel Pinion meshes with Skew Bevel Gear

Skew Bevel Gears—Type A

Taking up first the design of skew bevel gears designated as Type A, a typical lay-out is shown in Fig. 1, where the dimension X indicates the offset of the pinion shaft. It will be evident that the profile planes of the gear tooth actually in mesh with the pinion converge to the apex point, the pinion differing in no respect from an ordinary bevel gear having a center angle E'. As the gear revolves, the profile planes of each succeeding tooth must also converge to this same point, so that the gear really has a circle of apex points, having a diameter equal to twice the offset of the pinion shaft, instead of a common apex point as in the case of an ordinary bevel gear combination.

If it were not for the offset of the pinion shaft, the pitch diameter of the gear meshing with the equivalent pinion would equal AB, and no difficulty would be encountered in ascertaining the number of teeth, etc., required for both the gear and the pinion, the speed ratio and pitch of the combination being known. The pinion of the Type A skew bevel gear combination differs in no way, as far as pitch and number of teeth are concerned, from such requirements for an ordinary bevel gear combination of the same ratio, but the angles of the pinion and possibly its face width differ. The number of teeth in the gear must remain the same as that required for an ordinary bevel gear of pitch diameter AB, in order that the speed ratio of the combination may not vary, and the normal pitch of the skew bevel gear must conform to the circular pitch of the pinion with which it is to run. The actual pitch diameter of the skew bevel gear is considerably greater than its "equivalent pitch diameter," AB, but the number of teeth and their proportions remain the same, due to their obliquity. This is the secret of skew bevel gears, and it is failure to recognize this simple fact that has led to the common belief that skew bevel gears are difficult to design.

As the oblique teeth of the gear come in contact with the radial teeth of the pinion in this style of skew bevel gear combination, a certain sliding action takes place. Referring to Fig. 1 and the pitch lines of the gear and pinion, the outer end of the pinion tooth first comes into contact with its mating gear tooth at point G and contact ceases with the outer end of the pinion tooth in contact with the gear at point M, *i. e.*, the end of the pinion tooth has slid on the gear tooth from G to M, which is equal to the distance HO. This sliding action is accentuated by any increase in the obliquity of the gear teeth, which, in turn, varies with the amount of pinion shaft offset. The normal pitch of the gear IL obviously must conform to the circular pitch of the pinion, while the circular pitch of the gear MH is considerably greater than the circular pitch of the pinion.

The various angles and tooth proportions of the pinion are the same as those of any ordinary bevel gear of the same number of teeth, pitch, etc., and of similar center angle; and they are easily calculated by the use of the familiar formulas for such gears. The calculations involved in laying out skew

* For other articles on the subject of skew bevel gearing published in MACHINERY, see "Generating the Skew Bevel Gear," March, 1913; "A Practical Form of Tooth for Skew Bevel Gears," January, 1913; and "The Skew Bevel Gear Model," January, 1907.

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bevel gears require the use of somewhat different formulas, as given in the following, the derivation of which will be explained subsequently.

Notation for Skew Bevel Gears—Type A

p = diametral pitch;
n = number of teeth in pinion;
N = number of teeth in gear;
X = offset of pinion shaft;
ϕ = angle of offset;
d = pitch diameter of pinion;
D_e = equivalent pitch diameter of gear;
D = pitch diameter of gear;
d' = outside diameter of pinion;
D' = outside diameter of gear;
p' = circular pitch of pinion;
P' = circular pitch of gear;
E' = center angle of pinion;
F' = face angle of pinion;
C' = cutting angle of pinion;
E = center angle of gear (shop angle);
F = face angle of gear (shop angle);
C = cutting angle of gear (shop angle);
E'' = center angle of gear (design angle);
F'' = face angle of gear (design angle);
C'' = cutting angle of gear (design angle);
J = angle increment of pinion;
K = angle decrement of pinion;
d'' = diameter increment of pinion;
D'' = diameter increment of gear;
s = addendum.

Formulas for Skew Bevel Gears—Type A

$$d = \frac{n}{p} \qquad (1)$$

$$D_e = \frac{N}{p} \qquad (2)$$

$$\tan \phi = \frac{2X}{D_e} \qquad (3)$$

$$D = \frac{2X}{\sin \phi} \qquad (4)$$

$$P' = \frac{3.1416D}{N} \qquad (5)$$

$$\tan E' = \frac{d}{D_e} \qquad (6)$$

$$\tan J = \frac{2 \sin E'}{n} \qquad (7)$$

$$\tan K = \frac{2.314 \sin E'}{n} \qquad (8)$$

$$F' = E' + J \qquad (9)$$

$$C' = E' - K \qquad (10)$$

$$s = \frac{d}{n} = \frac{D}{N} \qquad (11)$$

$$d'' = s \cos E' \qquad (12)$$

$$d' = d + 2d'' \qquad (13)$$

$$E = 90 - E' \text{ (shop angle)} \qquad (14)$$

$$\tan E'' = \frac{D - 2X}{d} \text{ (design angle)} \qquad (14\text{ a})$$

$$D'' = s \cos E \qquad (15)$$

$$D' = D + 2D'' \qquad (16)$$

or for greater accuracy:

$$D' = D + \frac{2D''D_e}{D}$$

$$C = E - K \text{ (shop angle)} \qquad (17)$$

$$C'' = E'' - \frac{KD_e}{D} \text{ (design angle)} \qquad (17\text{ a})$$

$$F = E + J \text{ (shop angle)} \qquad (18)$$

$$F'' = E'' + \frac{JD_e}{D} \text{ (design angle)} \qquad (18\text{ a})$$

Derivation of Foregoing Formulas

The formulas applying to the dimensions and angles of the pinion are similar to those for any ordinary bevel gear, when the center angle of the pinion has once been ascertained.

The equivalent pitch diameter D_e of the gear is equal to the number of gear teeth N divided by the diametral pitch p.

The angle of offset ϕ is the angle formed by the intersection of a horizontal plane with a vertical plane through the axis of the gear shaft parallel to the pinion shaft and a vertical plane through the gear shaft axis and point B of tangency of the pitch circles of the gear and pinion. Tangent ϕ equals the offset X of the pinion shaft divided by half the equivalent pitch diameter D_e of the gear, or twice the offset X of the pinion shaft divided by the equivalent pitch diameter D_e of the gear.

The pitch diameter D of the gear is then equal to twice the pinion shaft offset X divided by the sine of the angle of offset ϕ.

The circular pitch P' of the gear is equal to the quotient of its pitch circumference πD divided by the number of teeth N.

The tangent of center angle E' of the pinion is the quotient of the pitch diameter d of the pinion divided by the equivalent pitch diameter D_e of the gear.

The ordinary method of arriving at the outside diameter D' of a bevel gear by adding to its pitch diameter D twice the diameter increment D'' may also be used in the case of skew bevel gears when the pinion offset X is slight, but this method is not quite accurate on account of the obliquity of the teeth. The greater the pinion shaft offset the smaller, proportionally, does the diameter increment of the gear become, and so the second formula for ascertaining the outside diameter of the gear, which is based on the arbitrary assumption that the decrease in diameter increment is proportional to the ratio of the equivalent pitch diameter D_e of the gear to the actual pitch diameter, is more reliable. This relationship is not quite accurate either, but any possible error which might arise would be so slight as to be quite immaterial from a practical standpoint.

The various angles of the skew bevel gear evidently depend upon the point from which they are viewed. The tooth profile planes all converge to the circle of apexes, fixed by the pinion shaft offset X. If, therefore, the angles are measured on such a profile on lines conforming to the obliquity of the teeth, it is evident that they will differ from similar angles measured on such planes, but on lines converging to a common point, *i. e.*, the apex of the imaginary cone of which the figure bounded by the pitch circle of the gear and the circle of apexes forms a frustum. The former set of angles, *i. e.*, those measured to the circle of apexes, and therefore normal to the pitch circle of the gear, may then be referred to as "shop angles," as they are employed in machining the gears; and the latter set of angles, *i. e.*, those measured on lines converging to the apex of the imaginary cone, are known as "design angles," for they are useful in designing the gears and the patterns for the blanks.

The shop center angle E is evidently the complement of the center angle E' of the pinion, for each tooth of the gear must mesh exactly with the pinion teeth on the line of contact. The design center angle E'' of the gear is naturally half the apex angle of the imaginary cone, of which a frustum would be the figure having its larger base diameter equal to the pitch diameter D of the gear, its smaller base diameter equal to twice the pinion shaft offset X, and a height equal to half the pitch diameter d of the pinion. The tangent of half this apex angle of the imaginary cone reduces to the equation given as Formula (14 a). This angle is somewhat smaller, the amount depending upon the pinion shaft offset, than the complement of the center angle E' of the pinion, the shop center angle of the gear.

The shop cutting and face angles C and F of the gear are evidently ascertained in a manner similar to that employed for arriving at such angles for an ordinary bevel gear, *i. e.*, by subtracting the angle decrement in one case and adding the angle increment in the other, from and to the shop center angle, respectively. To arrive at the design cutting and face angles C and F of the gear, however, the fact that both the angle increment and the angle decrement of the gear are af-

fected by the offset X of the pinion shaft must be taken into consideration, so that subtracting and adding these angles to the design center angle E''' of the gear would not give the true design cutting and face angles. The actual decrement and increment design angles are so small, however, that such respective angles of the pinion modified by multiplication by the ratio of the equivalent pitch diameter D_e of the gear to its pitch diameter D may be taken as measuring the true decrement and increment design angles for all practical purposes. Such modifications are based on the assumption that the decrease in the respective design angles is proportional to the amount of pinion offset and are included in Formulas (17 a) and (18 a).

Example in Design of Skew Bevel Gears—Type A

Example.—Required: A pair of skew bevel gears, 8 diametral pitch, 96 teeth in gear, 20 teeth in pinion; pinion shaft offset 3 inches.

Pitch diameter d of pinion:

$$d = \frac{20}{8} = 2.50 \text{ inches} \quad (1)$$

Equivalent pitch diameter D_e of gear:

$$D_e = \frac{96}{8} = 12 \text{ inches} \quad (2)$$

Angle of offset ϕ:

$$\tan\phi = \frac{2 \times 3}{12} = 0.5000 \quad (3)$$

$$\phi = 26 \text{ degrees, } 34 \text{ minutes}$$

Pitch diameter D of gear:

$$D = \frac{2 \times 3}{0.4472} = 13.41 \text{ inches} \quad (4)$$

Circular pitch P' of gear:

$$P' = \frac{3.1416 \times 13.41}{96} = 0.4388 \text{ inch} \quad (5)$$

Center angle E' of pinion:

$$\tan E' = \frac{2.50}{12} = 0.2083 \quad (6)$$

$$E' = 11 \text{ degrees, } 46 \text{ minutes}$$

Angle increment J of pinion:

$$\tan J = \frac{2 \times 0.2039}{20} = 0.0204 \quad (7)$$

$$J = 1 \text{ degree, } 10 \text{ minutes}$$

Angle decrement K of pinion:

$$\tan K = \frac{2.314 \times 0.2039}{20} = 0.0236 \quad (8)$$

$$K = 1 \text{ degree, } 21 \text{ minutes}$$

Face angle F' of pinion:

$F' = 11$ deg., 46 min. + 1 deg., 10 min. = 12 deg., 56 min. (9)

Cutting angle C' of pinion:

$C' = 11$ deg., 46 min. — 1 deg., 21 min. = 10 deg., 25 min. (10)

Addendums:

$$s = \frac{2.50}{20} = 0.125 \text{ inch} \quad (11)$$

Diameter increment d'' of pinion:

$$d'' = 0.125 \times 0.9790 = 0.1227 \text{ inch} \quad (12)$$

Outside diameter d' of pinion:

$$d' = 2.50 + (2 \times 0.1227) = 2.7454 \text{ inches} \quad (13)$$

Center angle of gear, E "shop" and E''' "design":

$E = 90 - 11$ deg., 46 min. = 78 deg., 14 min. (shop angle) (14)

$$\tan E''' = \frac{13.41 - (2 \times 3)}{2.50} = 2.9640 \quad (14\text{ a})$$

$E''' = 71$ degrees, 21 minutes (design angle)

Diameter increment D'' of gear:

$$D'' = 0.125 \times 0.2039 = 0.0255 \text{ inch} \quad (15)$$

Outside diameter D' of gear:

$$D' = 13.41 + (2 \times 0.0255) = 13.461 \text{ inches} \quad (16)$$

or for greater accuracy:

$$D' = 13.41 + \frac{2 \times 0.0255 \times 12}{13.41} = 13.4556 \text{ inches,}$$

or, say, 13.46 inches

Cutting angle of gear:

$C = 78$ deg., 14 min. — 1 deg., 21 min. = 76 deg., 53 min. (shop angle) (17)

$$C''' = 71 \text{ deg., } 21 \text{ min.} - \frac{1 \text{ deg., } 21 \text{ min.} \times 12}{13.41} = 70 \text{ deg., } 9 \text{ min. (design angle)} \quad (17\text{ a})$$

Face angle of gear:

$F = 78$ deg., 14 min. + 1 deg., 10 min. = 79 deg., 24 min. (shop angle) (18)

$$F''' = 71 \text{ deg., } 21 \text{ min.} + \frac{1 \text{ deg., } 10 \text{ min.} \times 12}{13.41} = 72 \text{ deg., } 24 \text{ minutes (design angle)} \quad (18\text{ a})$$

Cutting Skew Bevel Gears—Type A

Skew bevel gears are, in reality, very little more difficult to cut than bevel gears of the ordinary type, but the distinction between the shop angles and design angles must be kept in mind. Any machine suitable for cutting ordinary bevel gears can be employed in cutting skew bevel gears by making simple adjustments or modifications of the machine. The pinion of type A skew bevel gears is cut just like any ordinary bevel gear; and it is only in the case of the skew bevel gear that the special machine adjustments are necessary. The gear blank is usually turned to the required design face angle in a lathe, and it is then mounted on the spindle of the machine employed for cutting the teeth. The spindle of this machine must be offset from the plane of travel of the cutting tool, the cutting tool being dropped a distance X equal to the offset of the pinion shaft; and the path of the cutting tool must conform to the normal profile planes of the gear teeth. That is, the cutting tool must reproduce the action of the engaging pinion tooth in the contact plane in which the pinion and gear mesh.

Subsequent operations are then similar to those employed in cutting ordinary bevel gears, except that the path of the cutting tool is always tangent to the gear's circle of apexes,

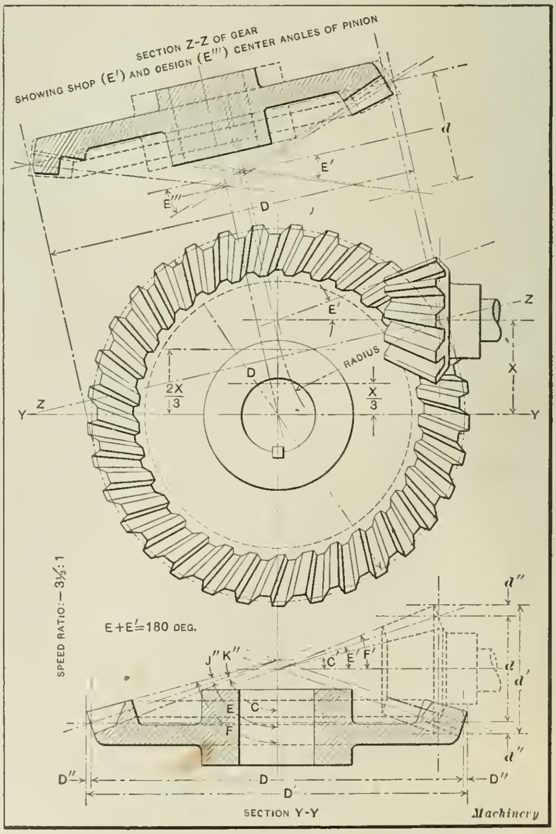

Fig. 2. Diagram showing Principles involved in Lay-out of Type B Skew Bevel Gears, in which both Gear and Pinion have Skew Teeth

represented by the amount of spindle offset, so that the shop angles must be employed and not the design angles. The adjustments of the gear blank are controlled by the circular pitch of the gear, not its normal pitch which conforms to the circular pitch of the pinion. When the rough gear blank is placed on the spindle of the finishing machine to avoid the preliminary operation of facing the blank in a lathe or other machine, the shop face angle is employed, not the design face angle. This practice is not to be commended, however, for the gear-tooth cutting machine is an expensive and sensitive one, so that it usually pays to perform the rough-facing operation on a more rugged machine.

Skew Bevel Gears—Type B

The second type of skew bevel gear is illustrated in Fig. 2, and although apparently more complicated than the type which has been described, it is more easily laid out—at least, the calculations required are simpler—if this type of gear is not less complicated to machine. The teeth in both the gear and pinion being cut askew, the cutting of such gears is greatly simplified by making the obliquity of the teeth the same in both pinion and gear. The obliquity of the teeth being the same in the two gears, the center angles of the pitch surfaces are supplements of each other—see Fig. 2—and are very nearly the same as the true center angles of the respective gears, the latter being slightly greater. The close similarity between the pitch surface center angles and the true center angles of the gears has led to the common practice of employing the same formulas for the angles of type B skew bevel gears as are used for ordinary bevel gears, and of making all proportions of such gears the same as those of ordinary bevels of the same pitch, number of teeth and ratio. This practice has the advantage of involving only calculations with which every gear designer is familiar, but it is nevertheless incorrect. The angles are practically the same, it is true, but the diameters of skew bevel gears should be somewhat greater than those of similar plain bevel gears on account of the obliquity of the teeth—that is, if the full strength of the teeth is to be realized.

The obliquity of the teeth being equal in the two gears, the circles of apexes are proportional to the speed ratio of the gears. That is, the radius of the respective circles of apexes is not equal to the total offset of the pinion shaft, as is the case in type A skew bevel gears where the obliquity of teeth is confined to the gear; but the radius of the circle of apexes for each gear is proportional to its diameter, the sum of the two radii equaling the total offset. For instance, in a pair of skew bevel gears of this type in which the pinion shaft offset is 3 inches and the speed or diameter ratio 3 to 1, the radius for the apex circle of the pinion would be $3 \times 1/4 = 0.75$ inch, and for the gear $3 \times 3/4 = 2.25$ inches. Though the formulas for the design of type *B* skew bevel gears are much the same as the well-known formulas for ordinary bevel gears, their insertion here is necessary for a comprehensive understanding of the skew bevel gear principle of teeth of equal obliquity in the two gears, even assuming the various angles to be the same as those for similar ordinary bevel gears.

Notation for Skew Bevel Gears—Type B

The notation is the same as that for type A gears with the following additions:

V = radius of circle of apexes for pinion;
W = radius of circle of apexes for gear;
X = total offset of pinion shaft = $V + W$;
y = angle of offset for pinion;
z = angle of offset for gear;
R = speed ratio = N/n;
J'' = angle increment;
K'' = angle decrement;
P'' = circular pitch;
d_e = equivalent pitch diameter of pinion.

Formulas for Skew Bevel Gears—Type B

$$V = \frac{X}{R+1} \qquad (1)$$

$$W = RV \qquad (2)$$

$$D_e = \frac{N}{p} \qquad (3)$$

$$\tan y = \frac{2V}{D_e} \qquad (4)$$

$$D = \frac{2V}{\sin y} \qquad (5)$$

$$d = \frac{Dn}{N} \qquad (6)$$

$$P'' = \frac{3.1416d}{n} = \frac{3.1416D}{N} \qquad (7)$$

$$\tan E' = \frac{d}{D} \qquad (8)$$

$$E = 90 - E' \qquad (9)$$

$$\tan J'' = \frac{2 \sin E'}{n} \qquad (10)$$

$$\tan K'' = \frac{2.314 \sin E'}{n} \qquad (11)$$

$$F' = E' + J'' \qquad (12)$$

$$C' = E' - K'' \qquad (13)$$

$$F = E + J'' \qquad (14)$$

$$C = E - K'' \qquad (15)$$

$$s = \frac{d}{n} = \frac{D}{N} \qquad (16)$$

$$d'' = s \cos E' \qquad (17)$$

$$D'' = s \cos E \qquad (18)$$

$$d_e = \frac{n}{p} \qquad (19)$$

$$d' = d + 2d'' \qquad (20)$$

or for greater accuracy:

$$d' = d + \frac{2d''d_e}{d}$$

$$D' = D + 2D'' \qquad (21)$$

or for greater accuracy:

$$D' = D + \frac{2D''D_e}{D}$$

Derivation of Foregoing Formulas

The similarity of the formulas for type B skew bevel gears and for ordinary bevel gears is so marked that little explanation of their derivation is necessary, other than that of the equivalent pitch diameter formulas.

The equivalent pitch diameters of ordinary bevel gears which would give the same speed ratio as gears with oblique teeth are not quite so evident from Fig. 2 as the equivalent pitch diameter of type A skew bevel gears is made from Fig. 1; but it is quite evident that the actual pitch diameters of the gears with oblique teeth must be greater than those of a similar combination of gears with straight (radial) teeth. In the case of type A skew bevel gears it was quite apparent that the pitch diameter D of the gear depended upon the offset X of the pinion shaft; so it must follow that for skew bevel gears of type B, where the increase in diameter is reduced by making both the pinion and gear teeth equally oblique, the pitch diameter is also dependent upon the offset X of the pinion shaft, *i. e.*, that proportion of the total offset which governs the obliquity of the teeth. The formulas for the actual pitch diameters must then be similar to that for the actual pitch diameter of the type A skew bevel gear, the proportional offset governing the obliquity of the teeth, and its corresponding angle of offset simply taking the place of the total offset and its angle of offset used in the formula for type A gears.

The circular pitch of both gear and pinion are necessarily the same in type B gears, but are somewhat greater than the normal pitch which conforms to the circular pitch of similar gears with radial instead of oblique teeth. The diameter increments of both gear and pinion are actually somewhat less than they would be if the teeth were radial, so in the formulas for outside diameters (the ones for greater accuracy) the same modification is employed as for type A gears.

Example in Design of Skew Bevel Gears—Type B

Example.—Required: A pair of skew bevel gears of 5 diametral pitch, with 60 teeth in gear and 15 teeth in pinion; the pinion shaft offset to be 5 inches. The diametral pitch corresponds to the normal pitch of the gears.

Radius V of circle of apexes for pinion:

$$V = \frac{5}{4+1} = 1 \text{ inch.} \quad (1)$$

Radius W of circle of apexes for gear:

$$W = 4 \times 1 = 4 \text{ inches} \quad (2)$$

Equivalent pitch diameter D_e of gear:

$$D_e = \frac{60}{5} = 12 \text{ inches} \quad (3)$$

Angle of offset y for pinion:

$$\tan y = \frac{2 \times 1}{12} = 0.1667 \quad (4)$$

$$y = 9 \text{ degrees, } 28 \text{ minutes}$$

Pitch diameter D of gear:

$$D = \frac{2 \times 1.0}{0.16447} = 12.16 \text{ inches} \quad (5)$$

Pitch diameter d of pinion:

$$d = \frac{12.16 \times 15}{60} = 3.04 \text{ inches} \quad (6)$$

Circular pitch P'':

$$P'' = \frac{3.1416 \times 3.04}{15} = 0.6367 \text{ inch} \quad (7)$$

Center angle E' of pinion:

$$\tan E' = \frac{3.04}{12.16} = 0.2500 \quad (8)$$

$$E' = 14 \text{ degrees, } 2 \text{ minutes}$$

Center angle E of gear:

$$E = 90 - 14 \text{ degrees, } 2 \text{ minutes} = 75 \text{ degrees, } 58 \text{ minutes} \quad (9)$$

Angle increment J'':

$$\tan J'' = \frac{2 \times 0.2425}{15} = 0.03233 \quad (10)$$

$$J'' = 1 \text{ degree, } 51 \text{ minutes}$$

Angle decrement K'':

$$\tan K'' = \frac{2.314 \times 0.2425}{15} = 0.03741 \quad (11)$$

$$K'' = 2 \text{ degrees, } 9 \text{ minutes}$$

Face angle F' of pinion:

$$F' = 14 \text{ deg., } 2 \text{ min.} + 1 \text{ deg., } 51 \text{ min.} = 15 \text{ deg., } 53 \text{ min.} \quad (12)$$

Cutting angle C' of pinion:

$$C' = 14 \text{ deg., } 2 \text{ min.} - 2 \text{ deg., } 9 \text{ min.} = 11 \text{ deg., } 53 \text{ min.} \quad (13)$$

Face angle F of gear:

$$F = 75 \text{ deg., } 58 \text{ min.} + 1 \text{ deg., } 51 \text{ min.} = 77 \text{ deg., } 49 \text{ min.} \quad (14)$$

Cutting angle C of gear:

$$C = 75 \text{ deg., } 58 \text{ min.} - 2 \text{ deg., } 9 \text{ min.} = 73 \text{ deg., } 49 \text{ min.} \quad (15)$$

Addendums:

$$s = \frac{3.04}{15} = 0.2027 \text{ inch} \quad (16)$$

Diameter increment d'' of pinion:

$$d'' = 0.2027 \times 0.97015 = 0.1967 \text{ inch} \quad (17)$$

Diameter increment D'' of gear:

$$D'' = 0.2027 \times 0.24249 = 0.0492 \text{ inch} \quad (18)$$

Equivalent pitch diameter d_e of pinion:

$$d_e = \frac{15}{5} = 3 \text{ inches} \quad (19)$$

Outside diameter d' of pinion:

$$d' = 3.04 + (2 \times 0.1967) = 3.433 \text{ inches} \quad (20)$$

or for greater accuracy:

$$d' = 3.04 + \frac{2 \times 0.1967 \times 3}{3.04} = 3.428 \text{ inches}$$

Outside diameter D' of gear:

$$D' = 12.16 + (2 \times 0.0492) = 12.258 \text{ inches} \quad (21)$$

or for greater accuracy:

$$D' = 12.16 + \frac{2 \times 0.0492 \times 12}{12.16} = 12.257 \text{ inches}$$

Machining Skew Bevel Gears—Type B

Skew bevel gears, in which the teeth of both pinion and gear are of equal obliquity, should be completely cut on one machine with its spindle offset from the plane of the cutting tool a distance equal to the radius of the circle of apexes for the gear being cut, the facing angle (shop angle) cut being taken with the machine so adjusted, as well as all the operations of cutting the teeth. The angularity of the facing angle thus cut is the true angularity of the face surface—also of the pitch surface, if teeth of equal depth are cut—so that the true face angle is the requisite amount greater than the angularity of the face surface. The slight inaccuracy of assuming the radial line angles of the gears to be the same as those on lines normal to the circular pitch circumferences is thus automatically corrected. However, should it be deemed advisable to perform the facing cut on a lathe, as in the case of type A skew bevel gears, the face angles ascertained by Formulas (12) and (14) may be safely used, unless the offset of the pinion shaft should be very pronounced and the speed ratio of the gears also large, for the slight error arising would tend only very slightly to throw the teeth out of perfect mesh toward the inner edge of the gears, where but a small proportion of the power is really transmitted. The operations following the facing of the gear blanks are exactly similar to those employed when finishing type A skew bevels and demand the same care.

Sliding and Tooth Proportions of Skew Bevel Gears

The obliquity of type B skew bevel gears produces the sliding action referred to in the discussion of type A skew bevel gears—though to a lesser degree—and this results in both a slight drawback and a decided advantage. The drawback is due to failure of the teeth to clear properly if the common 14½-degree involute tooth is used, but this is overcome by employing a more obtuse angled tooth. In the ordinary installation, a 20-degree involute tooth clears satisfactorily, and this is the type of tooth usually cut. In extreme cases, where the offset of the pinion shaft is particularly pronounced, an even greater tooth angle might be employed to advantage, but it is very doubtful whether such need would arise in any but extremely freak gear combinations. The advantage possessed by skew bevel gears is their smooth and powerful action, as compared with that of common bevel gears. The sliding action of the teeth reduces the impact shock, which is the chief disadvantage of spur gearing, while the rolling action of the teeth makes the gears more powerful and reliable than spiral gears which depend entirely upon sliding action for their operation. Skew bevel gears are really excellent power transmitters and deserve greater popularity, particularly as they are in reality neither difficult to lay out nor hard to machine.

* * *

BILL FOR LEGALIZING THE CENTIGRADE SCALE

A committee of the National Academy of Sciences, consisting of Messrs. Abbot, Stratton and Marvin (the heads, respectively, of the Smithsonian Astrophysical Observatory, the Bureau of Standards and the Weather Bureau), appointed to consider the bill before congress discontinuing the use of the Fahrenheit temperature scale in government publications, reported at the last annual meeting of the academy in favor of the bill, but recommended two amendments. One of the latter provides that "when in the publication of tables containing several meteorological and climatic elements the use of data in centigrade temperatures leads to manifest incongruities, the chief of the weather bureau is directed to publish related data in such units as are necessary to make the tables homogeneous and to secure international uniformity as far as practicable." The other amendment would authorize the use of the absolute centigrade scale.

* * *

Steel cast flywheels running at peripheral speeds in excess of 4000 feet per minute should be double annealed; heavy steel gears should be annealed once, but steel frames and similar steel casting machine members seldom require annealing.

MACHINERY POUND PRICES

BY A. B. HAZARD*

Builders of standard machinery are usually averse to having their products referred to by a pound price. Manufacturers who have designed, built and refined high-grade machinery have always been greatly irritated by having a customer who has received a quotation, together with weights, specifications, etc., refer to the matter by quoting a price by the pound. This in an injustice to the manufacturer and invariably shows the inability of the buyer and his lack of mechanical knowledge.

In the first place, the average purchasing agent does not buy large machinery often enough to keep in touch with the progress of improvements. It is obviously unfair to make comparisons between machine tools of the same type unless the various types of machines possess the same degree of refinement and are provided with the same improvements. The design and relative efficiency of many types of machines are so varied that they cannot be compared with any degree of justice by referring to one or the other by a pound price. A universal milling machine having a single-pulley drive and quick-feed change-gears cannot be compared by a pound price with a Lincoln type milling machine having a cone head and belt feed of the same working dimensions, regardless of the number that are manufactured. The latter would cost probably half the price of the former, and yet both would take the same size milling cutters and would perform the same operations in many cases. Yet the adaptability of the universal machine to conditions which could not be met on the Lincoln type milling machine would make any comparison by a pound price between the two types of machines an unfair one. Taking another example, a 6-foot swing lathe will cost over twice as much as a 6-foot vertical boring mill, and each will have its respective advantages over the other with certain classes of work.

A number of illustrations can be given along these lines, such as comparing a standard engine lathe with the average toolmaker's lathe designed for precision work. The standard lathe will do many pieces of good tool work, especially when handled by an experienced operator, and while it cannot be handled as quickly as the quick-change gear type of machine, the class of work produced compares very favorably with that of the higher-priced machine. The same principles are applicable to parts for automobiles. The frame must be made to suit the design, and although a plain straight frame is cheaper to make than one with an offset at the rear or one tapered front and back, the weight of the two frames would be about the same. A cellular type radiator is bought for its efficiency, while the fin and tube type is much cheaper to make, and yet the weights of the two would not differ greatly. So with an engine, transmission or rear axle for an automobile, the degree of refinement to which these parts are subjected in the machining and the improvements in design would all have an effect on the pound price, and yet the weight of a cheap axle or other part and the weight of one of the more improved types might not be very different.

MACHINERY POUND PRICES

Machine Tools	Price per Pound	
	Minimum	Maximum
Boring mills, vertical (large)	$0.12	$0.16
Drilling machines, upright (plain)	0.20	0.25
Drilling machines, radial (plain, cone pulley drive)	0.14	0.18
Drilling machines, radial (quick-change feeds, motor drive)	0.18	0.26
Lathes, engine—standard type (cone pulley drive)	0.12	0.18
Lathes, engine—patent head (quick-change gears)	0.14	0.24
Lathes, gap	0.15	0.25
Lathes, turret chucking (18 to 24 inches)	0.15	0.28
Milling machines, plain	0.18	0.25
Milling machines, universal (quick-change gears)	0.30	0.55
Planers, regular	0.10	0.18
General		
Aeroplanes	0.60	2.00
Aeroplane motors—six-cylinder	1.50	4.75
Aeroplane motors—eight-cylinder	2.50	5.50
Air compressors	0.10	0.25
Automobile motors—four-cylinder	0.32	0.60
Automobile motors—six-cylinder	0.38	0.70
Automobile radiators	0.42	0.80
Barbed wire machines	0.17	0.24
Locomotives	0.07	0.12
Steam engines, Corliss type	0.08	0.14
Steam engines, vertical marine type	0.12	0.18

The factory engineers who are constantly working out the different mechanical propositions connected with the machining of the parts in a motor car, and who have to do with jigs, fixtures and other devices for the production of these parts, are among the few people who can even talk about pound prices with any degree of accuracy. On this class of work it is very difficult to make an estimate of a price per pound, because of the variations in the types of fixtures and their requirements for accuracy. A fixture might be large and heavy and weigh several hundred pounds, yet it might have very little accurate work in its manufacture; while, on the other hand, a small fixture of little weight might have many refinements in its design and might require to be very carefully made, so that the price per pound would be extremely high. A Corliss engine of a horsepower corresponding to that of a triple expansion vertical marine engine might perform the same duty, yet could not be compared to the other by a price per pound. Machined castings for structural work, sole plates, furnace parts, etc., are very rough work, and have therefore been sold largely on a pound price basis.

When new machinery is to be purchased, the factory engineer must carefully consider the class of work and the amount to be done, as well as the accuracy, and select a machine tool of suitable type to perform the required work. The designing engineer who builds machinery, tools or engines generally estimates the weight and the labor separately and adds the cost of the two together, finally converting the whole into a pound price for labor and material. This is done for his own information, but when completed and the cost is turned over to the works manager and sales department, the pound price is entirely lost. When contracts are to be let for large special machinery, the large shops with a heavy overhead expense often have an advantage over the smaller factories, because their equipment is more suited to the handling of this heavy work. When light machines are to be built, however, the small shops can many times build them cheaper because of their lighter overhead expense.

It should be remembered that although pig iron costs from $16 to $20 per ton and steel from $30 to $60 per ton, this does not mean that any kind of machinery can be made for any fixed price per pound. There are so many factors that enter into the manufacturing of any mechanical device that there is no good reason why a price per pound should be considered in purchasing. It is of interest, however, to note the range in prices for the various mechanical devices, and to permit of making these comparisons the accompanying table has been prepared.

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* * *

The diamond tool is the most efficient means for truing the face of grinding wheels for precision work so far discovered. The reasons are: (1) Diamonds or bortz are harder than the wheel to be trued. (2) They are obtainable in sufficient quantities to meet the demand. (3) They provide a means of making the wheel a true cylinder and at the same time provide any kind of wheel service desired. (4) They lend themselves to a reasonably easy setting and are conveniently applied to the work. (5) The waste of the wheel is negligible.—*Grits and Grinds.*

TESTING SPECIAL SHELL-BORING LATHES

BY L. C. MORROW*

The operation of testing various machine tools for accuracy and the methods used in aligning the parts are always of interest. The special shell-boring lathe illustrated in Fig. 1 is designed to bore 12-inch high-explosive shells having an open base and screwed adapter. The fundamental features of the design are as follows: flat bed, two-step cone, double back-gears, bell chuck supported by steadyrest, stationary carriage while boring, power traverse to carriage for running back to permit removal of shell after boring, movable boring-bar with feed, and link former for nose. This machine is made by the Giddings & Lewis Mfg. Co., Fond du Lac, Wis. Reference to Fig. 1 will show the general characteristics of the lathe, and a shell A can be noted in the chuck ready for boring.

Method of Aligning Spindle

Fig. 2 shows the method of aligning the spindle when erecting the lathe. The disks A are machined very accurately, the faces of both disks and hubs being machined while on the arbor. They have a diameter equal to one-half the length of the base of the headstock. One disk fits over the spindle nose and is pulled up against the shoulder of the spindle by a long bolt (not shown) running through the spindle. The other disk is attached to a bar which is supported on two brackets B, which are set on the bed. The pins D bear against the vertical surface on the bed, against which the thrust of the carriage is taken and on which it slides. The disks are brought together and thickness gages tried between them when testing. In this way it is easy to determine in which direction the spindle is out of alignment and just how much it may be out. The thickness of the gages which will enter between the disks should be multiplied by two, in order to find the error in alignment of the headstock.

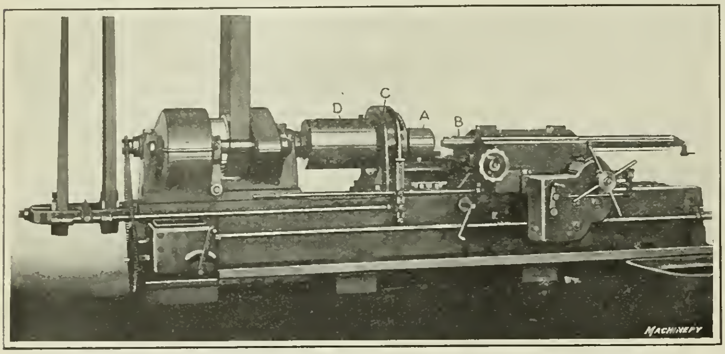

Fig. 1. Special 12-inch Shell-boring Lathe

Method of Aligning Boring-bar

Referring once more to Fig. 1, it will be seen that the alignment of the boring-bar B is quite important in order that accurate work may be done by the machine. In aligning the boring-bar an indicator is attached to a stand of suitable form (not shown) which rests on the bed and has a bearing against the vertical grinding surface as in the case of the support B in Fig. 2.

* Address: Lockland, Ohio.

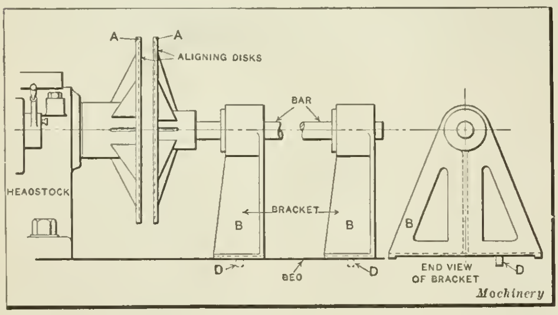

Fig. 2. Spindle Aligning Tools used in testing Shell-boring Lathe

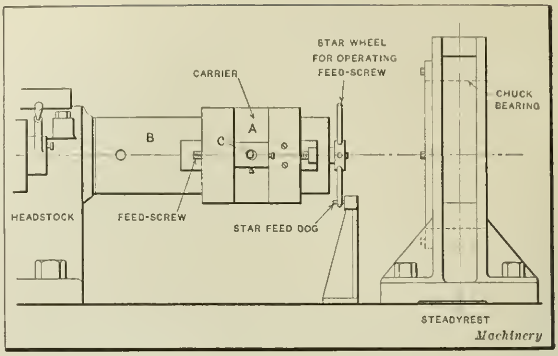

Fig. 3. Combination Boring and Turning Tool

Boring Steadyrest

In order to insure accuracy, the steadyrest shown at C in Fig. 1 must be bored in position, and, furthermore, each steadyrest must be bored in position on its own lathe. This work is accomplished by a special cutter-head or boring head shown in Fig. 3. This cutter-head is provided with a tool C, which is adjustably mounted on the carrier A. This carrier, in turn, is a sliding fit along the cylinder B, which is mounted on the spindle nose. The feeding mechanism is operated on the star wheel principle, as indicated in the illustration. The steadyrest is shown out of its true position so that the details of the boring head may be more clearly apparent. The steadyrest is supplied with a bushing that may be renewed at any time when worn.

Turning Chuck Steadyrest Bearing Surface

That part of the chuck which runs in the steadyrest must also be turned in position, as any error made in fitting the thread of the chuck to the nose of the spindle would be considerably exaggerated at the outer end of the chuck. It is important, therefore, that the turning should be done on the lathe on which it is to be used, so that accuracy will be assured. The same tool which is used for boring out the steadyrest is employed in turning the bearing mentioned, the tool being clamped to the bed of the machine for the purpose and

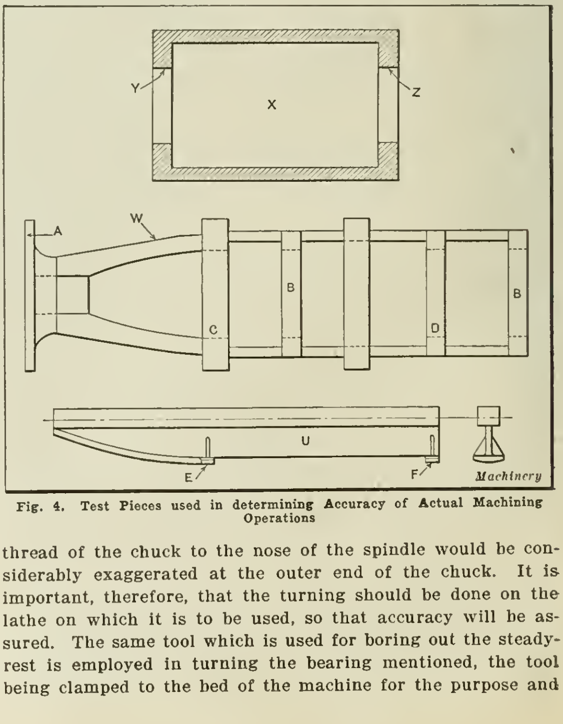

Fig. 4. Test Pieces used in determining Accuracy of Actual Machining Operations

the star feed dog attached to the chuck to provide the necessary feed movement.

Boring and Testing Chuck

After the chuck and steadyrest have been applied to the machine, it is necessary to bore the inside of the chuck for a distance of about 6 inches from the rear end, this bored portion later receiving a bushing machined to the proper shape to center and support the nose end of the shell. In order to know that the boring-bar is properly set to bore this hole straight, a test cylinder *X* shown in Fig. 4 is first bored. The cylinder collars *Y* and *Z* must show that the bore is parallel or at least that it will not be small on the front end. Naturally, the bore in the chuck is tested for accuracy during the machining process.

Final Test

The final test of the machine is to bore a shell in order to see that the alignment is within the permissible limits of error and that the curve of the nose on the shell is properly formed. For this purpose a cast-iron test shell *W* is used, this shell having a flange *A* which fits the bored portion of the chuck, thus giving practically the same support which the forged shell receives. The diameters of the collars *B* are measured in order to determine that the straight bore is parallel and cylindrical. The curve on the nose of the shell is measured by an accurately made templet shown at *U* in Fig. 4, this templet having two feet *E* and *F* which rest at the points *C* and *D* in the shell. The amount of error in the curve is determined by thickness gages. By using the test shell with segments cored out as shown, yet having the heavy collars as braces, a strong piece is obtained to which the templet may be applied at any time without sawing out a section. This piece can be quickly bored and may also be rebored a great many times, so that its economy is apparent.

* * *

A. S. C. E. TO SHARE ENGINEERING SOCIETIES BUILDING

The American Society of Civil Engineers has voted to accept the offer of the United Engineering Society to become an equal partner with the three founder societies, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and the American Society of Mechanical Engineers, in ownership, occupancy and administration of the Engineering Societies Building and all other activities which the societies may jointly undertake. Thus is the hope of Andrew Carnegie, the donor of the building, fully realized—that the building should become the home and headquarters of the engineering profession in America.

Three stories will be added to the top of the Engineering Societies Building, and planned for the extension of the library and for the use of the A. S. C. E. The cost will not exceed $250,000. The arrangement with the A. S. C. E. is to permit it to reimburse the United Engineering Society for the cost of the enlarged building, this sum being substantially the same as the amount paid by the founder societies originally for their participation in the enterprise. Thus all four societies enter upon the same basis and share equally in all respects.

Ten years ago, when the Engineering Societies Building was constructed, the A. S. C. E. was invited by Mr. Carnegie to be a founder society in the building. The society decided at that time not to accept the offer, however, but to continue to occupy its own house on 57th St., which it had built about ten years earlier.

At the time of the undertaking of the founder societies, there was doubt as to the success, financially and technically, of the scheme for associating several societies in one building. The construction and dedication of the building were looked upon by some as the first steps of a severe trial of the management of the societies. Many questioned whether the three participating societies in Mr. Carnegie's gift would live together in harmony and be able to carry out the plans suggested. Some questioned the feasibility also of uniting the three independent libraries of the societies into one joint library, useful to members of any of the three societies for research and consultation. Some did not see how the housing of the three national societies and several minor associations under one roof would bring about the desirable closer cooperation of the various members of the profession without at the same time causing some of the organizations to be "swallowed up" by some of the others.

The experience of ten years has shown that all these criticisms of the project have become groundless. The financial stability of the Engineering Societies Building is now fully established. The building represents an investment of practically $2,000,000. The societies own it free of all encumbrance, and have in addition over $70,000 in a separate reserve fund to provide for depreciation and amortization. Each society has itself prospered. The American Society of Civil Engineers will now pay about $225,000 for the addition to the building, and each of the four founder societies will then hold an equity in the property of over half a million dollars.

Eighteen societies, including the three original founder societies, now make the building their headquarters. Each is under its own management absolutely, and all live in independence and harmony. Frequent conferences are held in matters pertaining to the welfare of the engineering profession as a whole. With the civil engineers, the total membership represented in the building will be 52,677, as shown by the following figures of present membership of the resident societies:

American Society of Civil Engineers	8022
American Institute of Electrical Engineers	8308
American Institute of Mining Engineers	5597
The American Society of Mechanical Engineers	7149
Aeronautical Society of America	200
American Society of Heating and Ventilating Engineers	705
American Gas Institute	1530
Association of Edison Illuminating Companies	73
American Institute of Aeronautical Engineers	121
Empire Gas and Electric Association	115
Illuminating Engineering Society	1350
Municipal Engineers of the City of New York	600
National Electric Light Association	14,000
National Association of Engine and Boat Manufacturers	175
New York Electrical Society	705
Society for Electrical Development	1128
Society of Naval Architects and Marine Engineers	900
Society of Automobile Engineers	1975
U. S. Naval Consulting Board	24

The joint library of the United Engineering Society has in ten years become the greatest and potentially the most useful engineering library in the world. Accessions are now being made at the rate of three thousand annually, and the collection amounted, at the time of the last annual report of the library board, to over 62,500 volumes. At that date, 1020 publications were being received periodically, and current numbers of over 1000 periodicals were on file upon the shelves in the reading room so as to be readily accessible. The consolidation of the valuable A. S. C. E. library with the others will enlarge the scope of the library so that it will become of use to any member of the entire engineering profession.—*Journal A. S. M. E.*

* * *

HARDENING IN ELECTRIC FURNACES

The latest electric furnaces cost about the same to operate as gas furnaces when the current is 3½ cents per kilowatt and the gas is 80 cents per thousand cubic feet, the gas having about 600 B.T.U. per cubic foot. One concern having electric furnaces using current at 1¾ cents per kilowatt gets its work hardened at a cost of about one-fourth cent a pound. But even if the cost were higher than with gas there is the great advantage of perfect control. An autographic record of the rise in temperature clearly indicates the critical point in the curve, and when the temperature has risen a few degrees above as shown by the recorder the charge is removed. Thus the hardener has an infallible guide, provided the pyrometers are checked daily and each heat is recorded. Inspection is checked against these records and each lot of steel is tested before fixing the temperature for quenching. By such exact methods do modern plants insure that work shall be uniform in hardness.

COMMERCIALIZING CARTRIDGE CASE MANUFACTURE*

DEVELOPMENT OF DIES, TOOLS AND METHODS FOR THIS WORK BY THE WORCESTER PRESSED STEEL CO.

THE first orders received in this country for munitions were taken by many concerns that did not appreciate the difficulties attending the production of this class of work. Many manufacturers without previous experience in the production of munitions took orders which proved very unsatisfactory, while others, after considerable delay and expense, were finally able to make deliveries. The number of concerns that met with the anticipated success were few, and, as might be expected, were those that possessed special ability in similar classes of work. One of the successful concerns is the Worcester Pressed Steel Co., Worcester, Mass., which for years has made a specialty of sheet metal stamping products. Orders placed with this firm for 1,300,000 4.5-inch British howitzer cartridge cases have been successfully filled in two weeks less than the time specified. This is one of the few contracts for munitions let in this country which has been completed ahead of the date set, by far the greater number being long over-due.

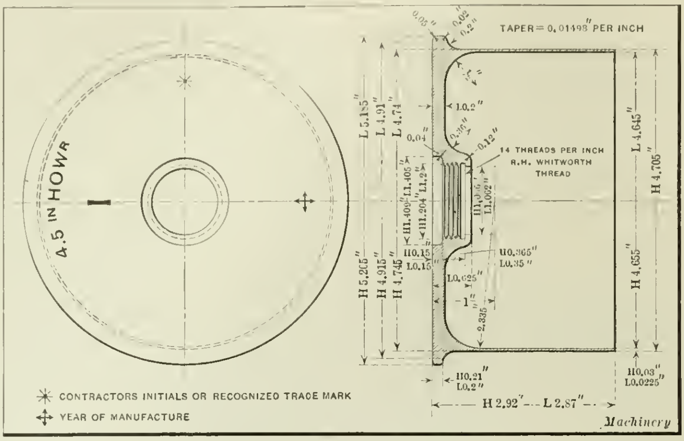

Fig. 1. British 4.5-inch Howitzer Cartridge Case

The solution of the problems of production was not by any means simple, and at least one month's time was taken to analyze the proposition before any work was started. When the plan of procedure was decided upon, all the dies, tools and fixtures were ready for operation inside of six weeks, and in two months' time shipments for testing were started. The original lay-out was planned to handle 4000 cartridge cases in twenty-four hours, and this was done without putting up any additional buildings, and with the purchase of only a few special machines, such as heading presses, drill presses and turret lathes. Inside of six months 10,000 cartridge cases were being turned out in twenty-four hours with the equipment that was laid out for handling 4000. The only reason why such an increase was made was the systematic way in which the work was handled, as will be explained later. Another remarkable thing is that not one cartridge case has been rejected by the government inspectors at the proving grounds for failing on firing test, and in this plant, before the order was finally completed, the percentage of scrap was 2½, and it never exceeded 6. Of course, there are many reasons why this proposition was so successfully worked out, and in the following a few of these will be covered, especially those pertaining to the design and construction of the tools and the methods of systematically routing the work.

Requirements that had to be Met

The following are some of the principal requirements and specifications to which the cartridge case must be made: (1) It must be made to certain dimensions within specified limits. (2) It must be of a certain hardness both on the head and on the walls. (3) It must have a certain ductility. (4) It

* For information on cartridge case manufacture previously published in MACHINERY, see "High-explosive Shell Cartridge Cases," December, 1915; "Making Cartridge Cases," April, 1915; "Loading and Clipping Cartridges," May, 1914, and articles there referred to.

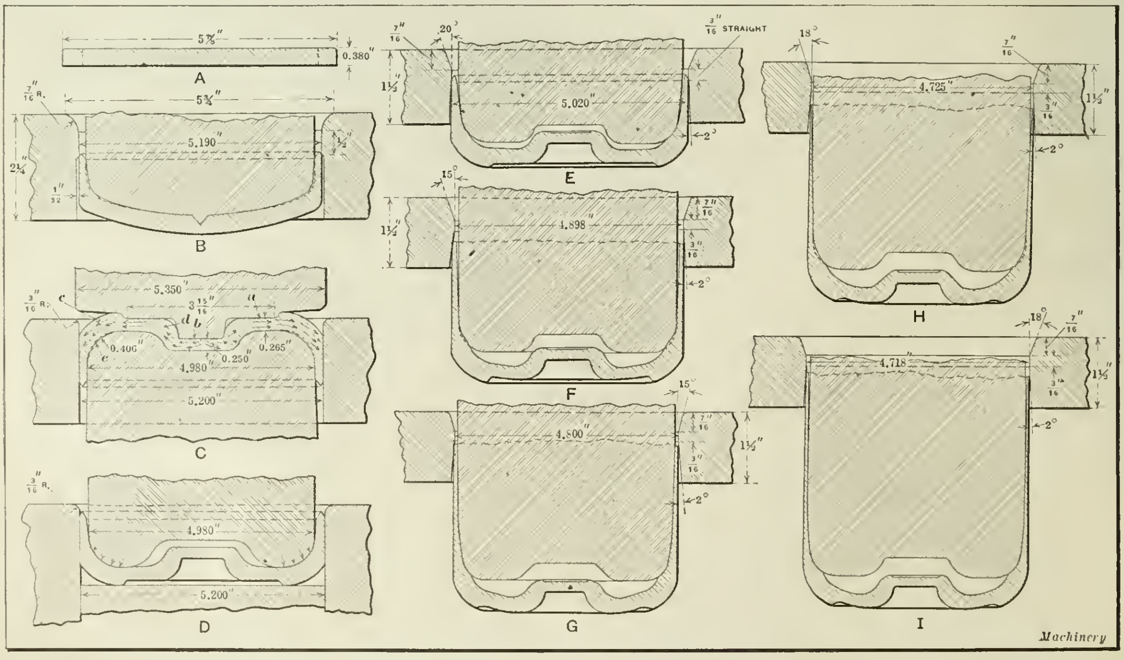

Fig. 2. Diagram illustrating Sequence of Cupping and Redrawing Operations, showing Shapes of Dies used and Distribution of Material

must be capable of resisting an excess charge and used for firing three shots; that is, it must be capable of withstanding three firings without being destroyed. (5) It must be free from all surface imperfections, such as cracks, flaws, etc. Another requirement demanded is that the case during its manufacture must receive a certain number of annealings. In other words, the number of annealings must not be less than five. To produce a cartridge case under these conditions is not as easy as it might seem, and satisfactory results are possible only by careful consideration of the work that must be accomplished and the requirements that must be obtained, and making suitable provision for meeting them.

Method of Analyzing Operations

When the Worcester Pressed Steel Co. took the contract for the manufacture of this cartridge case, it proceeded to analyze the various operations by the same method as would be followed on any regular contract work. The drawing of the cartridge case was carefully gone over and the method of procedure outlined. The size of the blank recognized as being standard for this particular case was 6 inches diameter, 0.380 inch thick. After several experiments, it was found that a 6-inch blank left too much scrap, and a blank 5⅞ inches diameter was decided upon. Another question that had to be settled was the size and shape of the cup. Upon referring to Fig. 1, which shows a drawing of the completed case, it will be seen that practically no material is to be taken from the head of the case; in fact, additional material has to be collected to form the head, especially at the corners. This means that a comparatively thick blank has to be drawn up into a very shallow cup and then the metal in the walls stretched to the required length without taking any more material from the corners. To meet this condition it was necessary that in no redrawing operation should the punch bear on the bottom of the cup, but should hit the inside of the cup so that the metal was confined at the point where the contact was made in such a way that no material was drawn from the base to form the extended walls. In other words, the metal existing in the walls was to be stretched until the desired length was attained. Another difficulty was the handling of such a shallow cup of large diameter. Great trouble was experienced in preventing the blank from tipping to one side. This was finally solved by the use of a center in the cupping punch which, as shown in Fig. 2, centers the blank accurately when it is being drawn through the die for the first operation. Of course this die, not having a blank holder, was provided with a circular guide around its top face in which the blank was accurately centered. Six blanks were made before the exact shape of the dies and punches was obtained, and considering the difficulties encountered, this result is remarkable. One of the greatest difficulties experienced was in getting the metal to flow in the right direction.

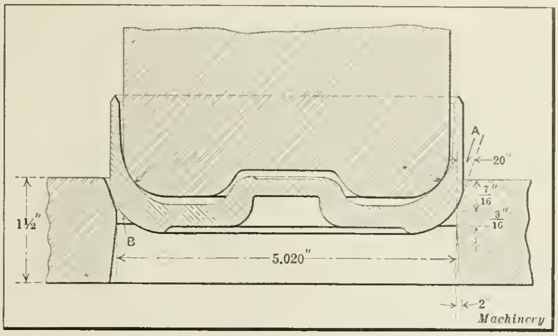

Fig. 3. Diagram illustrating Action that takes place when Cup is forced through Redrawing Die—this illustrates Relation of Cup to Die before Second Redrawing Operation

Controlling Flow of Metal

Starting with the operations in the order in which they are accomplished, the following are a few of the difficulties that were encountered. In the first place, it was found that, owing to the shallowness of the cup required, great difficulty was experienced in keeping the blank from sliding and tipping during the cupping operation. To overcome this difficulty, the first cupping punch, as previously mentioned, was provided with a teat as shown at *B* in Fig. 2, which produced a corresponding hole in the blank and thus centered it before the actual cupping took place. It was also found that the metal drew much more evenly when the blank was located in the cupping die with the rounded edge up.

After several cups had been made it was found that the thickness of the blank was slightly less than that actually required to produce the case most easily. In order to get sufficient material in the base, the cupping punch was "domed" and made considerably larger than the difference between the diameter of the die minus twice the thickness of the metal. (This is clearly shown at *B* in Fig. 2.) In other words, the thickness of the walls of the cup was reduced to about one-half the original thickness of the blank. As the cup was so short and the finished wall at the top edge comparatively thin, sufficient metal could be gathered in this way for redrawing in order to produce a case of the required shape. If more metal had been used, considerable waste of stock would have been involved.

Indenting and Flattening

In ordinary redrawing operations it is not usually necessary to prevent a slight flow of metal from the base of the cup. In this case, however, such a result had to be avoided, and, in fact, additional metal had to be forced toward the lower edges of the cup in order to furnish sufficient material to produce the thickness and shape of head required.

In order to prevent the metal from flowing from the bottom of the cup, the indenting operation was made to follow the first cupping operation. This, as shown at *C* in Fig. 2, was accomplished with the cup inverted and the indenting punch

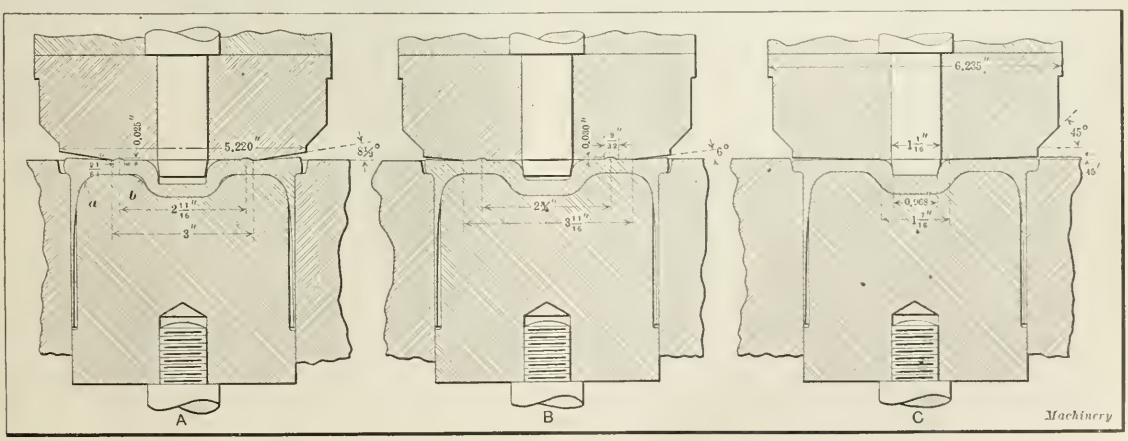

Fig. 4. Diagram illustrating Shape of Heading Punches and Flow of Metal in Head under Pressure

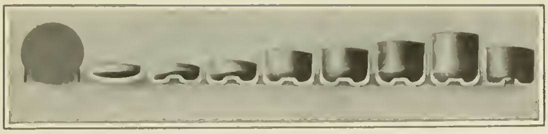

Fig. 5. Cupping, Redrawing and Heading Operations on Cartridge Case

Fig. 6. Shape of Case after cupping and indenting

so made that it "squirted" the material to the corner, as shown by the arrows, packing it up considerably.

It will be noticed in this case that the indenting punch reduced the thickness of the metal at point *a* from 0.380 inch to 0.265 inch; and at point *b* from 0.380 to 0.250 inch. This resulted in the displacement of considerable material which was distributed to points *c* and *d*. A reaction took place at the point *c*, so that as soon as the cup was removed from the die the material at the point mentioned sprung out about 1/32 inch.

Difficulty was also experienced in getting a sufficient amount of material around the primer pocket, and in getting the proper location of the indent for heading. In making the lower indenting punch, the recess to form the indent was made with a radius 1/32 inch greater than that called for on the drawing. This allowed this amount of material to be spread out in heading so as to harden the head and give the desired scleroscope reading. The radius on the inside corner was also increased from 1/2 to 9/16 inch, which provided material that could be spread out so as to fill up the corners in the final heading operation.

The amount of work done at this operation, however, was not sufficient to distribute the required amount of material to point *c*, and following the indenting operation a flattening operation was accomplished. This is shown at *D* in Fig. 2, and was handled with the cup in the same manner as that in which it would be redrawn. Instead of forcing the cup, however, through a die, which in this case was simply a retaining ring, it was butted down against a flat, hardened punch. The upper flattening punch was so made that the greatest pressure exerted was directly in the corners, resulting in throwing the material down ⅛ inch further; that is, the point where the radius joins the plain exterior surface of the cup was thrown down to this amount. These two operations were found to give the required amount of material in the corners, but in the subsequent operations, of course, care was taken not to disturb it. Referring to *D* in Fig. 2, it will be noticed that the flattening punch bears only in the corner and is relieved at all other points.

Redrawing Operations

An annealing operation takes place between the indenting and flattening operations, as will be described in detail later. The cup is taken directly from the flattening to the first redrawing operation. In the first redrawing operation, shown at *E* in Fig. 2, it will be noticed that the walls of the cup are extended very little and it is reduced 3.27 per cent (see Table II), which is considerably less than usual in ordinary redrawing operations. Generally the reduction varies all the way from 8 to 20 per cent, sometimes even more, depending on the thickness and character of the material. In this case it will be noticed that the reduction is comparatively slight. The reason for this is that an endeavor is made to coax the material to flow upward without disturbing the material in the base, and especially at the corners. Reference to Fig. 3 will show that the punch, in starting to draw the cup, bears only in the corners, the pressure being greatest at a point about ⅛ inch higher than where the cup contacts with the drawing angle in the die. In this way only the material in the walls of the cup is extended, the thickness of the metal in the bottom and at the corners being unchanged.

Considerable trouble was experienced in getting the cup to draw correctly in this operation. In the first die a round corner was tried similar to that used for cupping, but it was found that the metal shot under the punch and did not leave sufficient material to extend the walls to the required length. Next an entrance angle of 15 degrees was tried, but this gave results that were unsatisfactory. Finally the angle *A*, Fig. 3,

TABLE I. OPERATIONS ON BRITISH 4.5-INCH HOWITZER CARTRIDGE CASE

Operation No.	Operation	Machine Used	Lubricant	Furnace Used	Temperature, Degrees F.	Time in Minutes	Bath	No. of Operators	No. of Helpers	Production per Hour
1	Cup	Bliss 12" stroke	Lube-a-Tube	....	....	..	....	1	2	525
2	Indent	1000 ton Toledo knuckle press	Lube-a-Tube	....	....	..	....	1	1	500
3	Anneal, pickle and wash	......	......	Rockwell	1250	40	Water cooled	1	3	600
4	Flatten	Toledo 8" stroke	......	....	....	..	....	1	1	1100
5	First redraw	Toledo 8" stroke	Lube-a-Tube	....	....	..	....	1	2	900
6	Wash	Washing tank	......	....	....	..	....	1	1	700
7	Anneal, pickle and wash	......	......	Rockwell	1250	40	Water cooled	1	3	500
8	Second redraw	Bliss 12" stroke	Lube-a-Tube	....	....	..	....	1	2	550
9	Wash	Washing tank	......	....	....	..	....	1	1	540
10	Anneal, pickle and wash	......	......	Rockwell	1250	40	Water cooled	1	3	500
11	Third redraw	Bliss 12" stroke	......	....	....	..	....	1	2	550
12	Wash	Washing tank	......	....	....	..	....	1	1	540
13	Anneal, pickle and wash	......	......	Rockwell	1250	40	Water cooled	1	3	500
14	Fourth redraw	Bliss 12" stroke	Lube-a-Tube	....	....	..	....	1	2	500
15	Trim	Trim. mach.	......	....	....	..	....	1	..	400
16	Wash	Washing tank	......	....	....	..	....	1	1	500
17	Anneal, pickle and wash	......	......	Rockwell	1250	20	Water cooled	1	3	500
18	Fifth redraw	Bliss 12" stroke	......	....	....	..	....	1	2	450
19	Trim	Trim. mach.	......	....	....	..	....	1	1	400
20	Wash	Washing tank	......	....	....	..	....	1	1	600
21	Head	1350-ton Toledo knuckle joint press	......	....	....	..	....	2	..	500
22	Trim	Trim. mach.	......	....	....	..	....	1	..	450
23	Pierce hole	Toledo 5" press	......	....	....	..	....	1	..	700
24	Taper	Bliss 6" stroke	Lube-a-Tube	....	....	..	....	1	..	700
25	Inspect	Gages	......	....	....	..	....	1	..	500
26	Rough-face, form, chamfer, finish-face, drill, back-face, recess, tap, counterbore and trim	No. 4 Warner & Swasey	Soap and water	....	....	..	....	1	..	70
27	Finish-tap	Snyder drill press	Soap and water	....	....	..	....	1	..	530
28	Finish-ream and counterbore	Barnes drill press	Soap and water	....	....	..	....	1	..	530
29	Back-burr	Barnes drill press	Soap and water	....	....	..	....	1	..	530
30	Inspect	Gages	......	....	....	..	....	1	..	60
31	Wash and dry	Soda tanks	......	....	....	..	....	1	1	1200
32	Stamp	Noble & Westbrook	......	....	....	..	....	1	1	1300
33	Pack 100 in box	......	......	....	....	..	....	1	1	1300

Machinery

was increased to 20 degrees, which proved to be satisfactory. This gave a more abrupt angle which resulted in shooting the metal upward instead of downward. It was also found that the die worked best when the point B, where the angle joins the straight portion of the die, was provided with a very slight radius, just sufficient to remove the sharp corner. When this point on the die wore down to a radius of about 3/32 inch, the metal again began to shoot under the punch. After the first redraw and before annealing and pickling, the cup is washed. It is then rinsed in cold water and passed on to the second redrawing operation. This, as will be noticed at F in Fig. 2, extends and thins the walls of the cup considerably. The punch, as before, bears only in the corner, so as not to disturb the material in the base of the cup. In this case the drawing angle on the die is made 15 instead of 20 degrees. There are two reasons why the angle was reduced. In the first place, the percentage of reduction is considerably less; and in the second place, more drawing surface is necessary to stretch the metal evenly.

The shape of the end of the cup has a considerable bearing on the angle required on the edge of the drawing die. For instance, the first redrawing die was made with a drawing angle of 20 degrees. Reference to Fig. 2 will show that after the flattening operation the radius was lowered over ⅛ inch; that is, the point where the radius merges with the cylindrical part of the body was dropped that amount during the flattening operation. It was found that a slight angle—in other words, 15 degrees—on the drawing die carried the point of contact up higher on the case and started out with a smaller amount of material to stretch than was the case when the angle was greater or where the leading part of the die was made with a more obtuse angle. The die for the third redrawing operation is similar in shape to that used for the second redrawing operation, but the reduction is slightly less in this case, being 2 per cent instead of 2.43 per cent.

TABLE II. DATA ON CUPPING AND REDRAWING OPERATIONS

Operation	Diameter of Die in Inches	Difference Between Succeeding Redraw Dies in Inches	Reduction, Per Cent	Height of Cup in Inches	Approximate Diameter of Cup in Inches	Enlargement of Cup Over Die in Inches
Blank	5.875	.....	....	....	.....	.....
Cup	5.190	0.685	4.17	1 1/2	5.197	0.007
First redraw	5.020	0.170	3.27	1 7/8	5.028	0.008
Second redraw	4.898	0.122	2.43	2 3/4	4.906	0.008
Third redraw	4.800	0.098	2.00	3 3/4	4.806	0.006
Fourth redraw	4.725	0.075	1.56	4 1/4	4.730	0.005
Fifth redraw	4.718	0.007	0.148	5 3/16	4.722	0.004

Machinery

In the fourth and fifth redrawing operations two objects are necessary: first, to draw the walls of the case to the desired length and thickness; and second, to obtain the desired resiliency in the material. This was obtained in the following manner. The case after the fourth redrawing operation was annealed to a temperature of 1250 degrees F. for twenty minutes instead of forty, as was the case in all other annealing operations, and the same punch was used for the fifth redrawing operation as that used for the fourth, the reduction being in the die only. This ironed out the case to the required thickness and length and secured the desired resiliency.

Heading Operations

The operation of heading is accomplished on two different types of presses—hydraulic and knuckle power presses. In the hydraulic press, two heading operations are necessary, whereas in the toggle joint press three blows are required to bring the head to the desired shape and thickness. In Fig. 4 the toggle joint press method of heading is illustrated. In this case, it will be noticed that the heading punches are so made that the action is to "squirt" the metal toward the rim. For the second operation, the angle of slope on the end of the heading punch is slightly less than the first, and in the last operation the angle is forty-five minutes. This makes a head which is slightly concave, but as it is finished flush by machining in subsequent operations, the concavity does not make any difference. This method of beveling the heading punches is found necessary in order to place the metal at the rim. The pressure required for heading is 1350 tons. Reference to Fig. 4 will show that the lower face of the various heading punches, with the exception of the last, is provided with an annular groove. The object of this groove is to allow the metal to pack up at this point in order to get a smooth surface on the under side of the head in the final flattening operation. The flattening action, it will be noticed, is greatest between

Fig. 7. First Operation on Cartridge Case—Cupping—which is handled in a Bliss 12-inch Stroke Press at the Rate of 525 per Hour

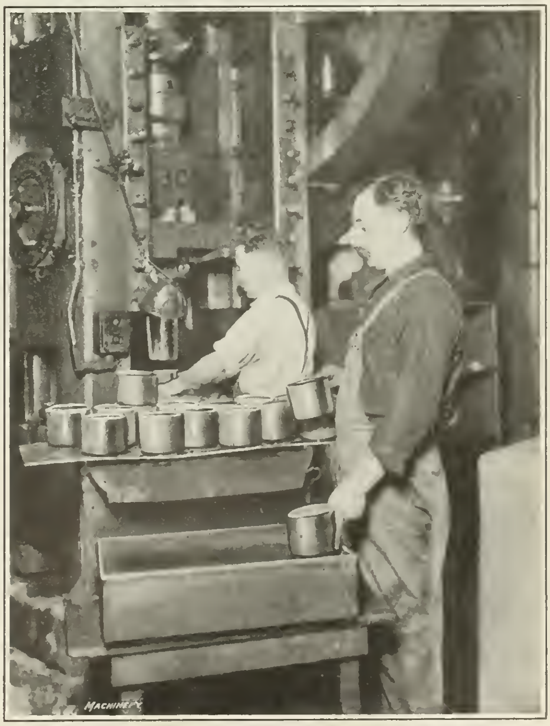

Fig. 8. Fifth Redrawing Operation which is handled in a Bliss 12-inch Stroke Press at the Rate of 450 per Hour

Fig. 9. Heading Cartridge Case in Toledo 1350-ton Press—Three Blows are required to finish Case and Two Operators attend to the Machine, One indexing the Punches and the Other inserting and removing the Cases. Production is 500 per Hour

the two radii *a* and *b;* this tends to cause a wrinkle to be formed on the under surface located between these points, which is avoided by providing a groove in the lower face of the upper punch. The shape and size of this groove were determined by experiment, and the dimensions shown at *A* and *B* were found satisfactory.

Sequence of Cupping, Annealing, Redrawing and Heading Operations

Fig. 5 shows the sequence of cupping, redrawing and heading operations that were followed in the production of this cartridge case, and Table I lists the sizes of the machines used, lubricant, furnace, temperatures in degrees for annealing, time of annealing, cooling bath, number of operators, number of helpers and production per hour. Table II gives the approximate data covering the dimensions of the dies used, reduction between each redrawing operation in inches as well as per cent, and difference between the diameter of the die and the diameter of the case produced by it, etc. This case is made from brass of a composition about 70 per cent copper,

Fig. 10. Ring Built-up Type of Heading Punches—this was the Only Type of Punch that proved Satisfactory

30 per cent zinc. This percentage of zinc in the case makes it quite hard when passed through redrawing operations; consequently there is considerable spring in the material, and the cup produced is slightly larger than the hole in the die through which it is drawn. The diameter, of course, varies in different cups, depending on the thickness of the case previous to drawing and the reduction made. The enlargement of the cup over the die varies between 0.002 and 0.003 inch from the figures given in Table II, according to the hardness of the metal.

Annealing, Pickling and Washing

For annealing, 110 cups, approximately, are placed in trays, five of which are put in a Rockwell under-fired furnace, burning fuel oil at the rate of seven gallons per hour. The temperature of the furnace is kept at 1250 degrees F. and the cups are allowed to anneal for forty minutes, then removed and cooled in water. The furnace is so arranged that a tray is put in and removed every eight minutes. After cooling, the cups are immersed in a pickling bath composed of one part sulphuric acid to ten parts water. This solution is kept at a temperature of from 100 to 125 degrees F., and the cups are allowed to remain in it for from four to five minutes. They are then removed and immersed in water to remove all traces

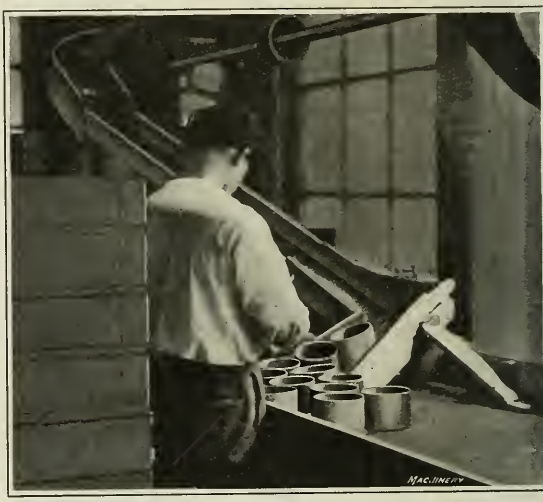

Fig. 11. One Type of Conveyor System used which carries Cases from Press to Machining Department—Inspector stands at End of Chute and gages Each Case as it comes through

of the acid. Before annealing, all lubricant and dirt is removed from the cups by immersing them in a sal-soda solution.

Trimming and Tapering

Trimming of the ragged edge is carried on between the fourth and fifth redrawing operations, after the fifth redrawing operation, and after heading. After heading, the hole for the primer is rough-punched in a punch press and the body is then tapered in a separate die. The tapering is accomplished in a simple die, and one operation finishes the case to the required taper. The following operations consist in machining the head, primer pocket and trimming off the end, after which several final operations, such as tapping and reaming, back-burring, etc., are performed. The case is then inspected, washed, dried, stamped and packed. The production for each operation, as well as the number of operators and helpers required, is given in Table I.

Drawing and Heading Tools

Drawing dies in all cases are made from solid blanks of class "C" Colonial steel which has a carbon content of 0.90 to 1.05 per cent. The blanks, after being machined to the desired shape, are hardened in a strong brine solution—strong enough to float a raw potato. After hardening, the die is allowed to cool off in the bath, then removed and drawn in oil at a temperature of 400 degrees F. to remove the strains. After hardening, the die is lapped out both on the entrance and drawing

faces and is good for producing anywhere from 30,000 to 40,000 cups after each successive hardening. The first cupping die, however, produced in the neighborhood of 50,000 cups before it was worn too large. Each is hardened five successive times, and used for the next larger size, before it is found that the steel develops cracks or other defects which prevent its further use. The punches are made from a similar grade of material and are hardened and drawn in a similar manner.

The heading die ring is made of the same grade of steel, hardened and drawn, whereas the upper and lower heading punches are built up in the form of rings varying from 1⅛ to 1¼ inch in thickness, as shown in Fig. 10. It was found that the enormous pressure—1350 tons—was so great that the resistance of a solid punch was not sufficient to withstand this pressure for any length of time, and it soon upset. The theory advanced was that the steel did not harden completely through, and only a scale of, say, ⅛ inch or more of very hard material would form. This did not offer sufficient resistance to withstand the pressure, and upsetting took place. With a punch of the ring form of construction, it was possible to secure more uniform hardening, and there was less liability of upsetting.

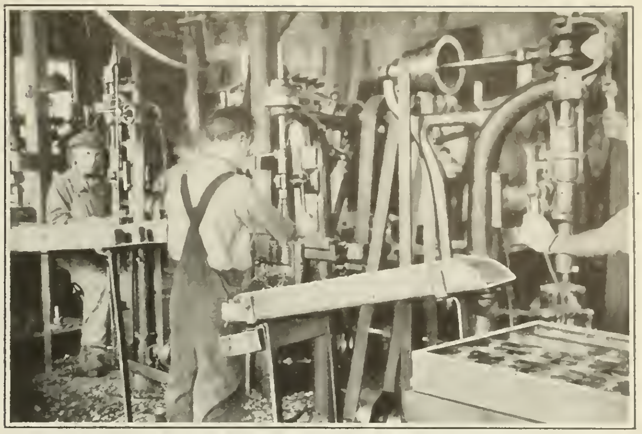

Fig. 13. Final Machining Operations, consisting in finish-reaming, counterboring, tapping, back-burring, etc. Production at Each Operation is at the Rate of 530 per Hour

Fig. 12. Inspecting Thread in Primer Pocket and gaging

Some of these sectional punches made stood up for producing about 1,000,000 cartridge cases and are still in good condition. Class "C" Colonial steel was also used for the heading punches. This had a carbon content varying from 0.95 to 1.05 per cent. After machining, the sections of the punch were heated in a Hoskins electric furnace to a temperature of 1500 degrees F. which required anywhere from 2½ to 3 hours. They were then dipped in a strong brine solution of a consistency such as to float a raw potato and were left in this until cold. They were then removed and put in pure lard oil heated to a temperature of 700 degrees F. After cooling, they were finally drawn until the lard oil would flash when placed on them. This would indicate a temperature of over 400 degrees F. After this, the punch was allowed to cool in the air.

It might be of interest here to note that there is an important difference between the behavior of fixed and mineral oils (fixed means animal or vegetable). Animal or vegetable oils do not evaporate and no vapors are given off, except possibly traces of moisture, on heating them until the oils become decomposed. The vapors then given off are products of the destructive distillation of the oil, which requires a fairly high temperature to bring it about, and consequently the flashing points of fixed oils are high—over 400 degrees F. On the other hand, all mineral or hydro-carbon oils evaporate when heated, and the temperature at which sufficient vapor is given off to cause a flash depends upon what hydro-carbons are contained in the oil. In mineral oils the flashing point varies all the way from 150 to 400 degrees F., and sometimes higher, depending upon the amount of hydro-carbon. It has been found that heading punches hardened and tempered in the manner outlined will turn out from 50,000 to 100,000 cases. They do not wear in this time, but sometimes swell out, which makes them unsuitable for use. One punch has been used for heading over 1,000,000 cases and is still in good condition.

Machining Cartridge Case

Machining of the cartridge case is performed on Warner & Swasey turret lathes and Bullard special cartridge case, facing and trimming machines. The operations performed on the Warner & Swasey No. 4 screw machine, shown in Fig. 14, are as follows: chuck, rough-face, form and chamfer, finish-face, drill, back-face, recess, tap, counterbore, and trim open end with a special trimming tool. The cartridge case runs at a speed of 400 R. P. M., except for the forming, which is done at a slower speed with the back-gears thrown in. The feed for finish-facing is 0.027 inch per revolution of the work, and the production is seventy per hour from each machine.

After these operations have been performed, the primer pocket is then finish-reamed, tapped and counterbored in drill-

Fig. 14. Machining Head and Primer Pocket in a Warner & Swasey No. 4 Hand Screw Machine at the Rate of Seventy per Hour

ing machines, as shown in Fig. 13, in the following order: finish-tap, speed 250 R. P. M., production 530 per hour; finish-ream and counterbore, speed 200 R. P. M., production 530 per hour; back-burr the primer hole, speed 300 R. P. M., production 530 per hour.

For all of these operations the cartridge case is held in a pneumatic chuck. The cartridge case now passes on to the inspectors shown in Fig. 12, where the thread, outside diameter, etc., is gaged. If the threaded hole is found to be small, it is hand tapped. The production is sixty per hour. The case is now washed in soda water and rinsed in hot water, after which it is dried in sawdust and buffed on a buffing wheel. The next operation after the cartridge case comes from the government inspectors is to stamp it on the head in a Noble & Westbrook stamping machine, shown in Fig. 15, at the rate of 1300 per hour. This machine is also provided with a pneumatic adjustable holding device for the work, which facilitates the speed at which the stamping is accomplished. The cartridge case is then put onto a traveling chain and is carried to a point where it is packed and boxed, as shown in Fig. 16. The cartridge cases are packed in boxes holding 100, in a similar manner to that used for packing eggs. The box measures 22 by 26½ by 19 inches.

Methods of Handling Work

As was mentioned in the introductory part of this article, the Worcester Pressed Steel Co. planned to turn out 4000 cartridge cases in twenty-four hours, and eventually turned out 10,000 in this time. One of the chief reasons why such an enormous increase in production was possible was the efficient

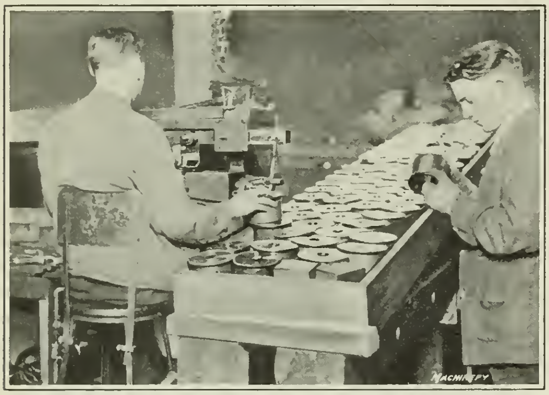

Fig. 15. Stamping Head in Noble & Westbrook Stamping Machine—note Conveyor for bringing Cases from Inspector to Machine

methods used in handling the work. Extensive use was made of conveyor systems, several types of which are used. In some cases only a plain chute is employed, this being the method followed when the operations are performed on machines located at close distances. Where the departments in which the various operations are accomplished are separated by a considerable distance, chain conveyors of various types are brought into use. For instance, the final punch press operation is tapering, and after tapering, the cartridge case is simply put on a conveyor and carried directly to the machining department which is in a remote part of the plant. Before passing on to machining, however, the diameter, length, etc., of the cartridge case is inspected. The inspector, as shown in Fig. 11, stands at the termination of this chute and picks up each case as it passes through, inspecting it at the points mentioned; he then places it in a box ready for passing on to the various machining operations. Owing to the short distances traveled between the first and second machining operations, trucks are used to convey the box of cases to the various machines. After this, the conveyor system is again brought into use for carrying the cases from the government inspectors to the stamping machine, and then from the stamping machine to the packing department.

Inspection and Tests

All cartridge cases receive two final inspections, which consist in looking over the cases to see if they have any defects, as well as gaging them to determine if all the dimensions are correct and up to specifications. These inspections are made both by plant and government inspectors. A number of cartridge cases are selected for what is called a proof test. The requirements are that six out of every twelve hundred are taken for a proof test. This consists in loading the cases three times, and they must be capable of resisting the enormous pressure developed by the smokeless powder after three loadings. One of these six cases is then taken and put through a destructive test. When the government inspectors found that the cases were coming good, it was finally decided that three out of forty-eight hundred, instead of six out of twelve hundred, would be sufficient for this proof test. The weight of the finished case is two pounds, ten ounces, and the blank weighs three pounds, so that only six ounces are removed by trimming and machining. D. T. H.

* * *

LEGAL HOLIDAYS

BY WILLIAM PHILIP*

Have any of the readers ever stopped to consider the field that is opened for discussion under the above title? Has this subject received the thought and consideration which it should have, especially in some sections of the country?

We have been standardizing and organizing and controlling all sort of evils (actual and fancied) of modern industry. It is my opinion that there is room for improvement along the line of legal holidays. There is no system or regulation; there are a few holidays which are celebrated in nearly all sections,

Fig. 16. Packing—note Belt Conveyor for carrying Cartridge Cases from Stamping Machine to Packing Department

but there are quite a number of holidays that are celebrated sectionally or locally, sometimes only affecting a certain town or city. For instance, if a group of men get together and decide that the town, city or state, as the case may be, is in need (?) of another holiday, they get the public officials and executives to appoint committees, declare a legal holiday, and the lid is off.

Here is where some of the dissatisfaction and confusion exists: Some establishments and plants recognize the holiday, others do not; the employes who do not get the holiday are put out about it, and in consequence it fosters ill-feeling, and even if there is no open rebellion, the men do not work up to their usual standard. Those employes who are granted the holiday also have a grievance if they are on an hourly basis; it means there will be a day's pay less the next pay day. The employer, too, has a grievance; if he grants the holiday, it disarranges his routine and production; if he does not grant the holiday, he lays the foundation for dissatisfaction, and in the end it probably would have been better had he granted the day off.

I hope the time will come when we shall celebrate holidays nationally and not in certain sections. If it is felt that more holidays are needed, they should be chosen nationally, not locally; and the closing of manufacturing plants should also be general.

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TREPANNING HEAVY CYLINDRICAL FORGINGS

BY W. R. B.

The operation of trepanning consists of cutting out material from the solid in such a way that the core is left intact, a comparatively small amount of material being formed into chips during the process of trepanning. In making large guns, the cost of material is an important factor, and for this reason the process of trepanning is also frequently resorted to in order to save the inner core. The process was much more prevalent before the invention of large hollow forgings for the A-tubes of large guns, which extend from muzzle to breech and contain the chamber and the rifling. Liners for the recoil cylinders of large gun carriages can also be trepanned at a profit. The first hollow gun forgings were made by the Sir Joseph Whitworth Co., Manchester, England, this company being later absorbed by the Armstrong Mitchell Co., Newcastle-on-Tyne, England.

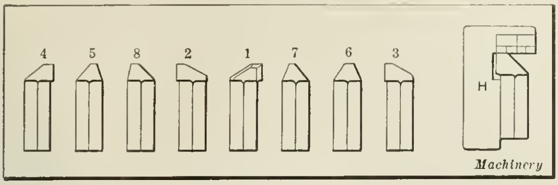


Fig. 1. Tools and Gage used with Bar shown in Fig. 2

The water pressure pipe is held stationary in a bracket at *C*, the outlet end being three or four inches from the face of the forging. The pressure should not be less than 200 pounds per square inch, and an even higher pressure than this will be found advantageous in forcing out the chips along the channels *E* provided in the tool. The tools used in the cutter-head are shown in Fig. 1. A set of tools is made up to each one of the different styles of points shown, and after these are made they are ground to fit the gage *H*.

By referring to the group of tools shown, it will be seen that the cutting points are so arranged as to break the chip to good advantage. This is an extremely important point in connection with work of this kind, as it is necessary to make the chips of such a size that they will be washed out through the grooves provided for them at *E* along the outside of the tool body. The corners *F* are cut away in order to assist this action by leading the chips easily into the grooves. The tools which cut the outside and inside diameters must be watched more closely than the others, as the former are for sizing the burnishers, while the others are to clear the core. The shapes to which the tools are ground depend entirely on the kind of material which is being cut, but the proper shapes are soon learned by any man engaged in trepanning. A piece of rod small enough to go easily up the groove *E* should always be at hand in case the chips need "tickling" to prevent their packing into the grooves when forced out by the lubricant.

The method of holding the bar or cutter-head must be such that the tension can be adjusted so that it will resist the cutting action without slipping, and yet will revolve before a breakage occurs in the event that any particularly hard cutting is encountered. The inserted pieces shown at *D* are made of *lignum vitae* and are used for burnishing the inside of the tube. These burnishers are soaked in oil before use, and the longer they are soaked the better will be their action. They should project from their recesses about 1/16 inch beyond the outside diameters of the cutters. They can be raised for repacking by means of the chamfered portion at the end and can be easily replaced after the repacking has been completed.

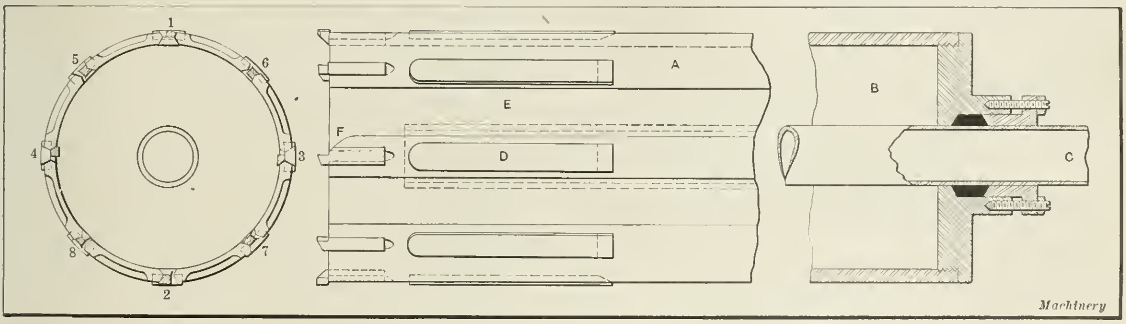


Fig. 2. Trepanning Bar for a Big Gun Tube

Trepanning can be done to advantage in a hollow spindle lathe having carriages to which boring-bars are applied and which are operated from each end of the gun simultaneously. In the course of general manufacturing, many parts are made which can be profitably trepanned, providing the tools are properly arranged, instead of drilling out the stock from the solid. It is essential, however, that a man be perfectly familiar with this kind of work in order to secure the best results, and it is somewhat difficult to find an operator who is an expert on trepanning, as many good machinists have been unsuccessful in handling this kind of work. This may have been partly due to the fact that the operation of trepanning is not by any means a simple or an easy one, and it is necessary at times to put in some good hard work as well as practical experience in order to obtain the desired results. In addition to this, there is always a chance for the operator to get a good "ducking" from the lubricant when at work.

Trepanning Cutter-head and Bar for 10¾-inch Holes

The cutter-head and bar shown in Fig. 2 is designed to trepan a core about 9½ inches diameter and a bore of 10¾ inches. It is obvious that the length of the bar is determined by the work to be done, the one shown being about 30 feet long. The bar is guided by bushings located in brackets on the bed of the lathe and is fed forward by the movement of the carriage.

Important Points in Trepanning

When preparing the cutter-head for its work on a new forging, a ring is first made on the face of the work, each cutter being carefully inspected to see that it is taking the proper amount of chip and doing its share of the work. This is quite important, as the breaking of the chips allows them to be washed out through the grooves along the driving tube. The outer edge of the ring made in testing the tools is jagged with a cold chisel in such a way that the projecting teeth will form cutting edges to turn the burnishers to size.

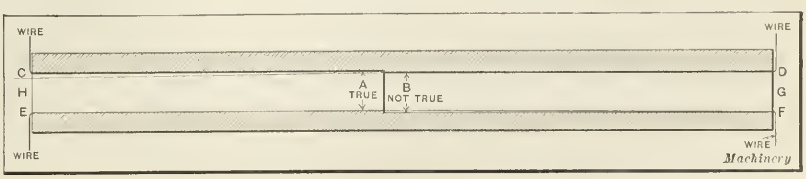


Fig. 3. Method used for testing Alignment of Trepanning Cuts

Fig. 3 shows a section taken through the tube, and the method by which the straightness of the bore can be determined is clearly shown. A fine wire drawn tightly from E to F and striking continuously all along the surface bored from the face marked H will clearly show the interruption at the junction of the two cuts which are machined from each end of the tube. In the same manner the wire when stretched from D to C shows that the bore started from the end G has not run straight. In order to determine these points, the use of an incandescent bulb on the end of a fish-pole or something of a similar nature may be necessary in order to throw the light into such a position that the points of contact and variation in the straightness of the wire can be easily seen by the operator. By determining these points before the boring operation, the centering of the work for subsequent cutting can be more easily accomplished.

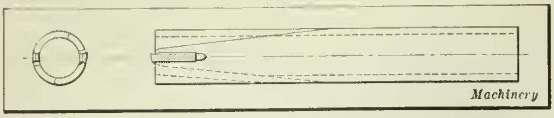


Fig. 4. Construction of Trepanning Bar for Small Work

Small Trepanning Tools

Various kinds of small trepanning tools are used, but there is nothing better for this purpose than a piece of pressed steel tubing with inserted cutters, as shown in Fig. 4. The cutter seats and tools for them are easily made and can be quickly replaced if necessary. It is obvious that the tools should always be thicker than the tube in which they are used. For example, a tube 1/8 inch thick would require tools to be made about 3/16 inch square in order to give sufficient back clearance. Small cutters of similar kind have been made from a solid piece of tool steel, turned and drilled as required and having one cutting edge at the end of a slot which is provided for the chips. This method of making a small trepanning tool is costly, as the tool must always be wider at the cutting point and it must be backed off or have back clearance so that it will not drag, as the life of the tool depends entirely on the cutting point.

The number of cutting points used in any trepanning operation is an important factor, as the cutting action is much better with a number of tools working at once and the chips are smaller and more easily forced out along the grooves provided for them. The number of teeth should always be proportional to the strength of the bar and the slots in which they are held.

* * *

MAKING DRILL JIG BUSHINGS

BY ERIC LEE*

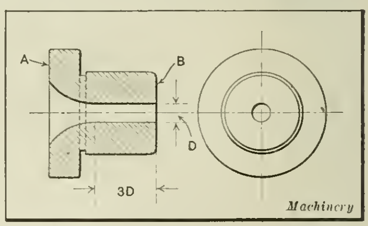
We experienced considerable difficulty in securing drill jig bushings possessing the required durability, and experiments conducted to determine the cause of the trouble showed that both the grade of steel used and the way in which the bushings were made were at fault. Our drill jig bushings were for drills from 1/16 to 5/8 inch in diameter, and the jigs were used for drilling holes in interchangeable gun parts. The form of bushing which we use is shown in the accompanying illustration, and in the following article is outlined the method of making these bushings which we have found to be most satisfactory.

For the purpose of discussion, we will consider the making of a bushing for guiding a 1/8-inch drill. The stock was turned down to a diameter of 3/8 inch for a sufficient distance to allow the stem of the bushing to pass through the wall of the jig and come within 1/16 inch of the work to be drilled. The piece to be drilled is made of steel, and experience has shown that it is advisable to bring the bottom of the bushing as near the work as possible, in order that the drill may have exactly the proper location and insure interchangeability of parts. If the work to be drilled had been made of cast iron, the bushing would have been made shorter in order to allow more space between the bottom of the bushing and the work for the clearance of chips.

In making bushings, when drilling a hole to finish to a diameter of 1/8 inch, a No. 31 drill is used. After drilling the hole, we use a flat taper reamer to form the bell mouth; and finally a rose reamer is employed, which is made out of a piece of 0.127 inch drill rod turned down to a diameter of 0.1235 inch, which leaves about 0.0015 inch on the side of the hole for lapping. It is important that the hole be reamed as smooth as possible in order to cut down frictional resistance between the drill and bushing to a minimum. The next step is to harden the bushing glass-hard and then test it with a plug gage. After the size of the hole has been ascertained in this way, the bushing is put into the chuck of a speed lathe and lapped from the bell-mouthed end A with a split copper lap charged with emery of about 120 grade. The inside end B of the bushing should be kept as straight as possible, as the formation of a bell mouth at this end will result in danger of a corresponding inaccuracy in the location of the drill. It is a difficult matter to lap a bushing and prevent both ends from being bell-mouthed, but if the lapping is done from the bell-mouthed end, the other end can be kept much straighter than if the lapping is done from both ends.

Experiments conducted to determine the best ratio between the diameter D of the hole and the length of the straight portion of the bushing hole showed that the most satisfactory balance between support for the drill and reduction of frictional resistance between the drill and bushing was obtained when the length of the straight part of the hole was made three times the diameter D. It is of interest to note that where there is a considerable amount of metal to be lapped out of the bushing, the best results will be obtained by running the lathe quite slowly, because the abrasive will cut more rapidly on a low than on a high speed. If the bushing hole is of nearly the desired size, the lathe is run at high speed—and the same applies when the hole has been lapped to approximately the required size—because under such conditions the abrasive tends to polish the metal rather than cut it, and so leaves a fine smooth surface on the inside of the bushing.

The hole in the jig in which the bushing is located should have a smooth surface before the bushing is pressed into place. It is the practice in many factories engaged in the manufacture of interchangeable parts to require drills to be a tight fit in their respective bushings; in fact, some shops will reject a bushing if the drill can be inserted by hand without the use of pliers. This practice is entirely wrong. If a drill is a snug fit, that is quite sufficient, and if the size of the bushing is such that it requires the use of a pair of pliers to push the drill into place, it is evident that either the drill or bushing will be under considerable strain while in operation, which, of course, should be avoided.



Approved Design for Drill Jig Bushing

As the bushing is considerably harder than the drill, it is reasonable to conclude that the drill is compressed, with the result that the holes are drilled under size until the bushing has been worn sufficiently to allow the drill to run under normal conditions. If the hole in the bushing is made of a size to afford just a snug fit between the drill and the bushing, the chips will free themselves more rapidly and the bushings will last much longer. As extreme accuracy is required in the drilling of interchangeable parts, it is important to provide for the replacement of drill jig bushings in the shortest possible time in order to avoid unnecessary delay in the process of manufacture. This point can be satisfactorily taken care of by keeping a supply of various sizes of bushings which can be substituted in the drill jigs as the necessity arises.

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GRINDING WHEEL SPEEDS

BY H. W. DUNBAR*

There is a popular notion that the greater number of revolutions the grinding wheel can make the greater will be the production. This is a mistaken idea when applied to machine grinding, although in hand grinding—where the act of the operator must be taken into consideration—it is usually true that the greater the speed of the wheel is, within the recommended limits, the greater will be the production. But if the wheel were stronger or harder and run at a slower speed, the operator would produce the same amount of work if he were to use greater pressure. The speed of the grinding wheel must be always relative to its own strength of particles and bonds, the size of its grain, the kind of material being ground, and the amount of force exerted by the operator when hand grinding, or depth of cut or amount of work done when machine grinding. In cylindrical and surface grinding the speed of the work and work-table are the limiting factors controlling the amount of work that can be done per minute, whatever the wheel and whatever the speed of it. So that within the range of grades in wheels that is known today, and the range of speeds of table and work on the machine, and the variety of materials being ground, we can vary the speed of the wheel within very wide limits and still accomplish the same amount of work.

To illustrate: a speed of 6000 surface feet per minute is commonly used on wheels for cylindrical grinding machines, but on a very successful surface grinding machine 4000 surface feet per minute removes an equal amount of material in the same time as that removed on the cylindrical grinding machine, in many cases, with the wheel revolving at 6000 feet per minute. In the case of surface grinding, where the arc of contact is so much greater than in cylindrical grinding, it becomes necessary to use a softer wheel and to adopt a slower speed in order to prevent the wheel from burning. In one case it has been found practical to use as low a surface speed as 2000 feet per minute. While it is not physically possible, if we could obtain the grains of grinding material and a bond of sufficient strength, it would not be necessary to revolve the wheel at all. The work could be forced against the grains which would act just as a planer tool does so that the material would be removed. But inasmuch as it is not physically possible to have this strength of particles and bonds, the wheel must revolve in order to distribute the work over many particles in the same time. Hence, the softer or weaker the wheel, the faster it must revolve if it is not to be worn away too rapidly; and conversely, the harder and stronger the wheel, the slower it may revolve and not be worn away too rapidly.

If it were mechanically practical to traverse the reciprocating table of a surface grinding machine 100 to 200 feet per minute, the grinding wheel that is now used at 4000 feet per minute would do more work in the same time if it revolved at 8000 or 9000 feet per minute. But it is neither mechanically possible to traverse the table at such a speed nor physically possible for such a wheel to be revolved at that speed with safety. Different kinds of material being ground cause the wheel to do more or less work, and accordingly affect either the speed of the work or wheel, or the grain and grade of the wheel. It is immaterial what the grain and the grade of the wheel is—within reason—as the speed will always regulate the amount of production or compensate for the variation in grade and grain. Different wheels will grind different materials by using different wheel speeds, but the speed of the wheel must always be relative to its own grade and grain, the kind of material being ground, and the amount of work being done; which brings us back to the same point from which we started, as the whole question is only a relative one and the wheel speed is only important as it relates to the physical possibilities of the wheel and the amount of work that it can accomplish. Do not get the idea that any wheel you may have may be revolved successfully at any speed, at any time, with any work. Speed must be relative to the other factors. But there is no fixed speed for wheels simply because they are grinding wheels.

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MACHINING AN AUTOMATIC SPRINKLER HEAD

The following method is suggested in response to an inquiry for a method of machining the automatic sprinkler head *A* shown in the accompanying illustrations. The inquiry states that the use of an automatic machine is not to be considered, and therefore the method of handling shown in Figs. 1 and 2 is applied to a hand screw machine.

First Setting

Operation 1.—The work shown at *A* in Fig. 1 is made of brass, and it is to be held for the first setting in a two-jawed chuck having special jaws *B* which are grooved to receive the arms on each side of the casting, thus centering the work and providing a fixed longitudinal location. The first opera-

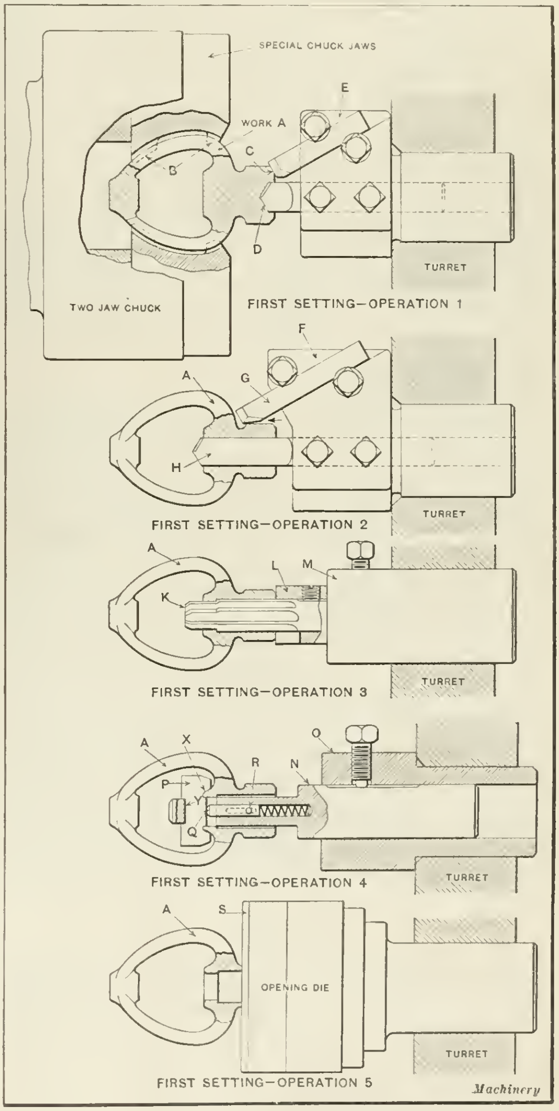

Fig. 1. Operations in First Setting of Sprinkler Head

tion, as shown in the upper illustration in Fig. 1, consists of spotting the ends of the work with a spotting drill of the flat type, as shown at *D*, and at the same time chamfering the end of the piece in preparation for the turning operation, by means of the tool *C* inserted in the holder *E*. A holder of this kind can be easily made with a shank of suitable size to fit the turret hole.

Operation 2.—This operation consists in drilling the hole previously spotted with a flat drill *H*, at the same time turning

the outside diameter with a tool G held in the holder F. This holder is similar to that used in the first operation.

Operation 3.—In this operation the reamer K is used to finish the two inside diameters, and the face mill L cleans up the ends of the casting. The mills and reamers are held in a toolholder M located in the turret.

Operation 4.—This operation consists of back-facing the inner surface, using a special tool provided with an inserted-blade cutter P, having the required form X. This tool is inserted in the holder N and is so fitted that it can be located by the shoulder at Y. It is held in place by the spring plunger Q which is restrained in its movement by the pin R working in the slot shown. It is advisable to cut away one side of the chuck a trifle in order to enable the operator to put his fingers in and manipulate the cutter blade P. In operating this back-facing tool, the workman first brings the turret forward to a point which permits the insertion of the blade; after this, he carries the turret back until it has reached a predetermined point, thus producing the contour shown at X.

Operation 5.—The final operation on this piece is the cutting of the thread on the end of the piece by means of the opening die shown at S. The opening die can be set in such a way that it will open at the correct position so that the thread will be cut to the desired length. The thread may also be cut by means of the regular die held in a releasing die-holder, and satisfactory results can be produced by this method, although it requires a reversal of the spindle to back the die off the work. This completes the series of operations for the first setting of the work.

Second Setting

The method of holding the work for the second setting and the sequence of operations with the necessary tools are shown in Fig. 2. Referring to the upper illustration, the method of holding is by means of a special arbor on which the work A is placed. The arbor is keyed at D in the special nose-piece B, and is drawn back into position by the nut and washer E. The shoulder C on the arbor acts as a stop for the finished end of the work, and the nose-piece is provided with driving arms H, in which set-screws G are so placed as to contact against the flatted portion of the work. These set-screws can be provided with check-nuts and set up so as to just come against the rough casting and act as drivers, also, to a certain extent, preventing vibration in the work. The work is held in place by means of a nut and a C-washer F.

Operation 1.—The first operation consists in spotting the ends of the piece preparatory to drilling, using the flat drill L, held in the regular type of holder K.

Operation 2.—This operation consists in drilling the tapped hole with the flat drill M, which is held in a holder like that in the previous operation. The facing of the ends of the work is done by a tool Q on the cross-slide of the machine. This may be operated simultaneously with the flat drill by turning the drill in such a position that the tool can pass the inner edge of the work without interference.

Operation 3.—This operation is simply tapping out the previously drilled hole with a tap O held in the releasing tap-holder shown in the illustration Fig. 2.

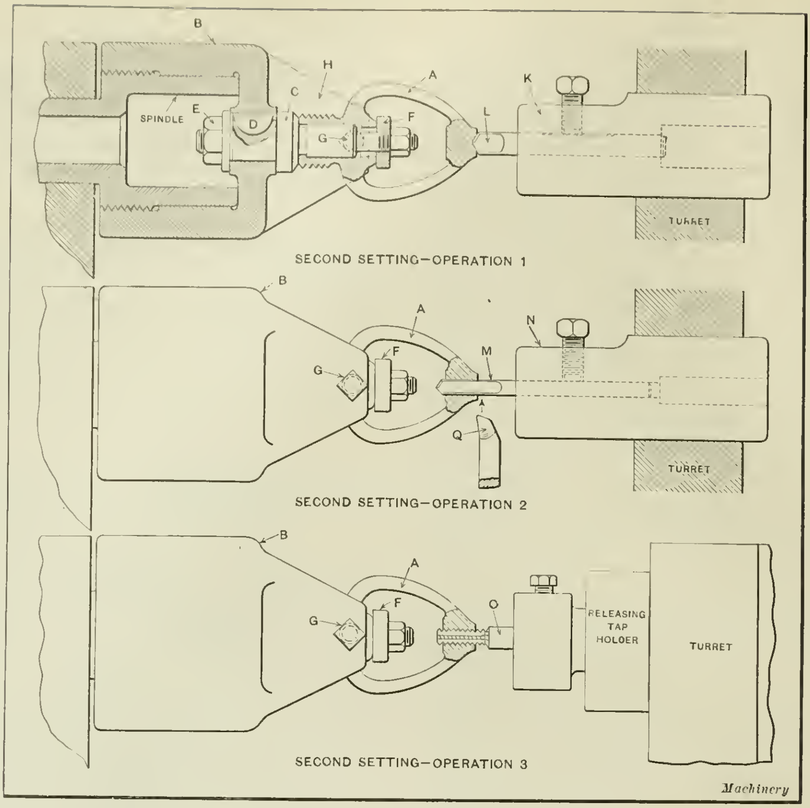

Fig. 2. Operations in Second Setting of Sprinkler Head

The tools shown in the series of operations described are simple in design and can be manufactured or adapted from other tools of similar kind with comparatively little work. The fixtures are not difficult to make, and the only operation requiring any special care is the back-facing operation shown in Fig. 1. The production for the first setting should be about 75 pieces per hour, assuming that a cutting speed of 150 to 200 feet per minute can be used. The second setting can be done at the rate of 140 pieces per hour, assuming a cutting speed of 150 feet per minute. Much depends upon the skill of the operator in the matter of production when a hand screw machine is used, and a capable man may easily secure an output considerably greater than that mentioned after he has worked on the job for a sufficient length of time to become thoroughly proficient in making the various settings needed on this work.

A. A. D.

* * *

LEARNING THE MACHINISTS' TRADE IN SIX EASY LESSONS!

Once in a while there is something of interest to be learned from a visit to a second-hand machinery dealer. Not long ago I happened into the office of a Connecticut machinery dealer and asked the customary question:

"What's new?"

"Have you heard about our new machinists' school that is turning out machinists for $25?" asked the machinery man.

"I should say not; tell me about it."

"There is an enterprising Italian over on the east side who realizes the dearth of machinists and is making a little money out of it. He advertised to teach the machinists' trade in six lessons of four hours apiece for the nominal sum of $25, payable in advance. He had no trouble in getting a class of twenty men together, and with the advance tuition fees bought three cheap lathes, a shaper and a drill press, and they are well under way now. Don't ask me what kind of machinists those chaps will be after their six easy lessons. Some of them may be able to put a piece on centers and take a roughing cut, but I don't believe any of the first-class machinists of the city need worry about their jobs being taken away by the products of this school."

C. L. L.

NOTES ON THE MACHINERY INDUSTRY IN GREAT BRITAIN

IMPORTATION OF MACHINE TOOLS—GENERAL INDUSTRIAL CONDITIONS—TRADE STATISTICS—WAGES

BY ALEXANDER LUCHARS*

ENGLAND presents much the same appearance as before the war. There are more women in the fields, running "lifts," as conductors of 'buses and in many other occupations formerly monopolized by men; fewer civilians to be seen, and soldiers, soldiers everywhere—all in khaki instead of the brilliant colors we used to see. The restrictions on "alien friends" are few and entirely reasonable. Within certain necessary limits they enjoy almost as much liberty as before the war—which is saying a great deal.

There appear to be no restrictions in regard to the sale or consumption of food. The cost of living has increased from 25 to 30 per cent, but the advance is confined principally to such commodities as have advanced almost as much with us.

The restrictions on imports of every kind—but especially machine tools and supplies—are very stringent; but this is grim war, on which depends the nation's existence. The agent of a well-known American concern recently obtained an order for six machines. He was allowed to send an order home for one only, and when that one arrived he was not allowed to deliver it to his customer, but to an entirely different plant where it was needed on government work. No complaint was made of this; it was related simply as a necessity of war conditions. Another equally well-known American concern, making machines urgently required in the manufacture of shells and similar material, had completed a large, up-to-date factory soon after the war broke out. The government took it—and, of course, paid for it—but the American owners are probably still thinking of the profits they might have made. All the machine tool manufacturers are "controlled" by the Machine Tool Committee of the Ministry of Munitions, which directs how their plants shall be employed and where their output shall go. This committee is comprised of well-known machinery manufacturers and merchants, all of whom give their entire time, and in some cases that of their executives, without any compensation, to the service of their country.

Immense factories continue to be erected for the manufacture of munitions, and this enormous output requires more machine tools, probably to replace those worn out; which accounts for the fact that many of the principal manufacturers in that line are still turning them out instead of making munitions.

Controlled concerns are those whose product is entirely disposed of by the government, and they are not allowed to sell or deliver any portion of it except under government direction. They are permitted first to retain their average annual profit, covering a period of two years previous to the war; but on all excess profits the government takes 80 per cent, leaving 20 per cent for the manufacturer. Other limited liability companies, which include virtually all the manufacturing concerns except the very smallest, pay to the government 60 per cent of their profits in excess of 6 per cent on their capital, or an equivalent in another form which virtually amounts to the same rate, the government taking the position that no one should expect to make more profit in time of war than is allowed by the above provisions. In addition to the percentages deducted by the government, a war income tax of 25 per cent is levied on all profits of every kind.

There were, on July 4, 3916 controlled concerns in the machinery, iron, steel, and other metal industries. How many uncontrolled small manufacturers are working for the controlled firms no one knows. One manufacturer who had eight others working for him said there were 3000 such small concerns; but that figure seems excessive, as there are only about 9000 manufacturers in metal, large and small, in the United Kingdom.

As stated above, many machine tool builders are not working on shells or gun work, but are turning out their regular line of machine tools, for which there seems to be a constant and increasing demand from the government. Many, but not all, of the machine tools employed in manufacturing munitions are subject to very severe use. One lot of 150 or more American metal-cutting machines which have been running for twelve months or more, I was told, had not yet become acquainted with a lubricant of any kind.

It is not allowed to finish the rough parts of machine tools. They are all painted a sort of chocolate color without filling or finishing. One concern I visited affixes a plate to each tool now turned out, stating that it was finished in accordance with government requirements, so that they may not suffer from future comparison with highly finished tools.

Manufacturers whom one would not think of as making war material are busy on what may be called indirect war products. One machinery manufacturer received an order from a maker of string and fish net, and doubted if permission would be given him to fill it; but on application to the Ministry of Munitions was told to rush the order through, as the machine was needed immediately—the use was not stated. When one considers the number and variety of industries producing war material of one kind or another, including coal, iron and gold mines, textile mills, chemical works and distilleries now making explosives, clothing, and the great variety of material required by the armies, the figures given in the following tables showing the comparative amounts manufactured during peace and war years, including those furnished by the Allies, do not seem excessive:

	Annual Average in Peace Years	Total Aug., 1914, to March 31, 1916
Cloth, woolen, worsted, yds	1,149,000	117,000,000
Flannel, yds	1,234,000	84,000,000
Cloth, cotton, yds	632,000	194,000,000
Boots, pairs	227,000	21,750,000
Jacket, service dress	78,000	11,490,000
Trousers	92,000	11,004,000
Frocks, khaki drill	58,000	1,134,000
Trousers, khaki drill	73,000	1,167,000
Pantaloons	13,000	2,507,000
Greatcoats	34,000	4,836,000
Caps, service dress	222,000	11,088,000
Socks, pairs	980,000	54,684,000
Cardigans and jerseys	77,000	7,555,000
Drawers, woolen and cotton	194,000	23,144,000
Vests	......	8,855,000

Great Britain is at present one vast workshop turning out war material. Although civilians continue to wear clothing and to consume or use material of various kinds, industries that are not connected directly or indirectly with the production of war material are inactive, and they may well be, because there are very few workmen to keep the wheels moving.

Considerable business is being done in "caterpillar" tractors, a development of the American farm tractor, but many times heavier, for use in dragging heavy guns to the front—and sometimes the other way. Our manufacturers might have had more of this business. An order has just been issued suspending the imports of American motor trucks, as these are now being turned out in sufficient quantities by British makers. Even the import of parts necessary for repairs of these vehicles is prohibited. Very few automobiles are being made in Great Britain, and the prices of these are naturally very much higher than before the war—the Rolls-Royce, a high-class car, sells for £1250. But for the restrictions on all kinds of imports and on the use of petrol (gasoline) our automobile manufacturers would have an unusually large and profitable field there at present.

According to the official figures furnished me on July 19, there were 2,468,000 women employed in various factories in the United Kingdom, of whom 265,000 were employed in the metal industries. The total number of men employed in the metal industries on the same date was 1,978,000.

The percentage of women employed in machine shops varies from five to ninety, the smaller percentage being on heavier work. In several shops turning out high-grade work the

* Publisher of MACHINERY.

average is ten per cent. On light munition work, such as fuses, nearly all the employes are women. It is really astonishing what heavy work women can handle. All these are earning wages which they never dreamed of before, and when the war ends and munition work is no longer required except in government arsenals, the return to conditions that existed before the war will involve an industrial revolution.

The war situation calls for various adjustments, some of which are not made without considerable difficulty. Controlled firms are permitted to build additions and extensions to their factories and to retain from their excess profits the difference between the former cost and present cost of building (which is nearly double what it was before the war). Among the advances in costs I noted that the wood for packing-cases has increased 600 per cent.

The labor situation in Great Britain has developed in a peculiar way since the beginning of the war. When it became necessary to speed up the production of munitions, an agreement was made between the leaders of the various parties in the House of Commons that the profits of manufacturers on munition production should be limited as before stated, and that the wages of the men should not be advanced beyond the prevailing rate either for day work or piece work. To insure a permanent supply of labor, the workmen are required to obtain a "leaving card" before leaving their employers, without which no one else can employ them. These agreements were enacted into law. But the demand for labor on munitions became so urgent that thousands of unskilled, non-union workmen and women were taken into the munition factories, and as they became proficient they were able to produce piece work in much less than the liberal time allowance provided by the unions, and as their efficiency further increased, they earned wages far in excess of the skilled men, who were generally employed on special work, such as toolmaking, etc. So it frequently happens that an unskilled hand, after he has six to twelve months' experience in the shop, may be earning twice what the skilled toolmaker is who furnishes him with his tools and sets them up.

The following tables give basic rates of wages before the war and at present, but under the bonus and premium system mentioned hereafter, actual earnings are very much greater today:

BIRMINGHAM AND DISTRICT RATE, PER WEEK OF 53 HOURS

	Pre-War £	s.	d.	Present Time £	s.	d.
Turners	2	0	0	2	3	0
Fitters	2	0	0	2	3	0
Drillers	1	14	0	1	17	0
Planers	2	0	0	2	3	0
Patternmakers	2	2	0	2	5	0
Smiths	2	0	0	2	3	0
Toolmakers	2	0	0	2	3	0

SCOTLAND—CLYDE DISTRICT, PER HOUR

	Pre-War d.	Present Time d.
Turners	8½	9½ to 10
Planers	8½	9.33 to 10
Machine Drillers (rate varies)	6 to 8½	7 to 9½
Fitters	8½	9½ to 10
Smiths	8¾ to 9¼	9¾ to 10¼
Toolmakers	8½ to 9	9½ to 10
Patternmakers	9	10

A large proportion of all workmen are employed on the bonus and premium system, under which, with overtime, some men make as much as 70s. per week. The most skillful piece hands are making from £5 a week up. An extreme case was mentioned of a boy about seventeen years old in the Birmingham district who made £7 a week, but for how many weeks was not stated. Many exaggerated statements are made about wages women earn.

The government order applying to controlled firms engaged in the production of arms, ammunition, ordnance, and in all branches of mechanical engineering and shipbuilding, specifies that the new rates for women shall be: 18 years and over, 4½d. an hour; 17 and under 18, 4d.; 16 and under 17, 3½d.; under 16, 3d. Women and girl workers in danger zones are to be paid ½d. an hour in addition to these rates. Allowances for processes which are dangerous or are injurious to health will be decided on the merits of the case. The same proportionate increase for overtime, premiums and bonuses applies to women as to men.

Numbers of outside manufacturers have gone into the machine tool line—one large "boot" making concern having produced a lot of grinding machines, and, of course, many more have gone into the manufacture of lathes; but this condition will be only transitory. These concerns realize that they are not equipped to turn out machine tools and cannot do so profitably against the competition of manufacturers who have been in the business for years and have established reputations. Moreover, their articles of incorporation do not allow them to manufacture anything except what is specified therein. The manufacture of machine tools by outside concerns has been limited to such machines as the greatest demand existed for, and of the more simple construction. Milling machines, automatics, turret lathes and other machines in which difficulties of manufacture are considerable, have therefore not been taken up. There are at present no manufacturers of automatics and similar high-class machines, and only one established manufacturer of grinding machines.

I believe that the demand for high-grade American tools will continue after the war, but the cheaper lines made by American manufacturers of little reputation, some of whom have lost that little by their treatment of buyers here, will be eliminated.

* * *

SHELBY SEAMLESS STEEL TUBING FOR BORING-BARS

It may not be generally known that seamless steel tubing can be used to good advantage for turret lathe boring-bars. The T. L. Harkins Machine Co., Boston, Mass., recently had a large order of boring-bars in which seamless steel tubing was employed with satisfactory results. Fig. 1 shows the tubing used. The bar is 40 inches long, and it was required to be 2⅛ inches outside diameter and have a ¾-inch hole

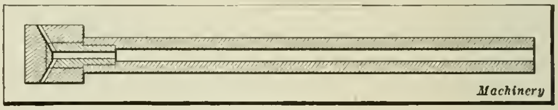

Fig. 1. Construction of Boring-bar to be made

through the center to transmit lubricant to the cutting point. The end of the tube was bored out to receive a plug that carried the tool head.

It is apparent that to machine this bar from solid stock, and especially to drill the ¾-inch hole through the entire length, would be a slow and difficult job. Shelby steel tubing was used for these bars, selecting a size with a ¾-inch hole and ¾-inch walls. Fig. 2 shows the turning of these boring-bars; it indicates extreme toughness of the material, and yet the chips show that the metal cuts freely.

By using seamless steel tubing for these bars, time was saved as compared with machining from solid stock, and a stronger, tougher boring-bar was obtained. C. L. L.

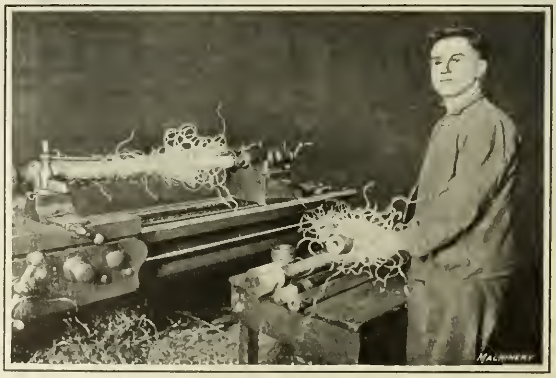

Fig. 2. Turning Tubing—note Stringy Chips

WORK-HOLDING FIXTURES FOR INTERNAL GRINDING

CHUCKS AND OTHER HOLDING DEVICES DEVELOPED BY THE HEALD MACHINE CO.

Many interesting devices have been developed for holding work for internal grinding, especially for holding gears and bushings. In the February number of Machinery several devices for holding gears and other classes of work were illustrated and described. In the following some additional chucks and devices developed by the Heald Machine Co., Worcester, Mass., will be reviewed.

Combination Collet and Adjustable Jaw Chuck

Fig. 1 shows a special chuck developed by the Heald Machine Co. for holding bushings, disks, gears, or similar work, which has a capacity ranging from 5/8 to 8 1/4 inches in diameter. The gripping of the work is accomplished by means of jaws *A* which are fastened by fillister-head screws to the three operating segments *B* of the collet chuck. The collet chuck is operated by a handwheel *C* attached to a tube that passes completely through the spindle of the machine and screws into the rear end of the collet. This operating mechanism is provided with a ball thrust bearing. In using this chuck, the jaws are adjusted to approximately the correct diameter and are then ground to run true. They are so designed that they can be reversed for holding smaller sizes of work down to 5/8 inch diameter. This chuck, on account of having the main collet made out of a single piece of alloy steel, will retain its accuracy longer than any chuck with which the manufacturers have had experience heretofore, while at the same time it has the ability to handle an extremely wide range of work.

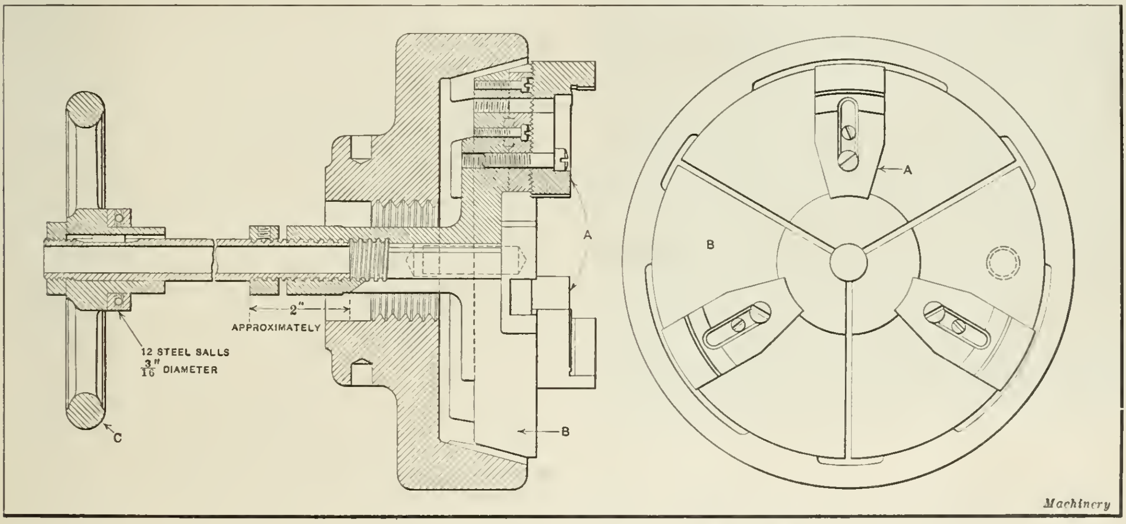

Fig. 1. Combination Collet and Adjustable Jaw Chuck for holding Bushings, Gears, etc.

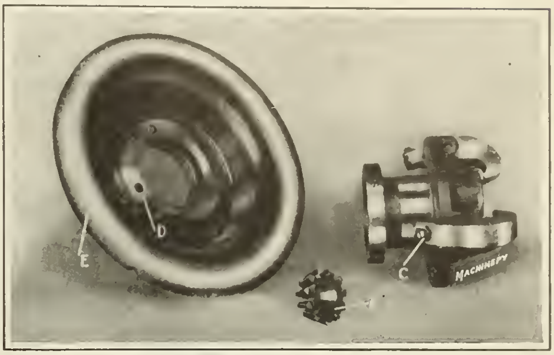

Fig. 3. Bevel Pinion Chuck shown in Fig. 2, dismantled to show Construction

Chuck for Holding Bevel Pinions

Figs. 2 and 3 illustrate an interesting chuck which is used for holding small bevel pinions. This chuck was designed by one of the largest automobile manufacturers in the country and uses three tapered rolls to true up the pinion, working from the pitch line. By referring to Fig. 3, which shows the fixture dismantled, a good idea can be obtained of its design and construction. The pinion, which is shown at *A*, is held in the chuck by means of three fingers that are provided with adjustable screws *C*, bearing on the three locking cams *D*. These three cams are mounted on a heavy handwheel *E*. This handwheel was made in these proportions with the idea that the starting and stopping of the work to a certain extent automatically clamped and released the work. The inertia of the wheel when starting tends to clamp the work tighter, and the tendency of the wheel to keep on turning when the work-spindle is stopped is likely to loosen the chuck, so that in actual operation the designer figured that the operator would be required to make almost no effort to clamp or release the work in the chuck. The most objectionable detail in regard to the construction is the amount the jaws project beyond the face of the work. With this particular pinion, having a short hole, it is not a serious matter,

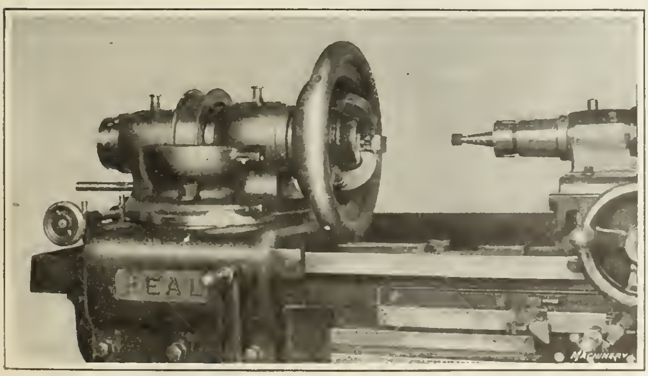

Fig. 2. Interesting Chuck for holding Small Bevel Pinions

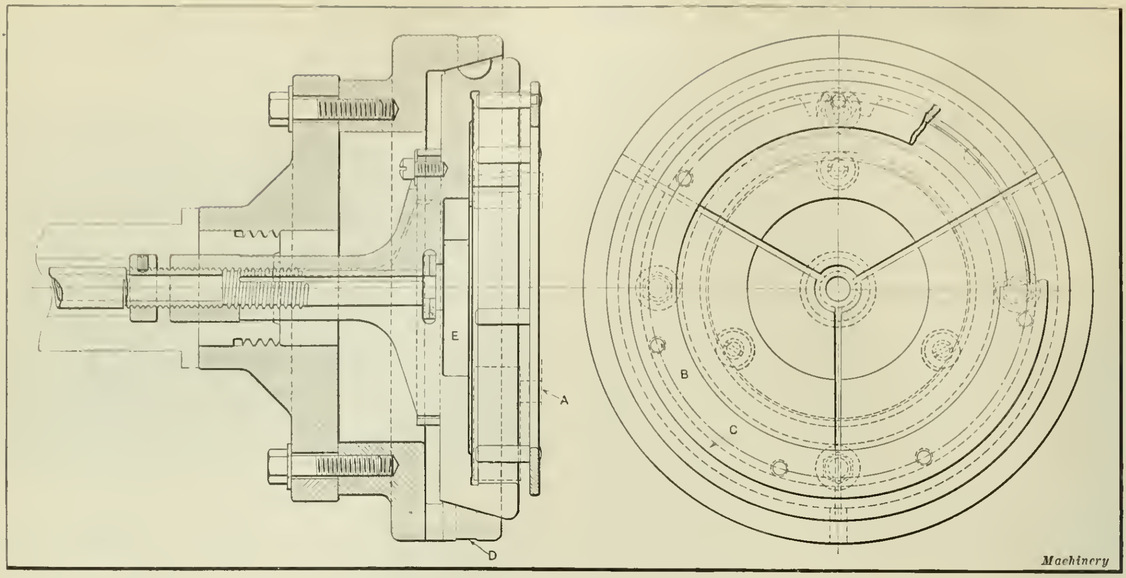

Fig. 4. Special Collet Chuck for holding Spur Gears

but it would take up valuable room and make it necessary to provide an unusually long grinding spindle if the work should happen to be of such a form that a relatively long hole was to be finished; this would necessitate using an extra long spindle to make up for the amount of space lost in this way.

Special Collet for Holding Spur Gears

In Figs. 4 and 5 is shown a special collet for holding spur gears. By referring to Fig. 4, it will be noticed that the gear *A* to be ground is held by seven pins or rolls *B*, bearing on the pitch circle of the teeth and carried in a retainer ring *C*, as illustrated. In fitting up the chuck, the opening in the collet is finished true by grinding, and then the outside is trued up by grinding at the point *D*. In operation, the gear, together with the rolls and retainer ring, are inserted in the opening in the chuck and the jaws closed sufficiently to hold the gear for grinding, which requires but a very light grip. This method of using rolls between the teeth gives pitch line control which seems to give in every case the best average setting for any gear to give smooth running qualities. If for any reason the chuck has to be removed from the machine and later replaced, its accuracy can be tested instantly by putting an indicator on the surface *D;* and if for any reason the collet has shifted so that it does not run true, it can be made to run true by loosening the large bolts in the rear and shifting it slightly on the faceplate until a true running position is obtained. The collet has a felt washer at *E* to prevent grinding dust from getting into the threaded portion where the collet is drawn in. The collet is closed and opened by a rod passing through the spindle of the machine and operated by a handwheel at the rear, similar to the arrangement shown in Fig. 1. This chuck can be provided with collets of various shapes for holding gears of various sizes, the collet for a smaller gear being shown at *A* in Fig. 5. D. T. H.

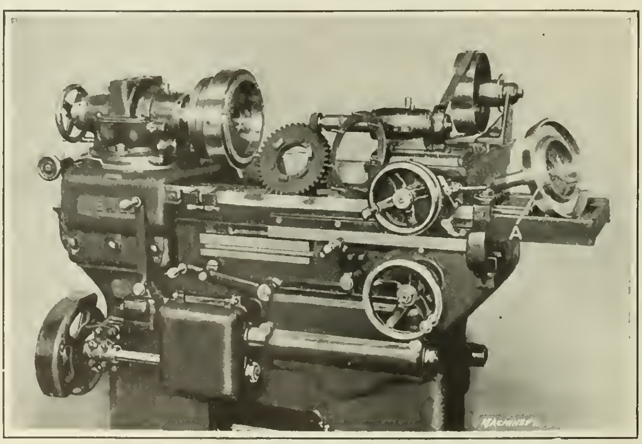

Fig. 5. Special Collet Chuck shown in Fig. 4 in Use on Heald Internal Grinding Machine

INCREASE IN COPPER OUTPUT

There has been a steady increase in the rate of copper output since early in 1915. The production during the latter half of 1915 considerably exceeded that of the first half according to a report of the United States Geological Survey. During the year the refineries produced from both domestic and foreign ores a total of 1,634,000,000 pounds of blister copper, of which 1,388,952,700 pounds was produced from ores mined in the United States. The average price for the copper has been higher than at any time in recent years, the average for the first six months of 1916 being more than twenty-six cents a pound. The cost has doubtless increased slightly, as the important copper companies have increased the wages of employes. Many small mines are operated that could not be profitably worked under normal conditions, and this, of course, tends to increase the average cost per pound.

* * *

Wooden roof trusses of unusual dimensions are being built in Europe according to a patented method known as "System Stephan." The wood is impregnated with a fireproofing impregnation; the roof construction is much lighter than one made from steel, and spans up to 200 feet have been constructed without any intermediate supports. The advantages claimed for this system of roof construction are that the covered area, being free from pillars and supports, can be used to better advantage, the illumination of the covered area can be arranged more advantageously, the impregnated wood is more fireproof than steel, and is not affected by dampness, acids, or acid gases, and, in addition, the construction is cheaper, and can be erected in a shorter time and with less elaborate hoisting apparatus than a steel construction. Up to the present time factory buildings, railway stations, and similar structures with a total floor area of 200 acres have been covered by these wooden roof trusses in northern Europe.

BETTER APPRENTICES

BY E. W. WRIGLEY*

Lately the scarcity of good mechanics has been causing considerable embarrassment to shop managers, and many ways have been devised to overcome it, but not enough attention has been given to the real cause of the trouble, namely, the failure of the managers themselves to keep up the supply by properly training apprentices. A first-class mechanic cannot be produced in a few months; it takes years, and the only way to keep up the number is to keep training the boys.

The increasing tendency toward specialization in modern shop practice has done much to cause managers to slight this department of their works. As long as mechanics were available, and especially if business were at all dull, they drifted along and gave scant attention to the boys supposed to be learning the trade. Now business is better and mechanics are at a premium—in some places they cannot be obtained at all—and business is suffering as a consequence.

The opportunities in the mechanical trades for an intelligent and properly trained man are as great as in any other line of work and greater than in many. The more education along general lines that he has had, the more easily he will be able to see and benefit by these opportunities. This fact seems to have escaped a great many, and it is quite rare these days to hear of a boy who has had a high school education starting in to learn the machinist trade. The majority of apprentices are boys who leave school as soon as the state laws permit, and if they ever reach the stage where they can calculate the thread cutting gears of a lathe, they have attained the height of their ambition.

The only remedy seems to be to start now what should have been started some time ago, and give more time and consideration to this branch of the industry. A few firms have a carefully worked out system of training their apprentices and find it profitable, but the majority give very little attention either to what is taught or to the class of boys that are hired. The boys are turned loose and drift around the shop in a haphazard way for the required four years, and if they turn out to be mechanics, it is because of a natural aptitude for the work and not because any attempt has been made to teach them. The result is that the apprentice system has fallen, to a certain extent, into disrepute among boys who are starting out to prepare themselves to earn a living. They are told that it is impossible to learn a trade thoroughly as an apprentice, and the better class seek an opportunity in some other line. This will have to be corrected if it is desired to keep up the supply of good mechanics.

This training of young mechanics need not necessarily be confined to the large manufacturing plants, but can be carried out in the smaller places as well. In fact, if conditions are as they should be, a small shop doing a general business is one of the best places for a boy to learn a trade. Here the right kind of boy will form acquaintances that will prove very valuable to him. As soon as the men understand that the management is making a serious attempt to get a better grade of apprentices and really intends to teach them something, they will do their share, not only in getting better boys to start, but also in helping them after they are started. Every mechanic who is any good has pride in his trade and thinks that it is just a little better than any other, and that he has to know a little more to hold his job than the other fellow. When he has been shown that a boy by starting as an apprentice will really be taught the trade, he will soon be inducing the desirable boy to start.

The writer well remembers when he started his apprenticeship. Being just from high school, he was older and larger than the other boys starting at the same time, and naturally was made the butt of some good-natured chaff. But it was not long before the older men saw that he really wanted to learn, and because of having been to school longer, could more easily grasp the things told him. After that it was much easier, for although there was little systematic training of apprentices in this shop, as in most shops at that time, he was taken in hand by some of the older men and taught the ins and outs of the work about as fast as he could learn them. At the end of his apprenticeship he was frankly told by the foreman that he could do better by leaving and seeking employment in some other shop, as they had a rule limiting the wage that could be paid a man for the first year after he had served his apprenticeship.

The introducing of new and better methods of handling the apprentice problem, and the attracting of a higher grade of boys, is a large and important phase of the manufacturing business today, and the way it develops will be watched by many.

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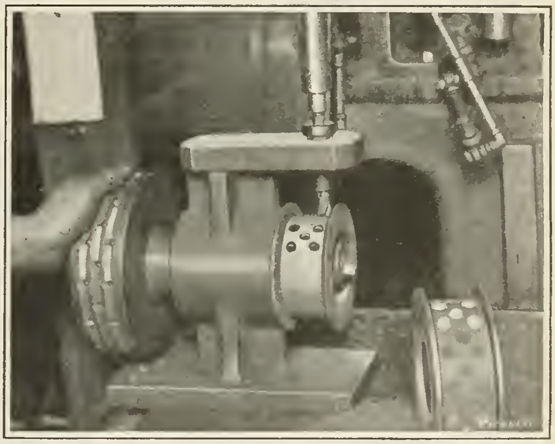
* * *

INDEXING DRILL JIG

The necessity for a drill jig of the indexing type was brought about by a certain design of flat-belt motorcycle drive pulley. This pulley is of the flat-belt, flanged type, having cork inserts over its entire periphery.

To the right in the accompanying illustration is shown a completed pulley with the cork inserts in place. Mounted on the drill jig is shown a pulley being drilled. The pulley is $4\frac{1}{2}$ inches in diameter and has forty-two holes, $\frac{1}{2}$ inch deep, arranged in three rows of fourteen equally spaced around the periphery. The drill jig is built in such a manner that it will take a large variety of sizes of pulleys.

At the left of the jig is shown a large drum which serves as a means of indexing the drill jig readily, and has three annular grooves on its periphery, spaced the same distance apart longitudinally as it is desired to have the holes drilled on the pulleys. Directly in the center of these grooves and spaced equidistantly around the periphery are fourteen tapered index pin holes. At the base of the drill jig is an index pin (not shown), which is tapered on the end to fit the tapered index hole. At the back of this index pin is a light spring which holds it constantly in contact with the index drum.



Pulley Drill Jig in Operation

In operation, the first row of holes is drilled. When enough pressure is applied to the drum to rotate it, the index pin, being correctly tapered, will jump out and allow the drum to revolve to the next index hole. After the first row of holes has been drilled in this manner, the second row is placed in line with the revolving drill by forcibly sliding the index drum and its shaft longitudinally until the index pin jumps into the middle groove. In this position the fourteen central holes are drilled as before. To drill the last row of holes it is only necessary to move the index drum over as in the second case.

For drill jigs where it is essential to drill holes accurately spaced around the periphery, this form of index drum and pin might not be accurate enough. However, in this case and in many other cases it is sufficiently accurate. It has the advantage of being quickly indexed, which is not always true of the ordinary index pin that has to be grasped by one hand while the other hand is employed in rotating the fixture. In this case, the right hand is never moved from the drill spindle lever. V. B.

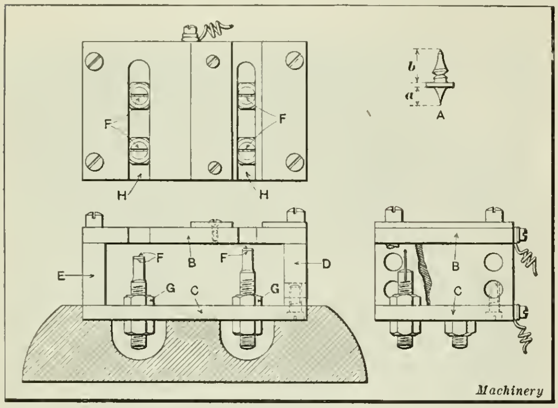
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

ELECTRICAL LIMIT GAGE

The following describes an interesting electrical limit gage for testing time fuse firing pins of the form shown at *A* in the accompanying illustration. The dimensions *a* and *b* have to be tested for accuracy, and it was for this purpose that the electrical limit gage was designed. It will be seen that the gage consists of top and bottom plates *B* and *C*; plate *B* is made of tool steel, hardened and ground, while plate *C* is made of machine steel and left soft. These two plates are fastened together by fillister-head screws and special nuts, which enter the fiber side pieces *D* and *E*. The fiber is used because it is a non-conductor and thus provides for insulating the top and bottom plates from each other.

This gage is of the "go" and "not go" type, and its operation depends upon having the work to be tested close the electrical circuit between the plates, which causes a telegraph sounder to click. Four contact points *F* made of spring steel are soldered into the heads of screws which provide for adjusting



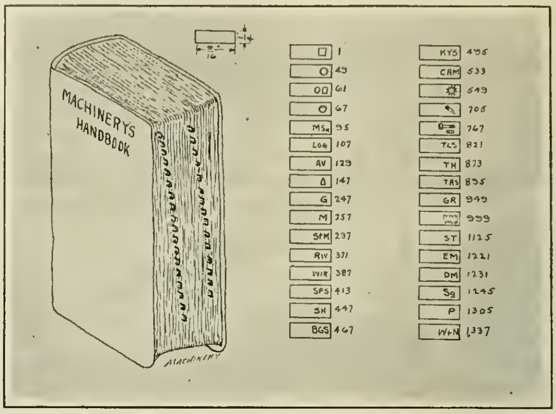
Electrical Limit Gage for testing Time Fuse Firing Pins

the height of the contacts. Lock-nuts *G* are for adjusting the contact points to the proper height and locking them in position.

In using the gage, the firing pins to be tested are placed in the front end of slots *H* and pushed forward over the contact points *F*. If the firing pin touches either of the points it completes the circuit and the sounder clicks. The first contact point is adjusted to such a height that if the tip of the firing pin touches it, it shows the work is too long; similarly, if the pin does not touch the second contact point, it is too short. In either case the work will be rejected. It will of course be evident that one of the slots *H* provides for testing dimension *a*, while the other slot is used for testing dimension *b*. It is a very easy matter to keep this gage accurately adjusted. DONALD BAKER

THUMB INDEX FOR MACHINERY'S HANDBOOK

In the June number of MACHINERY an abbreviated index for MACHINERY'S HANDBOOK was published, which made me think that I would like to pass along the method I have used for a thumb index on my handbook with success. The accompanying illustration shows the general scheme employed and the abbreviations which were used on the writer's index tabs. These index tabs can be altered to suit individual needs, depending upon the class of work on which the user is engaged. A chamois skin was purchased at a drug store and pieces



Method of indexing Handbook

9/16 by 1/4 inch were cut out of the smoothest part by using a cardboard templet, after which they were lettered as shown with black India ink, by spotting the ink on with little dots instead of in the usual way; they were then pasted on the right-hand pages of the handbook. Photo paste was used on the chamois skin very sparingly and the tab pressed firmly on the page until it adhered.

By holding the back of the book in the left hand and placing the right thumb on the index tab, references can be made very quickly. The writer has three reference books that he has indexed in this way, and has found the method convenient and readily applicable with comparatively small expense and little trouble.

Lyndonville, Vt. EARL W. PETERSON

ETCHING GRADUATIONS ON GAGES

In the September, 1915, number of MACHINERY, in an article entitled "Snapshots On the Road," I noticed a short description of a method of etching nameplates; and this suggested the means of overcoming difficulty which we had experienced in graduating gages of the form shown in the accompanying illustrations. These gages were made of ½-inch drill rod, and the largest diameter was 0.490 inch. There were four lines to be marked on each gage, and it was decided to grind the graduations in the hardened gages. But when an attempt was made to handle the work in this way, it was found that the wheel would not hold a sharp edge, with the result that very poor lines were obtained. As the limit of accuracy required on this work was ± 0.0002 inch, this method was obviously unsatisfactory, and we were in search of a more efficient way of doing the work when I happened to see the article referred to.

As a result, we decided to try etching; a thin coat of wax was spread over each gage, after which it was mounted on

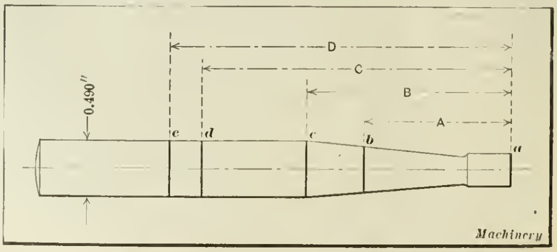


Fig. 1. Gage to be made showing Graduations at b, c, d and e

centers on the milling machine. The marker held in a fly-cutter shank, as shown in Fig. 2, had its point brought to coincide with end *a* of the gage, and it was then a simple matter to move the table through the required distance *A*, Fig. 1, to locate the marker for making the first line *b*. Then the table was moved successively through distances *A*, *B*, *C* and *D* in order to locate the marker in the proper positions for graduating lines *b*, *c*, *d* and *e*. It will be obvious that to

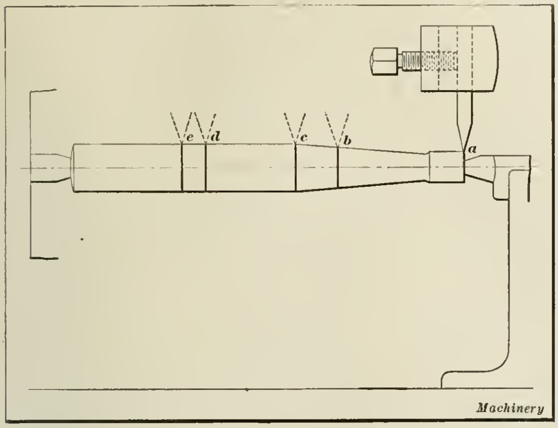


Fig. 2. Method of cutting Graduations in Wax preparatory to etching

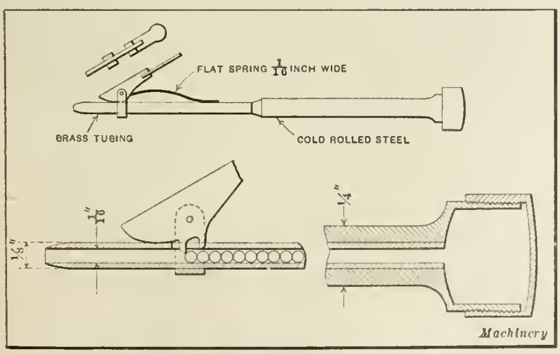
graduate each line in the wax, it was merely necessary to bring the pointer into contact with the work and then rotate the work through one complete revolution. A mixture of one part of nitric acid and one part of water was then applied and allowed to "work" for three or four minutes, after which the acid was thoroughly washed off with water and the wax removed from the work. The micrometer graduations on the screw of the milling machine enabled the lines to be spaced with the required degree of accuracy.

Bridgeport, Conn. CARL GOTTHARDT

STEEL BALL DROPPER

A steel ball 1/16 inch in diameter is not an easy thing to handle, even with the aid of a suitable pair of tweezers. Such a diminutive sphere, when removed from its fellows in the bearing, seems to become animated and determined to shoot through space without the impetus afforded by an explosion; and to avoid loss of time and balls occasioned by dropping and losing them in attempting to replace the balls in the race groove, we designed the ball dropper shown in the accompanying illustration, which proved to be a very useful tool in the shop.

The trigger and spring are made of tool-steel which was hardened and drawn to a blue color; the upper end and screw cap were turned from a piece of ½-inch round brass stock. The chute was made of a piece of 1/16-inch brass tubing which was sweated into the upper end of the ball reservoir; and the yoke for holding the trigger, pin and spring was



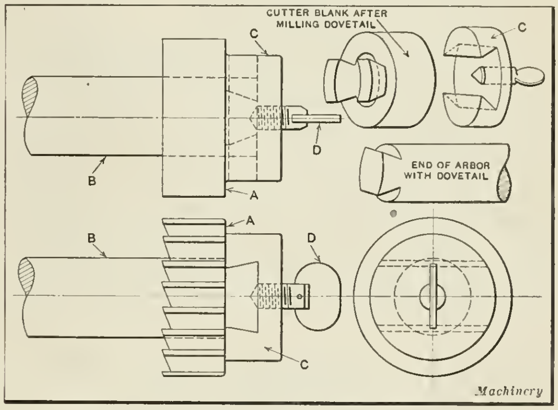
Steel Ball Dropper and Enlarged Partial Cross-section

soldered in place. Then all brass parts were nickel plated to improve the appearance of the tool. At the outlet from the ball reservoir, the corners of the brass tube were first made with a slight chamfer, but this allowed the balls to become jammed at the entrance to the tube so that they would not flow freely; we faced off the end of the tube to give a sharp corner, and after this no difficulty was experienced. It will be evident from the illustration that only one ball can be released at a time, a ball being dropped each time the trigger is pressed down.

Bayonne, N. J. WILLIAM A. HAWES

DRIVE FOR BACK COUNTERBORE

A very satisfactory way of driving back counterbores, back face mills and similar tools is shown in the accompanying illustration. This device is used where the cutter must be secured to the end of the arbor after the arbor has been passed through the hole. Cutter *A*, which is a sliding fit on arbor *B*, is turned down on the back end to a diameter just below the bottom of the flutes, and a dovetail is milled across each side. This dovetail is cut so as to register with a similar dovetail milled on the extension of the arbor. When the cutter and arbor are assembled, the complete dovetail is such as to fit the mate in cap *C;* and tightening the thumb-screw *D* holds



Arrangement of Drive for Back Counterbore or Back Face Mill

this cap in place. Thus the cap forms a driving coupling between the arbor and cutter which may be quickly slipped on and off.

Bridgeport, Conn. W. BURR BENNETT

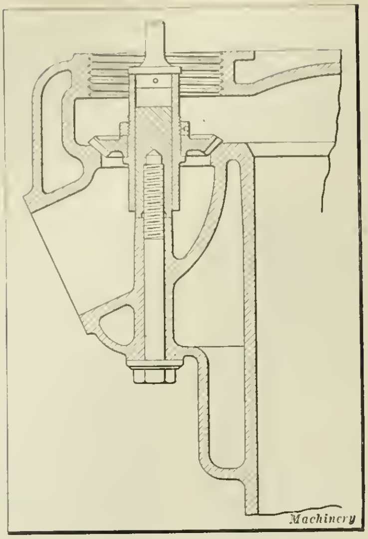
FITTING TAPERS

In fitting taper parts, such as lathe centers, miller arbors, etc., it is customary to rub chalk, Prussian blue or red lead on them before trying them together, so that the high spots will show bright after the parts have been wrung together. While chalk will answer the purpose on rough work, the other two are to be preferred for finer work, but as they are rather mussy and inconvenient, it may be of interest to learn that there is a blue pencil on the market used for marking on glass, china, metal, etc. This is much more convenient to use or to carry, either in the pocket or the tool kit, and it will give practically the same results as Prussian blue, while the marks made with it leave just the right amount of blue on the work without smearing or waste. The pencils I have were made by the Faber Co., and as they are a German product, it may be difficult to obtain them at present, although they are usually kept by stationery and art supply stores. D. B.

RESEATING GASOLINE MOTOR VALVES

The illustration presented in connection with the following description shows a gasoline motor valve seating tool which has been found to give very satisfactory results. I have never found the method of assembling the reamer directly on a 5/16 or 3/8 inch diameter stem to give sufficient rigidity to

insure obtaining a valve seat concentric or true with the valve stem hole in the guide; and I have often ground valves in which this method was entirely useless on account of poor hand reaming. Valves can be given a true seat in a very short time and with very little grinding if the seats are carefully reamed at the start; and an advantage of the tool shown in the accompanying illustration is that the cutter revolves around a large bearing surface which is located exactly at the center of the circle being reamed.



Efficient Type of Valve Seat Reaming Tool

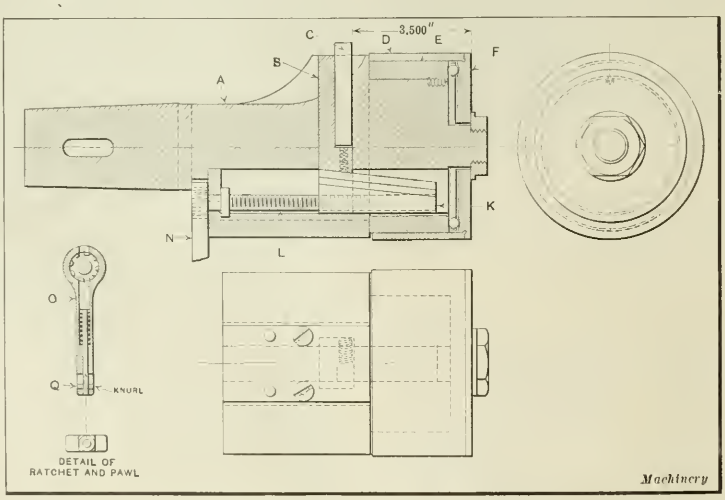
It will be seen that the cutter is mounted on a piece of steel tubing which is turned down to a shoulder and threaded to receive a nut for clamping the cutter in position, after being carefully reamed to give the tube a smooth concentric hole. The plug on which the tube turns can be made of a piece of good close-grained cast iron, and after being drilled and tapped, a hole should be drilled to a depth of about 1/8 inch, using a drill 1/32 or 1/16 inch larger than the tap size; then the end of the plug is faced off true, and it also ought to be ground to size on the outside. The form of clamping screw used in the guide and the method of mounting are so clearly shown that no description is required. Any suitable stem may be placed in the top of the tube to accommodate the form of drive which is to be used. If this joint is very loose and simply held with a large cotter-pin, very good results will be obtained, as the tool will be given more or less float and thus be able to center itself readily. Obviously, it is necessary to first spot-face the ends of the valve stem guides just enough to break away the scale and provide an accurate surface for the bearing plug to rest on.

Los Angeles, Cal. H. W. Ricks

RECESSING TOOL FOR HORIZONTAL BORING MILL

The tool shown in the accompanying illustration was designed for cutting a recess in the worm-gear bearing in a steel casting, the machine on which the work is done being a horizontal boring mill. The recess is used to locate and hold a thrust washer, and the requirements of the work are that the groove must be accurate in its width and correctly located from a shoulder 3½ inches distant.

Referring to the accompanying illustration, the body of the tool *A* is made of machine steel, and the shank is held in the end of the spindle bar by a draw-in slot and wedge. The tool-holder block *B* carries the tool *C*. The block is operated by wedge *K*, controlled by screw *L* through ratchet handle *N*. The diameter of the hole in which the recess is to be cut is 0.004 inch larger than the hardened bushing *D*, and the location is insured at the beginning of the operation by carrying the tool into the bored hole until the thrust washer *F* comes against the shoulder mentioned, being held in this position by pressure on the handwheel which controls the longitudinal movement of the spindle. As the machine spindle revolves, the friction is relieved by the ball bearing shown, the outer bushing remaining stationary and also serving as a pilot for the holder. At each revolution of the spindle, the handle *N* is given a partial turn by means of a knocker fastened to the table, and as the spindle continues to revolve, the handle returns to its original position by the action of gravity, the ratchet pawl *O* slipping past the teeth on the ratchet as indicated.



Recessing Tool for Horizontal Boring Mill

The depth of the cut is gaged by the end of the tool-holder block which is visible, and the chips drop out of the way through the cut which can be seen at the rear of the tool and holder. When the proper depth has been reached, the tool is withdrawn by reversing the ratchet pawl in the handle by means of the knurled portion *Q*. This method is somewhat slow, but is not at all complicated and the withdrawal can be accomplished in a short time. The bushing *E* is of hardened steel and is pressed onto the body to take the wear from the side pressure caused by the cutting action. Its use also prevents the hole in the casting from being scored. Prior to the use of the recessing tool, a roughing cutter is used to relieve the work, so that there is less metal to remove in the finishing cut and greater accuracy is insured. There is also less wear and tear on the tool itself, so that the maintenance cost is reduced to a minimum. The illustration will make the general points in construction perfectly clear and the method of operation readily understood.

Columbus, Ohio. Otto R. Winter

MILLING DOUBLE-ANGLE CLUTCH TEETH

On page 190 of Franklin D. Jones' book entitled "Planing and Milling," there is a formula for determining the angle a to which the axis of a clutch blank should be inclined while milling the teeth. This formula is perfectly accurate, but I find it more convenient to use when reduced to the following form:

$$\cos a = \tan \frac{180 \text{ degrees}}{N} \times \cot \text{ cutter angle} \qquad (1)$$

I have to mill a number of clutches for use on a certain machine, but they differ from the type referred to by Mr. Jones in that the teeth have a "double" angle as indicated in the accompanying illustration. Clutches with teeth designed in this way disengage more readily. In finding by calculation the angle a at which the clutch blank must be set for milling, the following equation is used:

$$\tan \beta \times \tan \beta_1 \times \cos^2 a + (\tan \beta + \tan \beta_1) \times \cot \frac{180 \text{ degrees}}{N} \times \cos a - 1 = 0 \qquad (2)$$

Reference to Formula (2) in connection with Fig. 1 will make it evident that

for a case where $\beta_1 = 0$, the clutch is of the type referred to by Mr. Jones, and for such a case Formula (2) reduces to the form given in Formula (1).

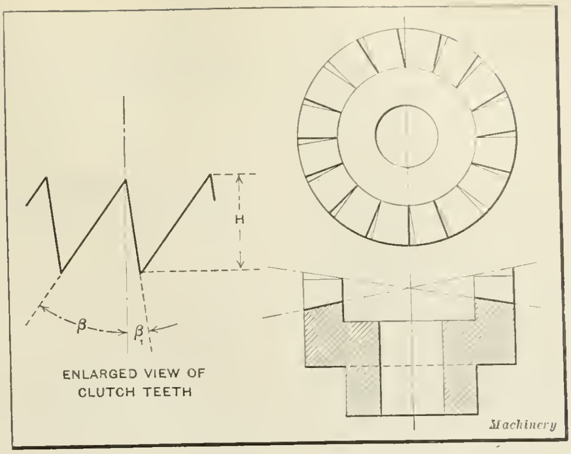
In designing these clutches I generally make angle $\beta = 55$ degrees, and angle $\beta_1 = 5$ degrees, and for these angles the values given in the accompanying table have been calculated. It will be seen that both the angle α and the value of cos α are given in the table, the latter being for the purpose of determining the drop of the cutter into the clutch blank at the rim. This value is indicated by H in the illustration, and has the following value:

$$H = D \cos \alpha$$

where D = diameter of clutch blank.

After the teeth have been cut, the sharp edges are faced off in the manner indicated, which leaves little triangular surfaces for the opposing teeth to rest on momentarily while the clutch is being closed in case the teeth happen to come point to point at the instant of engagement. If the points of the teeth are left sharp and the clutch engages in this way, it is found that the teeth do not slide easily on each other, so that the engagement of the clutch is made rather difficult.

Bridgeport, Conn. D. Petri-Palmedo



Form of Double-angle Clutch Teeth, and Method of milling to insure Easy Engagement

VALUES OF α AND COS α FOR DIFFERENT NUMBERS N OF CLUTCH TEETH

N	4	5	6	8	9	10	12	15	16
Angle α in Degrees and Minutes	51 10	62 10	68 5	74	76 10	77 40	79 20	82	82 30
Cos α	0.6271	0.4669	0.3733	0.2756	0.2391	0.2136	0.1851	0.1392	0.1305

N	18	20	24	25	28	30	32	36
α, Degrees and Minutes	83 30	84	85	85 15	85 40	86	86 15	86 45
Cos α	0.1132	0.1045	0.0872	0.0828	0.0756	0.0698	0.0654	0.0567

Machinery

COMMON CAUSE OF HIGH ELECTRIC POWER BILLS

Unsatisfactory power bills are not always the fault of the central station, neither are they always the fault of the consumer; but excessively high bills are sometimes the result of an unfortunate purchase of motors. While occurrences similar to the one here related are frequent, the following is probably the worst case that ever came to my attention. A consumer complained to the electric company about his bills and added the threat that if nothing could be done in the matter, he would be forced to abandon central station service and resort to the use of a gas engine for his power. Natural gas sold for thirty cents per thousand cubic feet, and the electric company knew from past experience that this was not idle talk on the part of the consumer.

The complaint was handed over to a solicitor with orders to investigate. The solicitor called, as directed, and the consumer produced his bills for the preceding year with the remark, "No matter how good or how slack business may be, I always get the same old bill for $40." The plant was an architectural iron works, *i. e.*, the company purchased I-beams, channels, angles, etc., drilled and cut them into such lengths as were required, and then erected the structural steel part of buildings. An examination of the bills showed that the statement of the consumer in regard to their amount was essentially correct.

At the suggestion of the solicitor, they went into the shop; and an inspection disclosed the fact that one fifteen-horsepower motor of standard make, more or less successfully rewound, was used for driving the whole plant. The solicitor asked the consumer to wait until the next day, so that he could conduct a test. This test was made as follows: The main belt was removed and the kilowatt input was observed when the motor was running free. The belt was then replaced and the power necessary to drive the motor and shafting was noted. The machines were then successively thrown on (loaded when convenient) and readings taken of the power drawn from the line. The following are the results of the test:

Motor running free (main belt removed), input..3.50 kilowatts
Motor plus lineshafting and loose pulleys, input..3.90
The same, plus small blower, input..............4.00
Last condition, plus Alstatter Shear accelerating, input....................................4.20
Last condition with shear running, plus Bliss punch accelerating, input..................4.10
Last condition with Bliss punch running and emery grinder working, input..............4.35

The last figure, namely, 4.35 kilowatts, represented what the customer called about average operation, and when multiplied by 240, which was the number of working hours per month, came surprisingly near to his average monthly consumption. One of the most remarkable things about this installation was that for about one hour and a half each day, immediately after the dinner hour, the fifteen-horsepower motor was operated to drive a small forge blower, for which a one-fourth-horsepower motor would have supplied ample power. The matter was laid before the customer, and the fact that he was paying about 80 per cent of his money to turn the motor and about 20 per cent for the energy which he required for producing his product was plainly shown to him. It was explained that while he could not escape paying something to turn a motor, that by trading in his fifteen-horsepower motor and with a slight additional investment he could equip his plant with small motors and reduce his power bill sufficiently to pay well for his added investment.

I could relate details of tests made on numerous other installations because of similar complaints. One of these was at an amusement park, where they were using a four-kilowatt belt-connected motor-generator set to supply current to a maximum connected load of less than one kilowatt in miniature lamps, and an average load of about one-fourth of a kilowatt; they were paying about $35 a month and got the benefit of about $3 or $4 worth of electricity. In another case a shop was operating a little one-half-horsepower forge blower with a five-horsepower second-hand motor; the proprietor picked up the motor cheap, and it ran the blower all right. I have seen so many of these instances that when a complaint of this kind comes in I take a wattmeter along and manage to see the consumer about noon, when the factory is shut down, so as to take his no-load motor input.

A. G. Drury
Cincinnati, Ohio.

METHODS OF CHECKING MULTIPLICATION

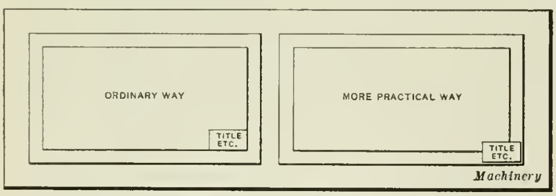
On page 700 of MACHINERY for April, 1916, under the heading "Methods of Checking Multiplication," it will be found that the process mentioned does not give quite correct results in all cases. The following method, which is taught in nearly all English elementary schools in India, is the quickest way of proving multiplication, and it will be found that it is absolutely correct in every case.

Example.—Multiply 84,689 by 5214 = 441,568,446. Add all the digits of the multiplicand till one digit is obtained, thus: $8 + 4 + 6 + 8 + 9 = 35 = 3 + 5 = 8$. Do likewise with the multiplier, thus: $5 + 2 + 1 + 4 = 12 = 1 + 2 = 3$. Multiply the two results and add the digits till one digit is obtained: $8 \times 3 = 24 = 2 + 4 = 6$. Lastly, add the digits of the product till one digit is obtained, thus: $4 + 4 + 1 + 5 + 6 + 8 + 4 + 4 + 6 = 42 = 4 + 2 = 6$, and if the the result agrees with the result obtained by adding the digits of the preceding multiplication, the product is correct. We get 6 in both cases. Hence the product is correct.

Calcutta, India. J. R. ACKOY

ARRANGEMENT OF BORDER LINES AND TITLE

It is my purpose to describe what I have found to be a very practical arrangement in laying out the border lines and title frame on drawings; this is often the means of saving space which may be required for showing certain views of one or more small parts, and avoids the necessity of making separate detail drawings. The paper is cut around the edge about ⅛ inch from the outside border line, and experience has shown that it pays to have plenty of room between the



Comparison of Arrangements of Border Lines and Title

outside and inside border lines; we use a space of 1 inch on our standard drawings. This prevents the blueprints from becoming badly finger marked along the edges and avoids loss of time through mechanics having to go to the foremen or draftsman for further information in regard to an operation on which they are engaged. DRAFTSMAN

LINK FOR LIFTING DRIVING BOXES

The device shown in the illustrations for lifting driving boxes on and off machines has been found a very satisfactory means for the purpose in the shops of a large eastern railroad. The link is made of ¾ inch square wrought iron, bent to form the large loop and a ring at the top, and welded together. Two of the rings are used in lifting a box, as seen in Fig. 2. The links are made to suit the length of driving box, and a ⅜-inch endless chain holds the two links together. The chain is made of the proper length to allow the device

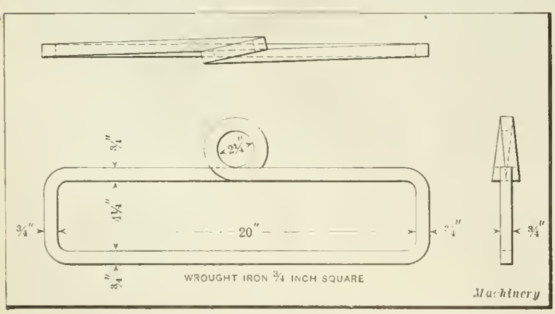


Fig. 1. Link for lifting Driving Boxes

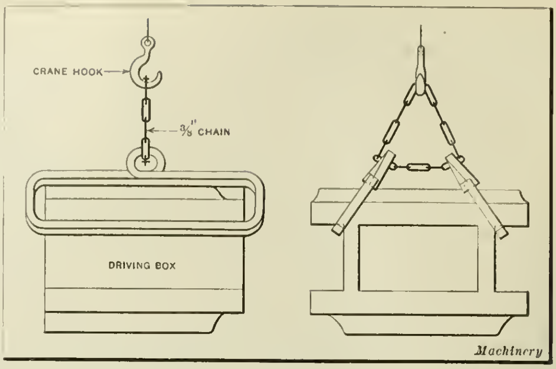
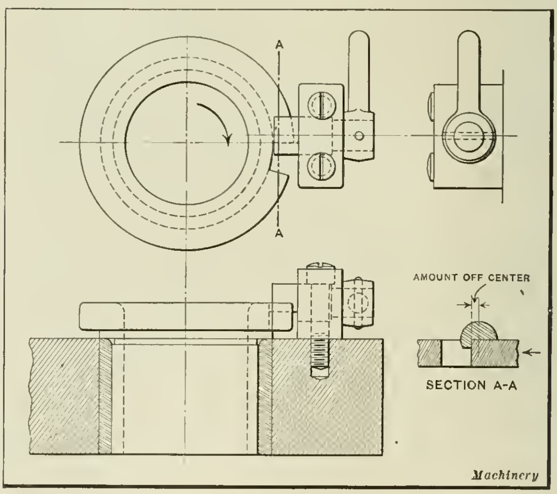


Fig. 2. Application of Pair of Links to Driving Box

to be quickly put on the box to be lifted and to adjust itself at about the angle shown when the box is being lifted. It is impossible for the links to slip in use, and there is nothing about the device to get out of order. L. K.

LOCK FOR SLIP BUSHINGS

It is considered good practice to use some sort of lock to prevent slip bushings from rotating and creeping up on the drill or reamer. This lock should be fool-proof, of few parts, and sturdy enough to withstand shop abuse. The accompanying illustration shows a lock which amply fulfills the above requirements and can be used for locking eccentric bushings. It consists of a pin milled out on the end, supported in a bearing, and having a lever pinned to the other end. The milled end of the pin when in position (as shown in section A–A) keeps the bushing from rotating and creeping upward. The shoulder which the edge of the bushing strikes is off center of the pin; this tends to rotate the pin as the bushing tries to turn from drill friction, thus locking it tighter. In the



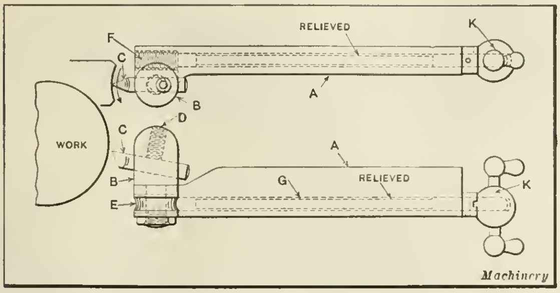
Lock for Slip Bushings

illustration, the bushing is shown as tending to turn clockwise, which would be the condition when using a right-hand drill. By lifting the lever to an upright position the bushing can be withdrawn vertically.

Bridgeport, Conn. W. BURR BENNETT

ADJUSTABLE RADIUS LATHE TOOL

The accompanying illustration shows an adjustable radius lathe tool made by the writer. The tool-holder *B* is ground true so that measurements can be easily taken from it to set the tool to any radius within its capacity. The body of the holder *A* is made from cold-rolled steel which is finished to size and casehardened. The end of the holder carrying the



Adjustable Radius Lathe Tool

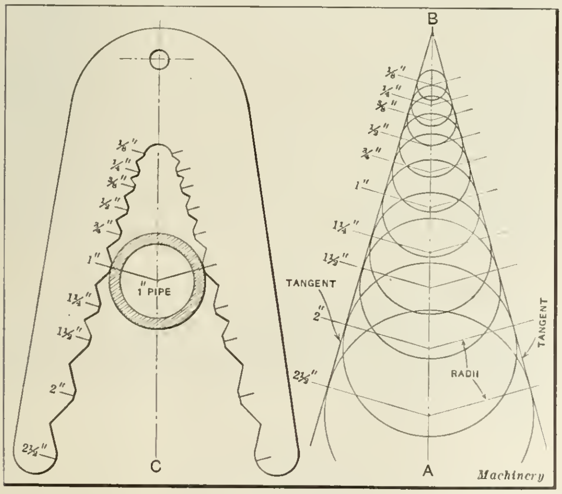
radius tool is formed as shown and is provided with the holder mentioned in which the tool C is secured by means of the set-screw D. The worm-wheel E is slipped onto the squared-up portion of the tool-holder B, and meshes with the worm at the end of the operating shaft G, the movement of which is controlled by the handle K. This handle can be readily removed so that the tool body A can be slipped into the holder on a lathe carriage. The worm is ⅜ by 16 inch and the shaft is relieved in the middle portion so that it obtains a bearing only on each end; that is, near the handle and near the screw. The tool shown has been in use in the tool-room for the past six months and has given complete satisfaction.

Kenosha, Wis. H. E. Anderson

CONVENIENT PIPE GAGE

I have often found, when called upon to measure up old pipe work, that considerable time is lost, especially when a number of various sized pipes are involved. The accompanying illustration shows a very convenient form of pipe gage which the writer has had made and which he has found to be a great help whenever pipe sizes of any kind are to be taken.

The following method will be found convenient for laying out the gage. The two points A and B are laid out 3 inches apart on a common center line, using a piece of 1/16-inch brass or copper sheet and scribing the line carefully upon it. With the points A and B as centers, describe two circles, respectively, 2.87 inches and 0.4 inch in diameter. These circles represent the outside diameters of the 2½-inch and ⅛-inch standard pipe sizes. Tangents should then be drawn to each circle, as shown, and other circles laid out on the center line, using the table of pipe sizes given herewith as a guide for the diameters. Each circle must have its circumference in the tangent, as shown in the diagram. Radii are now drawn in each circle perpendicular to the tangent, which gives the location of the various points of tangency. These will be the points of contact for pipes of similar size placed in the gage. After all the lines have been located, an outline can be shaped for the gage similar to that shown at C in the illustration. After this, the material can be cut out with a hacksaw and file and the different pipe sizes can be stamped at their proper locations with steel dies. It will be found advisable to cut notches between the measuring or contact points with a file so that the pipe size can be determined easily even when operating in a dark location. If desired, the finish of the tool can be improved by polishing and nickel-plating. The gage will give any pipe size accurately from ⅛ inch to 2½ inches diameter. The size of the gage is convenient and it will readily slip into the pocket.



Convenient Pipe Gage

STANDARD IRON PIPE SIZES

Nominal Size, Inches	Actual Outside Diameter, Inches	Nominal Size, Inches	Actual Outside Diameter, Inches	Nominal Size, Inches	Actual Outside Diameter, Inches
⅛	0.40	¾	1.05	2	2.37
¼	0.54	1	1.31	2½	2.87
⅜	0.67	1¼	1.66	...	....
½	0.84	1½	1.90	...	....

Machinery

Irvington, Baltimore, Md. B. Francis Dashiell

VALUE OF LOGARITHMS TO THE TOOLMAKER

The advice which Mr. Jacobs, in Machinery for July, gives to the ambitious toolmaker is very interesting to me, as it must be, I think, to all of us who have traveled the path he there maps out. I should like to add a bit of advice to the machinist whose ambition goes one step farther—who wishes to get a thorough knowledge of all the trigonometry that will be of use in his work, and is not content with the ability to deal with right-angled triangles. This advice is that, before he undertakes trigonometry, he should thoroughly master logarithms. I have had the pleasure of assisting many machinists to acquire a practical working knowledge of trigonometry, and have invariably found that those who can handle logarithms in an efficient, workmanlike manner make far more rapid progress and with much less wearisome labor than those who lack this simple accomplishment.

It is no light task for a man, after his day's work in the shop, to sit down in the "College of the Midnight Lamp" to a lot of problems which perhaps involve multiplication by two or three trigonometric functions and division of the product by one or two more. One who is of mature age, and whose school days are far in the past, is likely to find the arithmetical labor wearisome and to feel that, though he may be refreshing his grammar-school knowledge, he is making but slow advancement in trigonometry. It is not surprising that many such students grow discouraged.

If, however, one first learns to use logarithms with the same facility as one's shop tools, the study of trigonometry presents a wholly different aspect, for the drudgery is eliminated. Any number of multiplications and divisions can be performed simultaneously by a single addition of logarithms, and the extraction of square, cube or any other roots is a mere matter of short division. Incidentally, the use of logarithms tends to greater accuracy, as it removes the ever-present temptation to omit, in calculations, all but two or three places of decimals. I know that some yield, in this matter, to the lure of the easy way, for I have checked up many a jig drawing some of whose dimensions were several ten-thousandths off, because the man who figured them had used only two- or three-place functions in order to lessen his arithmetical toil.

Even if it were difficult to get a working familiarity with logarithms, the time and labor required would be well spent, but it is a very easy matter. One of Machinery's twenty-five cent reference books, No. 53, will give all the essential information, and if help is needed to get one over a hard place, it can be readily obtained, for every student, it seems to me, must have within reach someone who has been up against the same difficulty, and who will gladly explain the matter.

New London, N. H. Guy H. Gardner

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

"EFFECTIVE DIAMETER" OF SCREW THREADS

J. L.—What does the term "effective diameter" mean applied to screw threads? Is it the diameter of the screw at the root of the thread?

A.—The term "effective diameter" means the "mean diameter" or "pitch diameter," as it is generally called in America. The term is of British origin and its application is not apparent. The term "pitch diameter" commonly used in America is not good either. The term "mean diameter" is correct, as it means exactly what the term implies—that is, the diameter of the screw taken midway between the root and outside diameters.

VOLUME OF STEAM AT A GIVEN PRESSURE

A. E. H.—Is there any way that I can find the volume occupied by, say, 6 pounds of dry and saturated steam at a gage pressure of, say, 100 pounds per square inch, without the use of a steam table?

A.—Rankine's formula will probably give results sufficiently exact for your purpose; this formula is:

$$PV^{\frac{17}{16}} = 475$$

where P = absolute pressure in pounds per square inch;
V = volume in cubic feet occupied by one pound of steam.

The absolute pressure = gage pressure + pressure indicated by the barometer; if the latter is not known, it is customary to call it 14.7. In this case we have:

$$P = 100 + 14.7 = 114.7$$

$$PV^{\frac{17}{16}} = 114.7V^{\frac{17}{16}} = 475$$

Taking the logarithm of both sides of this equation:

$$\text{Log } 114.7 + \frac{17}{16} \log V = \log 475$$

$$\text{Log } V = \frac{16}{17} (\log 475 - \log 114.7) = \frac{16}{17} (2.67669 - 2.05956) =$$
0.58083.

$V = 3.8092$ = number of cubic feet occupied by one pound of steam under the above conditions. The volume occupied by six pounds is:

$$3.8092 \times 6 = 22.8552, \text{ say } 22.86 \text{ cubic feet}$$

The logarithm of any number (or quantity) having an exponent is equal to the logarithm of the number multiplied by the exponent; for instance, $\log A^c = c \times \log A$. J. J.

EXPLANATION OF THE TERM "FUNCTION"

C. O. T.—Quite frequently of late I have encountered the term "function"; please explain what it means.

A.—The labor of a mathematical investigation is greatly simplified by reason of numerous definitions and symbols that have been universally agreed upon. Among these, one of the most useful is the term "function" and its symbol. The area of a circle may be expressed mathematically as $A = \pi R^2$, in which $\pi = 3.14159 +$. The quantities A and R are called variables, since their values may be changed (varied) at will; π is called a constant, since its value is unchangeable. Note that the value of A cannot be determined until some value has been assigned to R; hence, A is called the dependent variable and R is called the independent variable. The entire expression πR^2 is called a function, or, more precisely, a function of R; and since A equals this expression, A is frequently called the function and R is called the variable. We may now define a function as any mathematical expression containing at least one variable, provided that when a definite value is assigned to the variable, a definite value results for the function. Thus, $x^2 + (a + x)(a - x)$ is not a function, because it is equal to a^2, an expression that does not contain a variable, a being a constant. The constants are usually represented by the first letters of the alphabet and the variables by the last letters, corresponding to the known and unknown quantities in algebra. When we do not wish to write the expression for the function, we symbolize it by enclosing the variable in parentheses, and to further identify it, write a letter, usually f or ϕ, before it. The above function could then be expressed $A = f(r)$ or $A = \phi(R)$. J. J.

FORCED FITS OF WHEELS AND AXLES

L. F. S.—Please advise as to the best modern practice in making allowances for forced fits of railway and street car wheels and axles. I have been working to the old rule of 0.005 inch plus 0.001 inch for each inch of diameter. With these allowances, from eight to ten tons pressure per inch diameter are required to assemble. Any reference that you can give will be appreciated.

A.—Authorities do not agree on allowances for forced fits of railway wheels and axles, but their disagreement may be more apparent than real, owing to factors not being considered or mentioned that vitally affect the result. In the first place, the finish and truth of the axle seat and the bore are important. In the October, 1912, number of MACHINERY an article appeared entitled "Wheel and Axle Pressed Fits," which included a table giving the diameters of fifty-two axle and wheel fits. The diameters of the axles were given at the outside and inside ends of the seat for both wheels, and the bore diameters of the wheels were given at the inside and outside ends also. These data showed that the axle seats are hardly ever of the same diameter at both ends, and the wheel bore diameters also vary from end to end; variations of 0.003 or 0.004 inch are common. Depth of cut and feed were given with these examples which, too, are important. A coarse feed permits the use of greater allowance than a fine feed and smooth finish. With the depth of cut 1/32 inch and feed 1/8 inch, the rule referred to by you agrees pretty closely with the allowance given for an axle 6 inches diameter forced into a cast-iron wheel. The allowance was 0.011 inch and the pressure required was fifty tons. But with smooth, true axle seats and wheel bores, less allowances than the rule calls for are advisable, about 0.001 inch per inch diameter being sufficient.

COLLAPSING PRESSURE OF PIPE

O. J. R.—In Merriman's "Mechanics of Materials," the following formula is given for the collapsing pressure of wrought-iron pipe, in which T, L, and D are the thickness, length and diameter, respectively, in inches, and P is the pressure in pounds per square inch:

$$P = 9{,}600{,}000 \frac{T^{2.18}}{LD}$$

He gives as an example, find T when $P = 120$ pounds per square inch, $L = 72$ inches, $D = 4$ inches, and the factor of safety = 10. By substitution in the formula:

$$T^{2.18} = \frac{10 \times 120 \times 72 \times 4}{9{,}600{,}000} = 0.036$$

From which, by the help of logarithms, he finds $T = 0.22$ inch. Please show me how to use logarithms to find T.

A.—Taking the logarithm of both sides of this equation:

$$2.18 \log T = \log 0.036 = \bar{2}.55630$$

$$\text{Log } T = \frac{\bar{2}.55630}{2.18} = \bar{1}.33775$$

$$T = 0.21765 = 0.22 \text{ inch, very nearly}$$

We presume that your trouble lies in performing the division, which may be done in two ways: First, make the dividend entirely negative by subtracting the positive mantissa from the negative characteristic (*i. e.*, add them algebraically),

the result being — 1.44370. Dividing this by 2.18, the quotient is — 0.66225; and in order to get the mantissa positive, we add — 1 and + 1 (which of course does not change its value) and obtain:

$$-1 + 1 - 0.66225 = -1 + 0.33775 = \bar{1}.33775$$

Second, if we add — 0.18 to the negative characteristic, it becomes — 2.18, which is exactly divisible by the divisor; but, if this be done, + 0.18 must be added to the mantissa.

Hence:

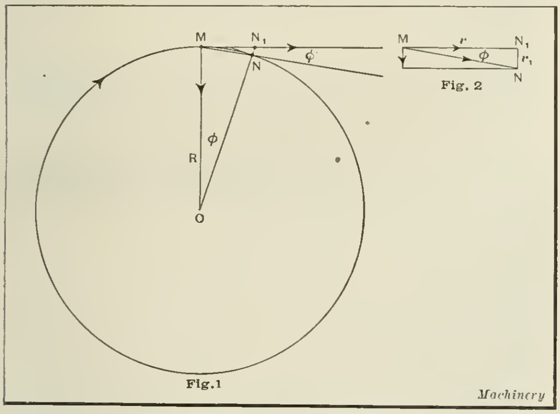
$$\text{Log } T = \frac{-2 + (-0.18) + 0.18 + 0.55630}{2.18} = \frac{-2.18 + 0.73630}{2.18} = -1 + 0.33775 = \bar{1}.33775$$

The number whose logarithm is $\bar{1}.33775$ is 0.21765, or, say, 0.22.

CENTRIFUGAL FORCE

J. A. G.—Please state what is meant by centrifugal force and show how the formula $F = 0.000341\,wrn^2$ is derived.

A.—Whenever a body moves in a curved orbit, it must be continually acted upon by some external force, since, other-



Figs. 1 and 2. Diagrams illustrating Meaning of Centrifugal Force

wise, according to the first law of motion, it would move in a straight line. If the orbit be a circle and the body attached to a string, the external force is the pull exerted on the body by the string, the direction being radial; it is, consequently, always perpendicular to the direction of motion of the body, which, for any point, is the tangent to the circle at that point. Thus, in Fig. 1, when the body is at M and revolving in the direction indicated by the arrow, its direction of motion is along the tangent MN, and the pull of the string is along the radial line MO, acting from M toward O. The pull is called the centripetal force, and the reaction, or pull exerted by the string on the center, is called the centrifugal force. Note that the centrifugal force is a reaction only and cannot produce motion. If the string be cut when the body reaches M, it will immediately move along the tangent MN with the same velocity that it had when moving in the circle. Since the centripetal force is always radial, it is always perpendicular to the direction of motion, and exerts no influence whatever toward changing the circumferential velocity of the body; it is also a constant force, and whenever a constant force acts on a moving body, it produces, in this case, a constant acceleration toward the center. The body, however, always stays at the same distance from the center, because the centripetal force is always only sufficient to change its path from a straight line to a circle. Suppose the body to have a velocity v; then, in a small interval of time t, it will move from M to N through the angle ϕ. During this time, it will have a constantly accelerated motion toward the center, the velocity being $v_1 = at$, in which a is the acceleration. If the body had not been deflected, it would have arrived at the point N_1 in the same time. Draw N_1N, ON, and MN; then, if the angle ϕ is minute, N_1N will practically coincide with ON and will be perpendicular to N_1M. Also, the angle N_1MN will then equal $MON = \phi$. Now draw the parallelogram of velocities, Fig. 2, in which $MN_1 = v =$ the circumferential velocity of the body, and $N_1N = v_1$ perpendicular to MN_1. Therefore, $\tan \phi = \frac{v_1}{v} = \frac{at}{v}$. But when the angle ϕ is extremely small, the tangent may be considered equal to the arc; hence, $\phi = \frac{at}{v}$. Letting R = radius of circle, arc $MN = vt$, and $\phi = \frac{vt}{R} = \frac{at}{v}$; whence, $a = \frac{v^2}{R}$. Letting M be the mass of the body and F the centripetal force or its equal, the centrifugal force, $F = M \times \frac{v^2}{R} = \frac{Mv^2}{R} = \frac{Wv^2}{gR}$, in which W is the weight of the body and g is the acceleration due to gravity. Taking g as 32.16 feet per second per second, v is in feet per second; if n = number of revolutions per minute, $v = \frac{2\pi Rn}{60}$, and $F = \frac{W}{32.16R}\left(\frac{2\pi Rn}{60}\right) = 0.000341\,WRn^2$. J. J.

MOMENT OF INERTIA

W. B. D.—Why is the product Ar^2 called the moment of inertia?

A.—According to the first law of motion, every body continues in a state of rest or of uniform motion in a straight line unless acted upon by some external force that compels a change. Consequently, if the motion or direction of motion is changed, it must be due to some external force and work must be done on the body. A rotating body is constantly changing its direction of motion; therefore, regardless of whether or not its angular velocity changes, a force must act and work must be done if the body continues to rotate. Referring to the illustration, let the disk M rotate about the axis through O; then all particles M_1, M_2, etc., turn through equal angles M_1ON_1, M_2ON_2, etc., $= \phi$ degrees during a small interval of time t. If the radius of the circle $A_1B_1A_2B_2$ be unity, arc A_1B_1 = arc A_2B_2 = etc. $= \phi = \frac{\phi}{180} \times \pi$ = angle in radians. The angular velocity of any particle is $w = \frac{\phi}{t}$, and the angular acceleration is $k = \frac{w}{t}$, in which w is the increase of angular velocity in the time t. Letting $M_1O = r_1$, $M_2O = r_2$, etc., the actual distance passed through by M_1 is $s_1 = \phi r_1$; by M_2 is $s_2 = \phi r_2$, etc. The linear velocity of M_1 is $v_1 = wr_1$; of M_2 is wr_1, etc. The linear acceleration of M_1 is $a_1 = kr_1$; of M_2 is $a_2 = kr_2$, etc. The mass M of the whole body is the sum of the masses of the particles $M_1 + M_2 + M_3 +$ etc., which are at distances from O equal to the radii r_1, r_2, r_3, etc., and the forces with which these particles *resist* turning are $F_1 = M_1a_1 = M_1kr_1$; $F_2 = M_2kr_2$; etc. The moments of these forces about O are $F_1r_1 = M_1kr_1^2$; $F_2r_2 = M_2kr_2^2$; etc. Hence, the moment of the force that turns the entire body with the angular acceleration k is (see figure) $F \times c = M_1kr_1^2 + M_2kr_2^2 +$ etc. $= k(M_1r_1^2 + M_2r_2^2 + M_3r_3^2 +$ etc.). Since the sum of all the masses M_1, M_2, etc., is equal to the entire mass M, we may write for the sum in parentheses the single term Mr^2, and we have $I = Mr^2 = M_1r_1^2 + M_2r_2^2 + M_3r_3^2 +$ etc. The quantity I is called the moment of inertia; it is a measure of the force required to rotate a body. M may be replaced by any quantity proportional to it; and since the area of a surface is proportional to its mass or weight, we may write for the moment of inertia of a surface $I = Ar^2 = A_1r_1^2 + A_2r_2^2 + A_3r_3^2 +$ etc. J. J.

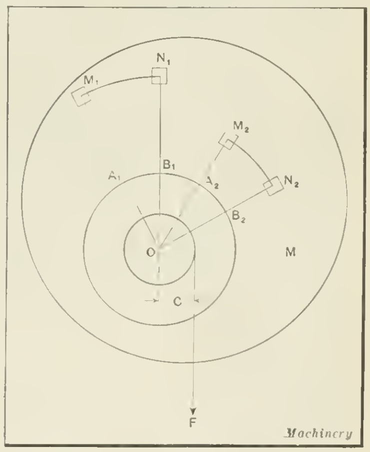


Diagram illustrating Significance of Term Moment of Inertia

DEFINITION OF "SPECIFIC"

A. A. K.—Please explain what is meant by the word "specific" in such terms as specific weight, specific pressure, specific volume, etc.

A.—The specific weight of any material is the weight of a unit of volume of that material, as the weight of a cubic foot, a cubic meter, etc.; specific pressure is the pressure per unit of area, as the pressure per square inch, per square centimeter, etc.; the specific volume of any material is the volume of a unit weight of that material, as the volume of a pound, a kilogram, etc. It will thus be seen that in every case the word "specific" implies comparison with a unit, as distinguished from total weight, total pressure, total volume, etc. Thus, specific resistance of wire is resistance of a unit of length of the wire. J. J.

LAYING OUT A CURVE IN ISOMETRIC PROJECTION

P. H. K.—The diagram at *X* in Fig 1 illustrates a problem which has given me some trouble and for which I have been unable to find a solution. Let it be required to draw in isometric projection the curve *AGF* in the rectangle *ABDC*. Laying out the isometric rectangle shown at *Y*, I obtained the form *A'B'D'C'*, and using the common method of determining the centers for the arcs, these centers are found to be at the intersection of the dotted lines at *R* and *S*. With radii equal to *RA'* and *SF'*, respectively, and using the two centers mentioned, it is seen that the arcs do not become tangent to each other at *E'*, but rather intersect and overlap each other on each side of this point. I should appreciate a solution of this problem, as it seems to me that as the radii for the curve shown in the rectangle *X* are equal, those in the isometric rectangle should also be equal and should produce the required curve in isometric projection.

A.—It must be remembered that isometric drawing is not true for every condition. This is especially the case in curves or circles which are tangent to each other and which are foreshortened like those shown. In a great many cases the method used in Fig. 1 can be applied to advantage, but when it is necessary to have an accurate delineation, the curve or curves must be obtained by another method called plotting. The method shown at Fig. 1 can be considered as an approximate method which is easier in its application and is used more frequently than the other, although the errors in delineation sometimes lead to complications in the construction of drawings, for example, when drawing a sphere, in circumscribing or inscribing a circle, or when a portion of the circle fits into or joins some other part or parts of an irregular figure.

In plotting the curves shown, a method by ordinates is used as follows: Referring to Fig. 2, the rectangle *ABDC* is constructed at *X* and the curve *AGF* laid out correctly with equal radii swung from the centers at *E* and *B*. Each complete arc of the circle is divided into six equal parts, from which ordinates *H*, *I*, *J*, *K*, *L*, *O*, *N*, and *M* are erected, perpendicular to the base of the rectangle, and from the same subdivisions on the arc other ordinates *H'*, *I'*, *J'*, *K'*, *L'*, and *P'*, *K'*, *O'*, *N'*, *M'*, are drawn parallel to the base line. In drawing the isometric rectangle *A'B'D'C'*, these ordinate spacings are laid out along the lines *E'F'* and also along the vertical lines *A'C'* and *B'D'*. At the proper intersection of the various lines as indicated at *X*, the curves are plotted so that the connected points form the foreshortened isometric curve *A'G'F'* shown at *Y*.

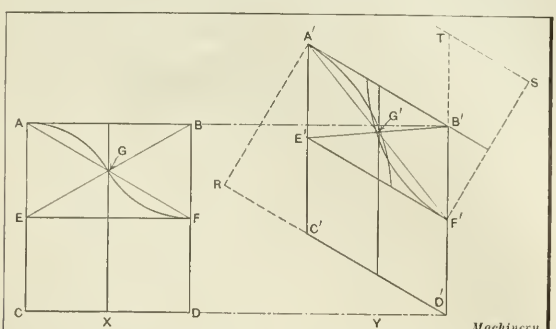


Fig. 1. Incorrect Method of laying out Tangent Curves in Isometric Projection

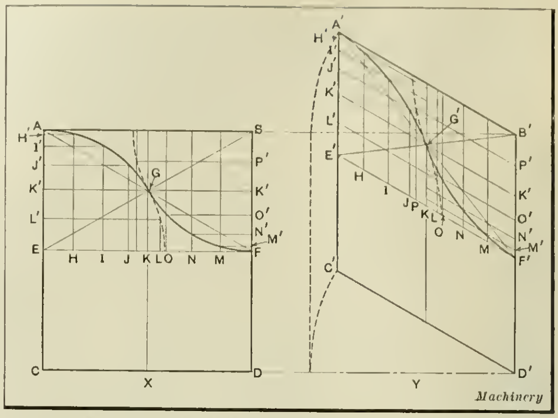


Fig. 2. Plotting Tangent Curves in Isometric Projection

FORCE OF IMPACT OF BALL AGAINST BAT

W. M. F.—A cricket ball weighing 4½ ounces (0.28 pound) is bowled at a velocity of 30 feet per second. What must be the force with which the bat returns the ball, assuming that the velocity of the returned ball is 30 feet per second and that the time of impact of the ball against the bat is 1/80 second? The answer is 15.82 pounds.

A.—Either the answer is wrong or the problem is not stated correctly, as the following considerations show. The force of a blow is determined by the following formula, $ft = mv$, in which f = force of impact, t = time required to bring body to rest, m = mass of body (in this case, the ball), and v = velocity of ball, all quantities being measured in similar units. If the ball were perfectly inelastic and were thrown against a solid, smooth, stone wall, there would be no rebound and the entire time of impact would be absorbed in bringing the ball to rest. The striking force would then be $f = \frac{mv}{t} = \frac{wv}{gt} = \frac{0.28 \times 30}{32.16} \div \frac{1}{80} = \frac{0.28 \times 30 \times 80}{32.16} = 20.9$ pounds. This force is exactly the same as would be required to give the ball a velocity of 30 feet per second in 1/80 second, and is the smallest possible effect that could be produced by a ball having this weight and velocity. If the ball were perfectly elastic, it would first be flattened by the impact and would then expand to its original form, the time of compression and of restitution being equal. The time of compression is the time required to bring the ball to rest and equals $1/80 \times 1/2 = 1/160$ second. The ball would bound back with the same velocity it had when striking, and the force of the blow would be $20.9 \times 2 = 41.8$ pounds. Evidently, the effect of the bat is just this, since it returns the ball with the same velocity it had when striking. However, the ball is not perfectly elastic; hence it does not entirely regain its shape during contact. If we take the index of elasticity as 0.9, the velocity after impact is $30 \times 0.9 = 27$ feet per second, and the excess, $30 - 27 = 3$ feet per second, must be made up by the bat in 1/160 second; that is, the striking force must equal $41.8 + \frac{0.28 \times 3 \times 160}{32.16} = 45.97$ pounds. The time of compression and the time of restitution during impact are assumed to be equal in all cases. J. J.

* * *

We have been informed by the Greenfield Tap & Die Corporation that the statement in the description of the Greenfield "gun tap" as to the origin of the term is incorrect. It is not true that the term originated because this type of tap has been largely used in gun work, but it owes its name rather to the fact that the tap "shoots" its chips straight ahead in long, unbroken curls.

SPECIAL MACHINES FOR MAKING FUSE PARTS

MAXIMUM PRODUCTION OBTAINED BY THE USE OF HIGHLY SPECIALIZED MACHINES AND EQUIPMENT FOR DRILLING AND MILLING OPERATIONS

THE tremendous production required in the manufacture of munitions has led to the development of many special types of machines for performing various operations in a minimum amount of time and within the required limits of accuracy. Fuse parts are required in great numbers for shrapnel and high-explosive shells, and, as a consequence, the processes of manufacture have received the most careful consideration. Some of the parts which go to make up the fuse have a number of angular holes drilled in them, all of which are closely grouped within a small circle, so that the requirements are rather severe if the holes are to be drilled simultaneously. Even when the drilled holes are not angular their compactness necessitates the spindles with which they are drilled to be set in a very small compass. It is evident that in order to produce work of this kind to the best advantage, it is necessary to use machines capable of high spindle speeds and which are very nearly automatic in their action and not likely to get out of alignment. The machines illustrated and described in this article have been developed by the Langelier Mfg. Co., Providence, R. I., especially for use in the manufacture of fuse parts. The numerous angular holes, powder passages and wrench flats to be machined in these parts can be produced with great rapidity.

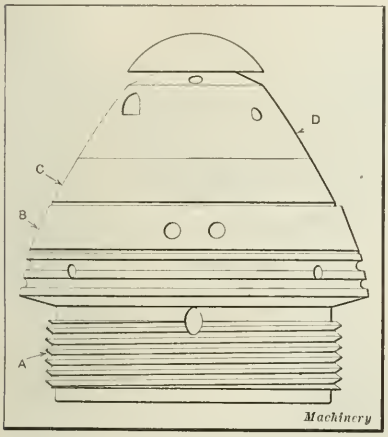


Fig. 1. Assembled View of Russian 75-millimeter Shrapnel Fuse

Fig. 1 shows an outline drawing of an assembled fuse for the Russian 75-millimeter shrapnel shell. In this illustration *A* is the fuse body, *B* is the graduated time train ring, *C* is the top time train ring, and *D* is the closing cap. Some of the other parts of the fuse are not shown in this assembly drawing, as they form a part of the inside construction, but they will be mentioned and shown in detail in a subsequent part of the article.

Machining Operations on Closing Cap

The closing cap, shown in detail in Fig. 2, is made from aluminum which has been die-pressed into a form that closely approximates the finished piece. The process employed in die-pressing castings was described in MACHINERY, January, 1916, in an article entitled "The Production of Die-Pressed Castings." After the castings have been die-pressed as mentioned, they are drilled, counterbored, formed, threaded, etc., on horizontal screw machines prior to the drilling and milling operations.

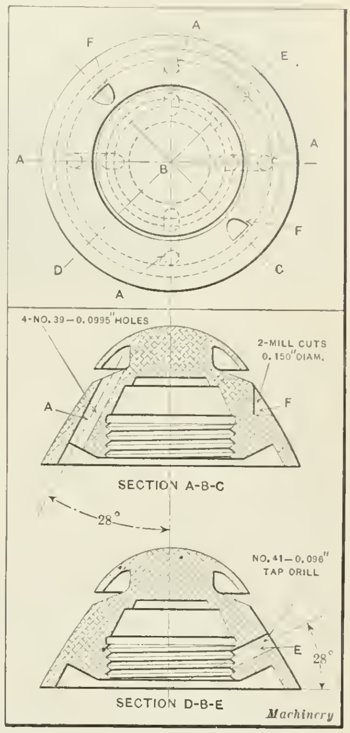


Fig. 2. Aluminum Closing Cap used on Shrapnel Fuse

Duplex Milling Machine for Closing Cap Wrench Notches

Referring again to Fig. 2, it will be seen that the section A–B–C shows one of the wrench notches *F*. These cuts are to be milled on opposite sides of the piece, as indicated in the upper view, and the machine shown in Fig. 6 has been especially designed for this work, so that both slots are milled simultaneously. Fig. 6 shows a view of the complete machine, while Fig. 4 shows a more detailed view of the working parts. Referring to Fig. 4, the closing cap *A* is located and held in position by a pressure spindle *B*. The head of the spindle is formed to fit the recess in the base of the cap, and no rotary location is necessary, because the milling operation is done prior to the drilling of the angular holes. The pressure spindle is actuated by a foot-treadle *C*, Fig. 6, having a link, lock-toggle and segment gear connection *D* to the spindle. An adjustable stop *E* is so arranged that the spindle movement can be easily adjusted to the proper milling position. A spring abutment bar *F*, having a sliding movement and located between the milling spindles, is used to hold the work against the pressure spindle while it is advanced to and from the correct milling position. The milling spindles *G* run in double taper adjustable phos-

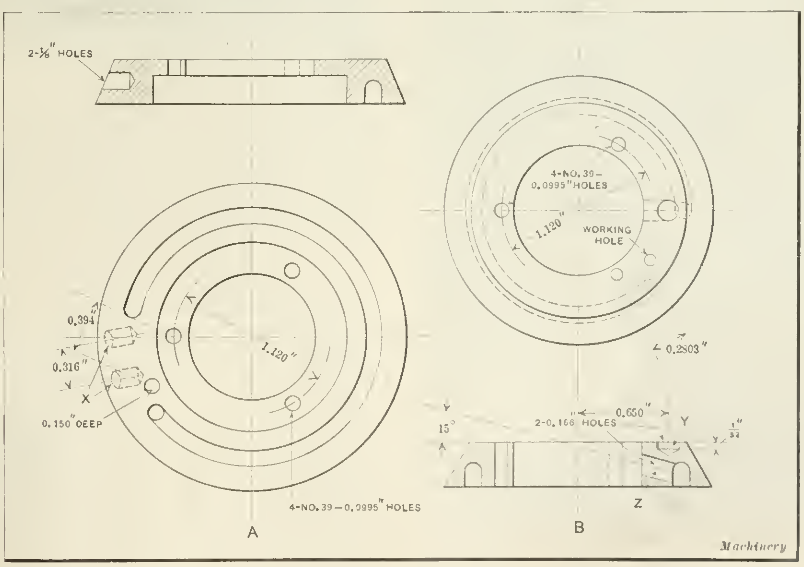


Fig. 3. Details of Graduated Time Train Ring and Top Time Train Ring on Shrapnel Fuse

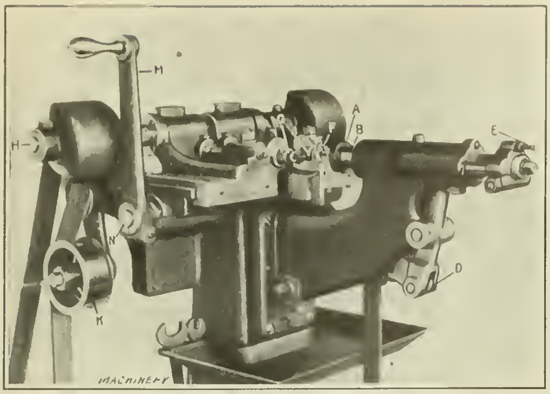


Fig. 4. Detail of Spindle and Operating Mechanism on Duplex Milling Machine for Closing Cap

phor-bronze bearings in cross-heads mounted adjacent to each other on saddles that feed crosswise to the axis of the spindles upon a long slide. These spindles are fitted with ball thrust bearings and the cross-heads are adjusted longitudinally so that the mills can be set to the required cutting depth. The spindles are driven by spiral gears from separate driving shafts on each side of the machine, these shafts being belted over the idler pulleys K to the countershaft L fastened to the column at the rear of the machine. The feed is actuated by hand-lever M mounted on the end of shaft N which is located lengthwise at the center of the saddle slide. The shaft has short lengths of right- and left-hand threads of coarse pitch that mesh with segment nuts fastened to each of the saddles and cause the milling heads to feed toward or away from each other in unison. Adjustable stops limit the amount of feed.

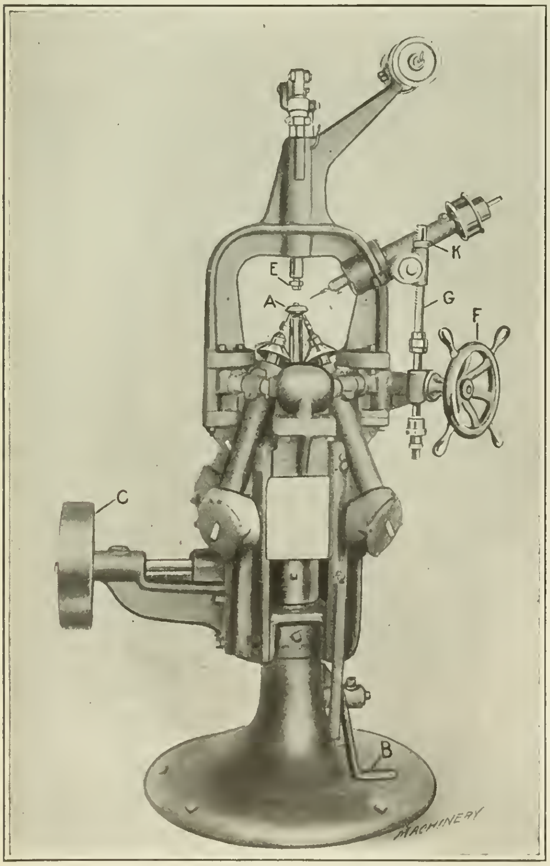


Fig. 5. Special Five-spindle High-speed Drilling Machine for Shrapnel Fuse Closing Cap

To operate the machine, the workman proceeds as follows: He locates the work on the head of the pressure spindle and holds it until it is brought into contact with the abutment bar, after which he advances the work to the milling position by depressing the foot-pedal and keeping it in this position. The milling is done by moving the hand-lever one-third of a turn downward, which advances the spindles toward each other, thus cutting the required slots in the work. After returning the hand-lever to its starting position, the operator releases the foot-pedal and holds his hand in such a position as to catch the work when it falls off the end of the work-

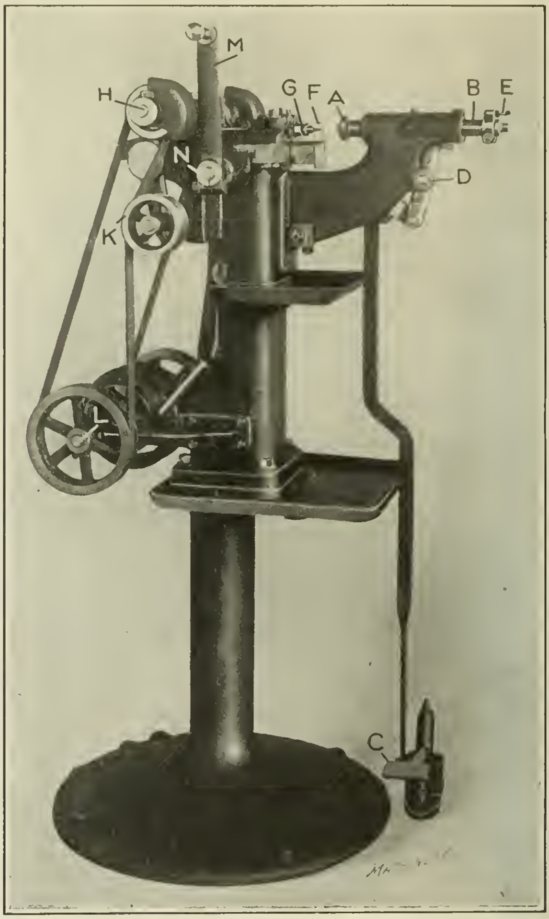


Fig. 6. Special Duplex Milling Machine for Wrench Slots in Closing Cap

holding spindle and breaks contact with the abutment bar. The machine is provided with belt tighteners and shifters and also a pan of suitable form for catching the chips. The end-mills are 0.150 inch in diameter and run at a speed of 2500 R. P. M. The output is five per minute, or 3000 per ten-hour day.

Five-spindle Angular Drilling Machine

Referring to Fig. 2, five angular holes A and E will be noticed. The holes A are at an angle of 28 degrees from the perpendicular, while the hole E is at 28 degrees from the base line. Fig. 5 shows a five-spindle high-speed drilling machine designed to drill all these holes simultaneously. The work A is located in the drilling position by a special jig with five drill guide bushings that is set on top of a central post which is vertically adjustable. The piece to be drilled is held on the jig by the pressure of plunger E which is operated by the foot-treadle B. The four lower drilling spindles are located 90 degrees apart and converge toward a common center, while the upper spindle is above the others and midway between two of them. The four lower spindles are driven

through bevel gearing by the main driving pulley *C* at the left of the machine. The upper spindle is belted direct to the countershaft through the pulley shown. All the drilling spindles are fed by the spider handwheel *F* in connection with a bevel gearing, rack and pinion mechanism *G*. The upper spindle feed can be disconnected from the lower so that the drilling position of each can be adjusted independently. The spindles are also provided with drill collets that are adjustable longitudinally for fine adjustments and to make up for the shortening of the drills caused by regrinding. An adjustable stop *K* is used on the vertical feed rack for limiting the drilling depth.

The jig is surrounded by a flared edge pan, and all gearing is encased or covered by suitable guards to prevent the chips from falling onto the lower spindles. The machine is driven by a separate countershaft running at 500 R. P. M. and the drills are speeded to 2000 R. P. M. The output of the machine is ten pieces per minute.

Machining Operations on Top Time Train Ring

Fig. 3 shows a detail drawing of the top time train ring at *B* and the graduated time train ring at *A*. These two pieces are both made from tobin bronze and are machined from the bar on a multiple-spindle automatic screw machine. The drilling of the four No. 39 0.0995-inch holes in each of the time train rings is done on a No. 2 Langelier multiple drilling machine illustrated in Figs. 7 and 9. Fig. 7 shows the entire machine, while Fig. 9 shows a detail of the drilling head with the various drills in position and the jig in place on the table. A machine of this type is also used for the bottom closing screw, the percussion primer screw and the percussion plunger (details of which are shown in Fig. 17), the jigs being arranged to suit the conditions, and the spacing of the holes. The spindles also must be arranged to fulfill the drilling requirements. Referring to Fig. 7, it will be seen that the spindle head carrying the various drills is arranged so that the cage acts as a flexible clamp which comes down upon the work after the latter is located in the fixture shown on the table. The cage also is provided with bushings through which the various drills pass, thus insuring their proper location. There are projecting prongs that exactly locate the parts to be drilled by pressure as the head comes down.

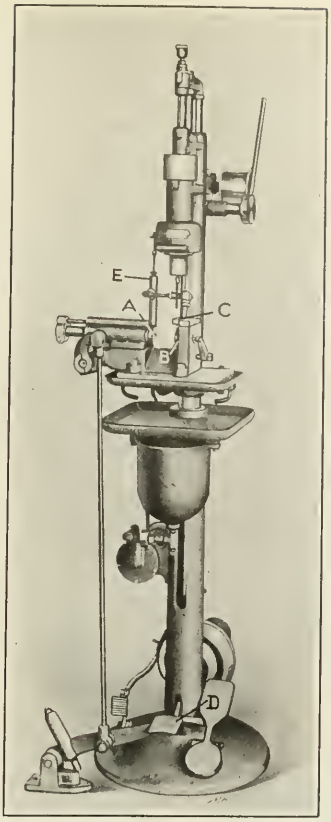


Fig. 8. High-speed Drilling Machine arranged for drilling Radial Holes in Graduated Time Train Ring

Fig. 9 shows clearly the construction at this point. Attention is called to the fact that lubrication of the drills is controlled by means of the spindle movement through arm *B* which actuates a valve through plunger *A*, thus opening and closing the supply pipe at predetermined points which can be regulated to a nicety by means of the check-nuts shown. The surplus lubricant drains off into the reservoir beneath the table, where it is strained and used over again, being forced through the pipes by the pump *D*, Fig. 7. When the output of any one of a number of parts is sufficient to keep a machine continuously in operation, a machine and head can be furnished as a unit to apply to this machine. If the amount of work to be done is not sufficient to keep one machine busy continuously, one or more heads with a different lay-out of spindles can be made to fit interchangeably on the same machine. The drill heads with their steadyrests are self-contained and may be readily interchanged.

In the construction of this machine the heads and drivers are made from phosphor-bronze and the drilling spindles are of a special steel which permits a deep case-hardening, so that they can be accurately ground to size, thus leaving a hard bearing surface with a tough but soft center. The feed is actuated by the hand-lever *E* in conjunction with a rack and pinion. The spindle pulley runs on sleeves anchored in the housing of the machine, thus avoiding pull of the belt on the main driving spindle. Loose perforated bushings are used in all running bearings, thereby increasing the wearing surface and insuring a free distribution of the oil. Reference to Fig. 7 will will show that the belt can be shifted from the tight to the loose pulleys by means of the operator's foot, this arrangement being very convenient in the high-speed production of parts. The production on the top time train ring *B* is three pieces per minute, while the graduated time train ring *A* can be produced at the rate of five pieces per minute.

Drilling Wrench Holes in Graduated Time Train Rings

Figs. 8 and 11 show, respectively, the machine for drilling the two holes *X* shown in Fig. 3, and a detail view of the work-table with the fixture in place. The type of jig used on this machine is designed to drill single or double holes in the periphery of cylindrical work at right angles to the axis. The construction of the jig is simple, consisting of a work-holding plunger *A* on which the

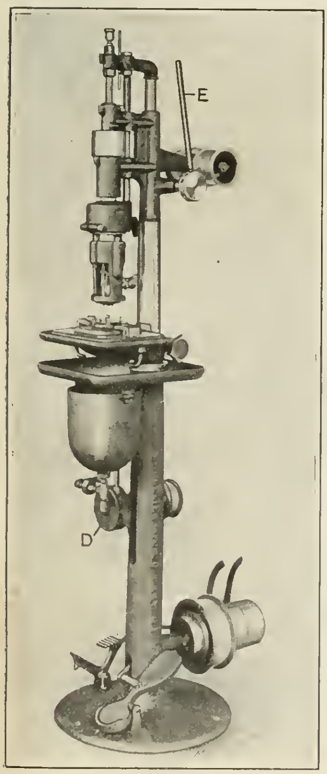


Fig. 7. Multiple-spindle Drilling Machine used on Graduated Time Train Ring

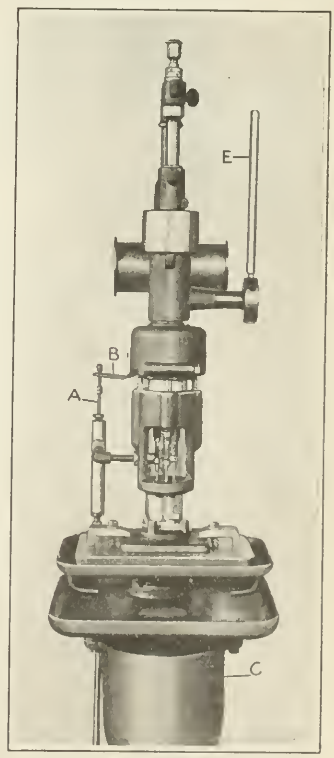


Fig. 9. Detail of Machine shown in Fig. 7

piece is located; an ejector; and a faceplate *B* on which is mounted a bushing plate *C* which locates the drills correctly with respect to the work. The jig is of the stationary type, being bolted to the drilling machine table. The plunger *A* is provided with a rack controlled by a gear segment operated by the foot-lever *D*. The plunger is brought forward against the faceplate *B*, thus securely clamping the work while it is being drilled. The plunger is returned to its original position by means of a compression spring inside the holder, and as it returns a pawl engages a ratchet in the shaft which carries the segment, thus bringing into action an ejector which automatically releases the work at the end of the stroke so that there is no interference in loading the next piece.

Both the plunger and faceplate are used in locating the work, the former being provided with a locating pin which engages a working hole in the ring while the faceplate is integral with the plug which fits the inside diameter of the work and locates it centrally. In operation, the work is slipped loosely onto the plunger and turned about until the pin and working hole engage, when a pressure of the foot-lever brings the plunger and work against the faceplate and under the drill spindle, simultaneously clamping the work. The drilling is accomplished by operating either the hand- or foot-lever. After drilling, the foot-lever operating the jig is released and the work automatically ejected. The rate of production is about 300 pieces per hour, using a carbon drill, as the material from which the pieces are made is bronze. The supply of lubricant is automatically controlled, as in the preceding instance, by the plunger which operates a valve in the barrel at *E*.

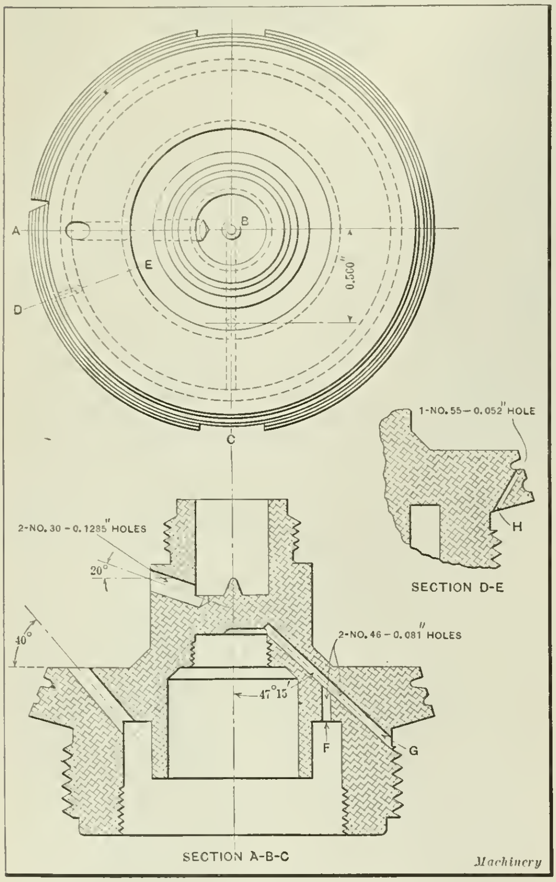


Fig. 10. Detail of Fuse Body

The holes *Y* and *Z* in the top time train ring are drilled one at a time on a No. 2 single-speed motor bench drill, a special jig being used; the net output is about six holes *Y* per minute and three holes *Z* per minute. The spindles on machines of this kind are driven directly by a belt from a 1/6-horsepower, alternating-current, 220-volt Holtzer-Cabot motor, giving a speed of 2500 R. P. M. The operation of the machine is similar to the type that was previously described.

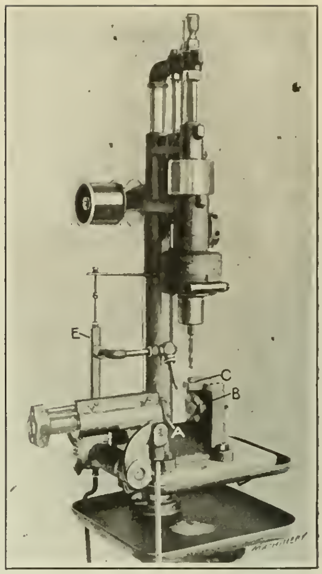


Fig. 11. Detail showing Jig Construction for Wrench Holes in Graduated Time Train Ring

The angular periphery of the timing train ring is graduated in seconds, starting at zero and running up to 21 seconds. The graduating of the timing ring is done on a special marking machine which was described in the article on shrapnel manufacture, MACHINERY, April, 1915.

Machining Operations on Fuse Body

The fuse body shown in Fig. 10 is made from a hot-pressed brass blank and is machined on an automatic screw machine in two settings. The first series of operations, in which the work is held by the small end in a collet chuck, consists in rough-forming the outer diameter and drilling out and trepanning the inside, performing the various operations on the inside of the work and finally cutting the thread on the outside. In performing the second series of operations on the fuse body, the work is located by being first screwed into a special bushing by means of which it is held in the collet. The remainder of the work on the small end of the piece is now finished in the same type of machine as that used for the first series of operations.

There are several holes to be drilled in an angular direction in this piece of work, the arrangement for drilling one of these being clearly shown in Figs. 12, 13 and 14. The machines used for these operations are of the high-speed ball bearing type. They can hardly be termed special machines, as they will not become useless if the present demand for shells should suddenly cease.

Referring to Fig. 12, *A* shows one of these machines of the single-spindle type arranged especially to drill the hole *F* in the work shown in Fig. 10. This hole must be drilled parallel

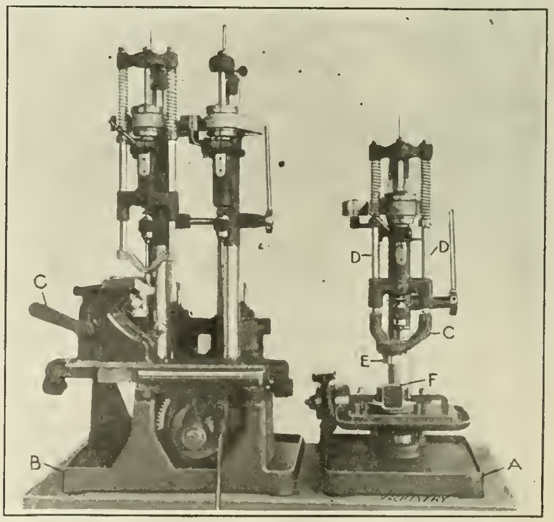


Fig. 12. Single-spindle and Gang Drills used for Straight and Angular Work on Fuse Body (Work removed)

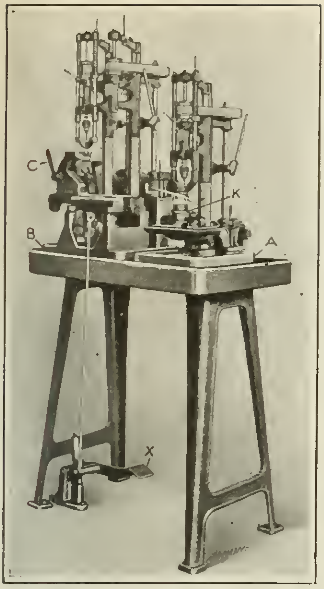


Fig. 13. Gang and Single-spindle Drilling Machines for drilling Fuse Body, showing Work in Position

with the axis of the fuse body and at a distance of 0.560 inch from the center line. This machine is almost identical with the regular No. 1 high-speed drill produced by the Langelier Mfg. Co., but a jig *C* is attached to the sliding rods *D* parallel to the axis of the spindle. It will be seen that the drill jig is thus located directly underneath the chuck and that the drill runs in it in a hardened and ground bushing. In the jig, a hardened plug *E*, having the same diameter as the inside of the work, locates the fuse body at the proper center distance, and a locating pawl (more clearly shown at *K* in Fig. 13), provided with a trigger, engages a slot in the rim of the work, thus insuring the correct location of the drilled hole. The floor plate or body of the jig *F* is clamped to the drill table directly under and in line with the locating plug, sufficient room being allowed between it and the jig to permit the operator to work rapidly without interference. In loading, the spindle is brought to the normal or upper position shown in Fig. 12, while the left hand of the operator depresses the trigger on the locating pawl. The work is then placed on the plug and the trigger released while the piece is twirled until the pawl engages the slot. The spindle is now lowered and the lower face of the fuse body *L* comes in contact with the floor plate as shown in Fig. 13. The springs on the side rods of the jig hold the piece securely while the spindle is brought down. After the drilling operation has been completed, the spindle is raised to its normal position and the drilled work removed.

The advantages of a jig of this kind are readily apparent, as the work to be machined is loaded in such a position that little trouble is likely to be caused by chips. There are no blind corners or pockets in which the chips may accumulate, so that the cleaning is very easily done. Another point worthy of note in connection with this method of drilling is that when the work is in place, the point of the drill is only 1/16 inch from the work, so that it enters the piece almost immediately after the work is clamped. Another advantage lies in the fact that the operator wastes no time in bringing the drill bushings into line with the spindle after loading, as is usual with the detached type of jig.

A machine of this type can readily be adapted to other classes of work by merely constructing a jig suitable for the piece to be machined and securing the jig to the sliding rods. Practically any number of holes may be handled economically, provided they are in a circle and of the same radius. By removing the jig and sliding rods entirely, the machine may be used as a regular high-speed bench drill. As a matter of fact, it is a high-speed drilling machine which can be readily adapted to many kinds of work, and the unit construction of machines and jigs which can be easily arranged to suit a given condition will appeal to any manufacturer having large quantities of work to be machined at a minimum of expense.

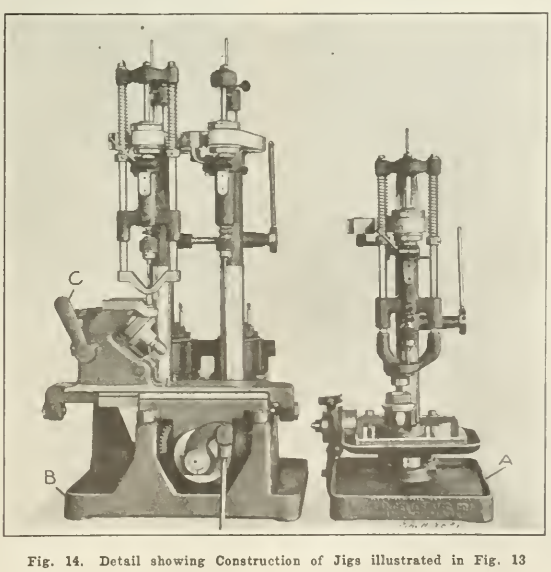


Fig. 14. Detail showing Construction of Jigs illustrated in Fig. 13

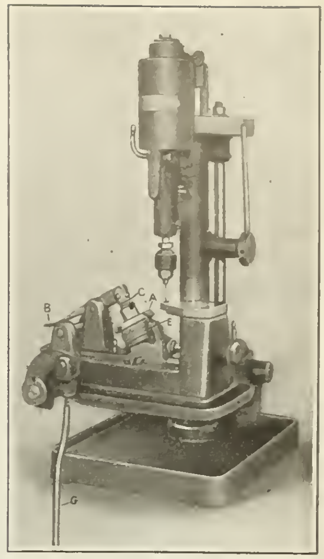


Fig. 15. Machine used for drilling Angular Hole in Fuse Body

The machine shown at *B* is of the two-spindle gang type, designed to handle work requiring drilling, counterboring or reaming at one setting or for drilling several holes having very close center distances, so that it is not possible to have two or more spindles perform the drilling operations simultaneously. If desired, one of the spindles can be slowed down for reaming or other operations requiring a slower speed than drilling. In the example shown, however, the spindles are run at a uniform speed of 5000 R. P. M. Reference to the illustrations will show that the machine is really composed of three units, consisting of a two-spindle gang drill, a bed, and a carriage, the latter combining the features of a jig in its construction. Should it be desired to use the machine as a two-spindle gang drill only, a table may be substituted for the jig and slide. Another departure from the usual practice lies in the fact that both spindles are operated by one feed lever, thus effecting a considerable saving in time over machines having independent feeds on both spindles. It has been found that in the majority of cases one independent adjustment is sufficient for the reaming or counterboring operations, so that the reamer or counterbore can be adjusted to the proper depth of cut while the drill is set at a suitable height to correspond with it. When it is necessary to make accurate adjustments, micrometer collets or independent stops can be used.

In operation, the work is loaded with the jig as shown under the left-hand spindle, and the first operation is completed by feeding the spindle down. After the first operation has been accomplished, the spindle is elevated and the foot-lever shown at *X* in Fig. 13 is pressed by the operator so that the jig is carried under the second spindle for the next operation. By releasing the foot-lever, the carriage automatically springs back to the first position, pneumatic buffers absorbing the shock as the carriage strikes the stop. The stops on each end are adjustable to compensate for wear, and the gibs on each side of the bed can be adjusted to take up the wear on the carriage so that it can be correctly aligned.

In ordinary process, when a detached type of jig is used, slip bushings are commonly provided for the jig where tools of different diameters are required to complete an operation. In this machine, however, a steady jig is provided for the first spindle, which carries a slip bushing in which the drill is running all the time the machine is in operation. A liner bushing is provided in the jig proper so that the slip bushing enters the liner as soon as the spindle is depressed. When the carriage is transferred to the second station, the stops are so arranged that it comes to rest with the drill hole directly under the spindle, and it may be readily seen that accurate results are thus obtained without the use of a second slip bushing. It is obvious that the liner bushing is made large enough so that the second tool clears the sides by a safe margin.

Jigs for Angular Hole in Fuse Body

The operation performed by the two-spindle gang drilling machine *B* is the drilling and counterboring of the 0.081-inch hole *G* at an angle of 47 degrees, 15 minutes from the vertical center line, the hole being required to meet the 0.081-inch hole

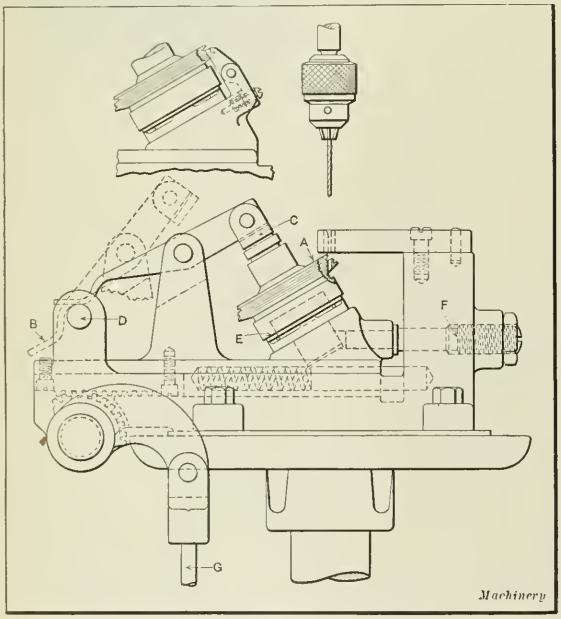


Fig. 16. Detail of Fixture shown in Fig. 15

F previously drilled by the single-spindle machine *A*. The work is located in much the same manner as on the single-spindle drilling machine, by means of a hardened plug, while a locating hole provides the correct alignment for the two holes. The method of clamping in this instance, however, is accomplished in a somewhat different manner: the hand-lever *C* at the front of the jig operates a toggle joint which, in turn, actuates a fulcrumed jaw. In clamping, the hand-lever brings the toggle joint a trifle beyond the dead center, securely locking the piece against a floor plate which is integral with the locating plug. The counterbore on the second spindle enters the drilled hole and counterbores this to a depth of 0.100 inch and to a diameter of 0.125 inch. In this connection it is of interest to note that during the automatic return of the carriage, an expert operator can remove the finished work before the carriage comes to rest at the first station, so that a minimum amount of time is lost between the cuts. It must not be inferred from this that the return movement of the carriage is slow, but the general design is such that the operator has both hands free at this time, and can therefore handle the piece very rapidly. The shock of the return stroke of the carriage is regulated by a pneumatic buffer, while the automatic return of the carriage can be adjusted to a slow or fast rate of movement by turning a drum that carries a flat spiral spring.

Adaptation of Single-spindle Drilling Machine for Drilling an Angular Hole in the Fuse Body

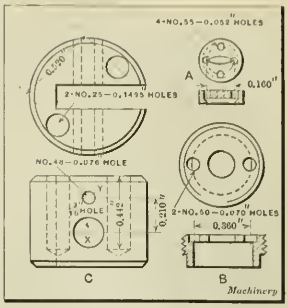


Fig. 17. Detail of Fuse Parts. (A) Concussion Primer. (B) Percussion Primer Screw. (C) Percussion Plunger

Fig. 15 shows one of the high-speed sensitive drilling machines arranged with a special high-speed jig for drilling the hole *H*, Fig. 10, in the fuse body. Fig. 16 shows a construction drawing of the jig. The hole for which this jig is adapted is 0.052 inch, drilled at an angle of 30 degrees from the vertical axis through the flange of the fuse body. Owing to the fact that the hole starts at an extremely steep angle, and is located against a floor plate and plug by the inside diameter of the work, it is necessary to so design the jig that the bushing can be brought very close to the work and at the same time allow space for loading and unloading. By making the locating and clamping device on the sliding principle operated by a foot-lever, segment and rack, this difficulty is easily overcome. The slide and bed are scraped to a bearing with gibs to compensate for wear.

As in all other drilling operations on the fuse body, the hole is located from a notch in the rim of the flange, the locating pawl (shown in Fig. 16), engaging with this notch to insure proper location. The spring tempered bar *B* carrying a floating jaw *C* is pivoted to the slide in such a way that when the latter is brought under the bushings, the feathered end of the spring bar rises on a cam *D* and brings the jaw firmly down on the work, clamping it against the floor plate *E* while the adjustable stop *F* locates the slide in the proper place under the bushing. In operation, the work is located on the plug with the slide back and is twirled around until the locating pawl engages, after which it is pressed down against the floor plate by the action of the spring bar as the slide is carried forward under the spindle. The foot-lever,

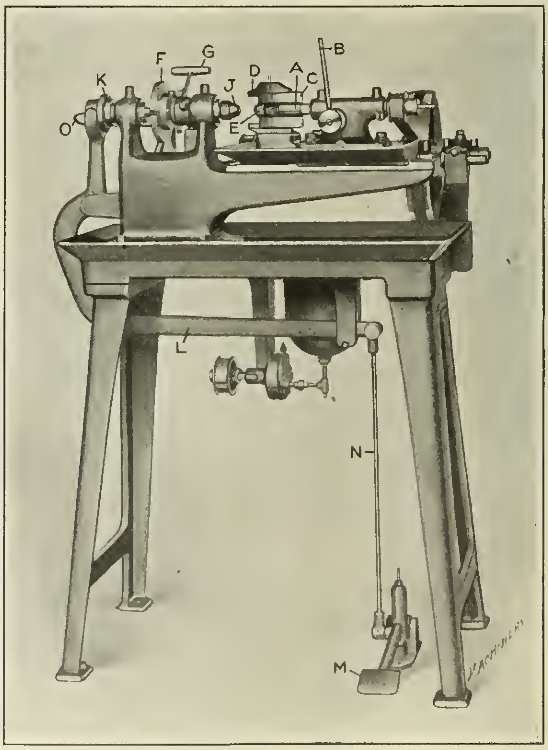


Fig. 18. Front View of High-speed Horizontal Drilling Machine with Indexing Attachment, used in drilling Concussion Primer

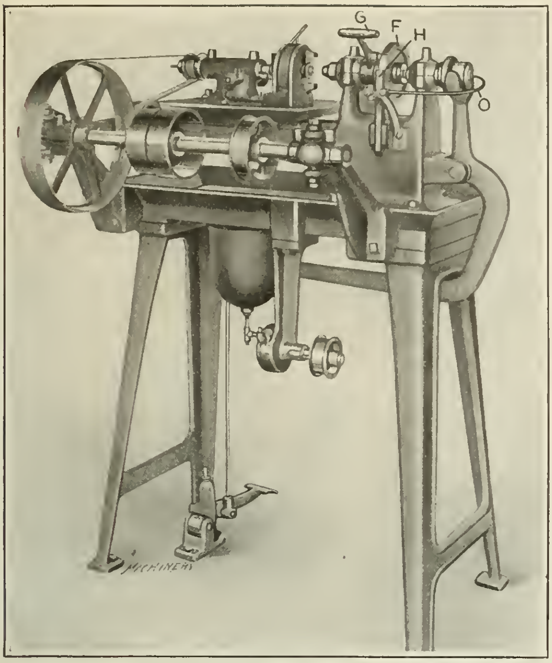


Fig. 19. Rear View of Machine shown in Fig. 18

being connected to the rod G, operates the entire mechanism. and as it is released after the drilling operation, the slide springs back to the loading position, releasing the work so that the operator can readily supply the jig with another piece. The output on this machine with the mechanism shown and using carbon drills is about 350 pieces per hour, and the drill speed is approximately 9000 R. P. M.

Machining Operations on Concussion Primer, Percussion Plunger, and Percussion Primer Screw

The concussion primer, percussion plunger, and percussion primer screw are made of brass and are machined, prior to drilling, on automatic screw machines. Referring to Fig. 17, A shows a detail of the concussion primer. Figs. 18 and 19 show, respectively, the front and rear views of the high-speed light drilling and indexing lathe designed especially for drilling the four holes in the piece mentioned.

The drilling is done by a light, sensitive spindle A which is fed by a hand-lever B at the front of the tailstock. The chuck end of the sleeve is provided with a sliding steadyrest C that travels in a guide D. In this steadyrest is a drill bushing E that supports and accurately starts the drill. In drilling, the steadyrest is fed up until it comes to a stop against the work being drilled, while the drill itself continues and performs the drilling operation. The spindle pulley runs on a sleeve clamped into the rear end of the tailstock and drives the drilling spindle by means of a double keyed collar fastened to the pulley, insuring a sensitiveness that is very desirable when drilling small holes. The spindle is driven by a 1-inch seamless belt from a countershaft fastened to the back of the machine, in connection with which a belt tightener is provided.

The headstock is a casting having an extending slide upon which the tailstock can be adjusted to its proper drilling position. The spindle in the headstock is provided with a four-notch index wheel F that is actuated through a ratchet and pawl by means of a hand-lever G, so as to bring each of the four holes in the percussion primer successively into line with the drilling spindle. The spindle is locked during the various drilling operations by the lever H shown in Fig. 19. A transverse adjustment to the tailstock makes it possible to locate it in any desired position, so that holes can be drilled in various diameters of circles. The spring chuck J is controlled by a sliding thimble connection on the left end of the machine, this spindle being actuated by the long bent lever L which passes underneath the table and is connected by means of a link rod N to the foot-pedal M. The chuck is closed by a heavy compression spring when the operator removes his foot from the pedal. After being drilled the work is automatically ejected by a jet of compressed air provided through a small shut-off valve that is open only during the interval that it takes to move the index wheel. The valve is connected to the rear end of the spindle by a brass tube O. The output on this machine is four completely drilled pieces per minute, or 240 per hour. The drill size is No. 55, 0.052 inch, and the drills are especially tempered and run at a speed of 6000 R. P. M.

Machining Operations on Percussion Plunger

Owing to the fact that the holes X and Y in the percussion plunger C, Fig. 17, are only 0.210 inch apart, it would be difficult to drill them simultaneously from the same side of the piece. Hence, the two-spindle opposed drilling machine shown in Fig. 21 was designed. The work-holding fixture is in the form of a vise, the jaws of which can be seen at E in Fig. 21, and it is only necessary for the operator to insert the pieces to be drilled between the jaws. In order to do this the work is placed on the end of the reciprocating pressure plunger A that slides in a holder fastened to the air cylinder on the front of the machine, and that is actuated by a foot-pedal B through a rack and pinion. As the foot-pedal is depressed, the work is advanced between the vise jaws to its proper drilling position. The operator then raises the feed lever C so as to feed both drilling spindles toward the piece from each side at the same time. As the feed lever is elevated, an air valve is automatically opened, letting compressed air at about 45 pounds pressure per square inch into an air cylinder F fastened to the front of the machine underneath the vise. The upward movement of a piston in this chamber causes a U-shaped yoke attached to it to close the vise upon the piece to be drilled. After the drilling operation has been completed, the return of the feed lever causes the air valve to exhaust

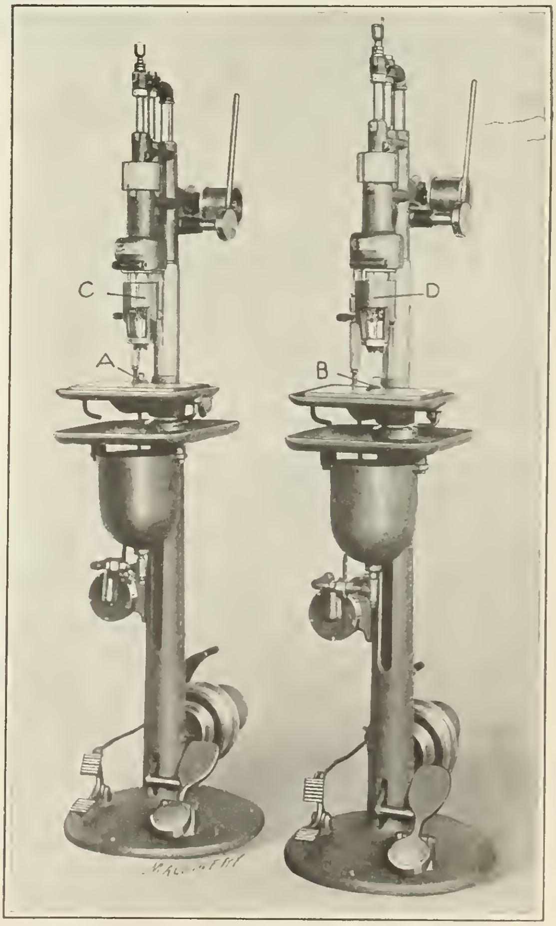


Fig. 20. Drilling Machines that drill Two Holes in Percussion Plunger

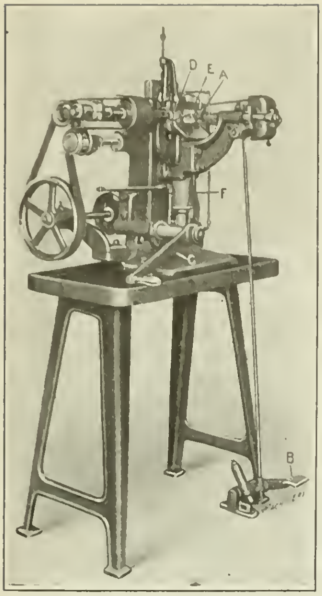


Fig. 21. Duplex Drilling Machine for Percussion Plunger

the cylinder automatically and the vise jaws to open. The foot-pedal is now released, causing the pressure plunger to return to its loading position. The exhaust air from the cylinder is piped to blow away and clear the vise of chips after the piece has been ejected from the vise.

The drilling spindles are belted over idler pulleys to a driving shaft at the rear of the machine. All pulleys and the driving shaft run on ball bearings. In order to avoid the use of a crossed belt for driving the right-hand spindle, a three-pulley construction is used that reverses the motion by driving from the back of the belt. One of the quarter-turn pulleys for each acts as a tightener. The method of feeding the drilling spindle is by means of the hand-lever C, connected to a shaft which, in turn, is geared to a vertical slide at the rear of the machine. This slide carries two wedge cams that are fastened to the inner ends of feed yokes, the outer ends of which have a clamp connection to the drilling spindle, this connection being used to set the spindles to their proper drilling positions. A stop is provided for drilling to the required depth, which is adjustable to suit any normal condition. In this instance, the left-hand spindles that carry the 3/16-inch drill run at 2666 R. P. M., while the opposite spindles, having a No. 48 drill, run at 3838 R. P. M. Under a test an unskilled operator maintained an output of five pieces per minute on this machine.

Drilling and Reaming Two Holes in Percussion Plunger

The drilling and reaming of the two holes in the percussion plunger are performed on two Langelier No. 2 multiple drilling machines having special jig heads attached to the spindles as shown at C and D in Fig. 20. The tables are provided with fixtures having rectangular pieces A and B which enter the slot in the work, and it is centered by means of the projecting points on the drill head, while it is held in place by the spring as in the other instances. The production on this piece is about three pieces per minute. The percussion primer screw shown at B in Fig. 17, is drilled on the same type of machine with a suitable jig. The production on this piece is about four pieces per minute.

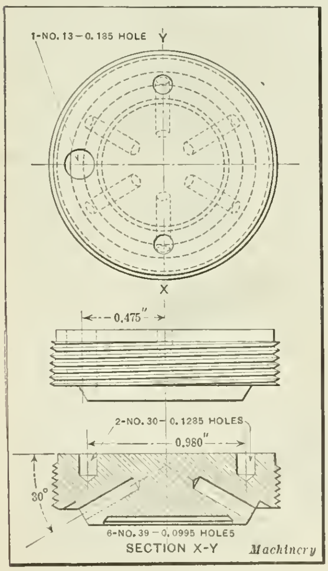


Fig. 22. Detail of Bottom Closing Screw

Machining Operations on Bottom Closing Screw

The bottom closing screw is also made of brass and is machined complete from the bar on an automatic screw machine prior to drilling. A detail of the piece is clearly shown in Fig. 22, in which it may be noted that there are six holes angularly placed in the piece and converging to a common center. These holes are to be made by a No. 39 0.0995-inch drill, and the machine designed especially for doing this work is shown in Fig. 23. The work is located in the drilling position by means of a jig head A that is mounted centrally among the drilling heads. The inner terminal of travel of the jig is the drilling position, while the outer terminal is the loading and ejecting position. This arrangement is made in order to facilitate the jigging of the work and also to protect the operator's hands from contact with the drills. The traveling spindle is actuated by the operator through a push-treadle B by means of a rack and pinion connection to the rod shown. The work is held in its correct position in the jig by an abutting spring plunger C that carries two pins which enter the No. 30 0.1285-inch holes that have been previously drilled.

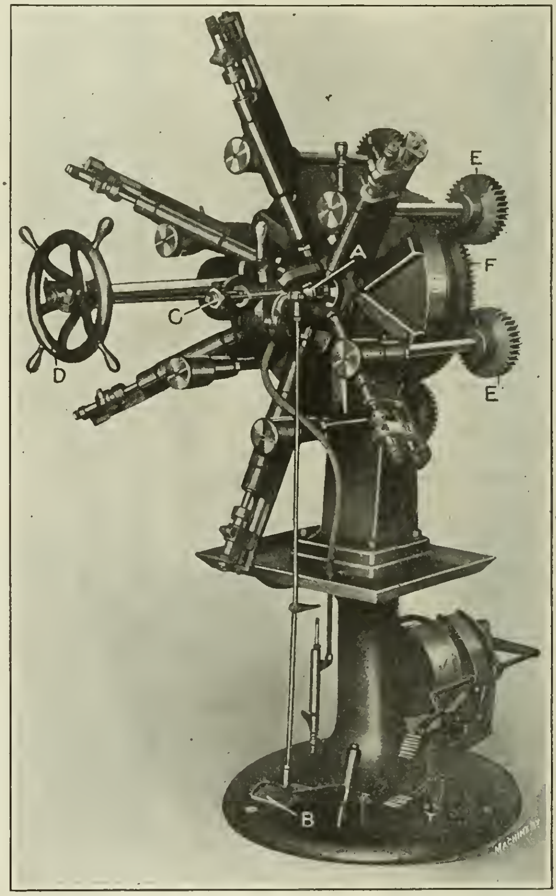


Fig. 23. Six-spindle High-speed Drilling Machine for drilling Angular Holes in Bottom Closing Screw

The feed of the drilling spindle is actuated by the handwheel D mounted on the end of a pinion shaft that meshes with a rim gear located inside the faceplate to which the drilling heads are attached. The rim gear carries segment cams which engage with roll levers that actuate the yoke. The spindles are driven by spiral gears, the drivers of each head extending to the rear and meshing with the main spindle driving gear F. The running thrust of the driver shaft is taken by ball thrust bearings.

The various machines described and illustrated in this article form a group which has greatly reduced the cost of production on fuse work, and while some of the machines have been designed entirely for increasing the production on the work shown, others are very similar to the standard type of machines built by the Langelier Mfg. Co., with special features to suit the particular cases shown throughout the article.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

CLEVELAND FULL AUTOMATIC MOTOR-DRIVEN MACHINE

There are numerous automatic screw machine operations in which it is desirable to make a change of speed during the operation, typical examples being found in cutting off, forming parts from square or hexagon stock, drilling, reaming, etc. To secure increased efficiency through the possibility of effecting such a change in speed, an automatically controlled motor drive has been developed for use on Cleveland automatics with provision for making any required changes of speed during the performance of a single operation or between successive operations. It consists of a controller box with levers that are actuated by cams on a drum, the cams being set in suitable relation to the tools so that speed changes will be made at the proper points in the cycle of operations.

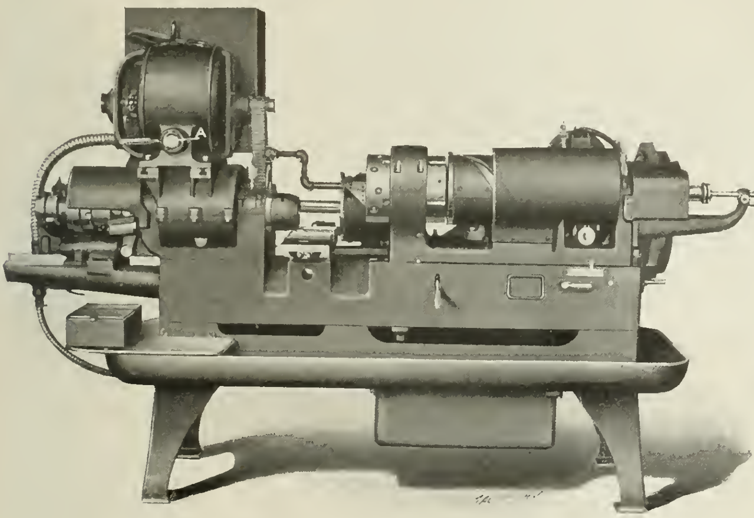


Fig. 1. Front View of Cleveland Full Automatic Motor-driven Machine

The Cleveland Automatic Machine Co., Cleveland, Ohio, has recently developed an automatically controlled motor drive for use on automatic screw machines of its manufacture, which is the means of increasing efficiency of operation and rate of production. Figs. 1 and 2 show one of the new machines equipped with the automatic motor drive, from which it will be seen that the design is the same as that of the well-known Cleveland automatic with the exception of the electrical equipment. This consists of a three-to-one variable-speed, quick-reversing inter-pole motor, direct connected by a silent chain to the spindle driving gears. The speed range of this motor is doubled by means of two sets of driving gears in the spindle head, either one of which may be automatically engaged. At the other end of the machine is a small constant-speed, compound-wound pilot motor which is direct connected by a silent chain to the feed driving mechanism and oil pump of the machine. Two motors are used, because the drive of the spindle is entirely independent of that of the feed, which gives the advantage of being able to obtain any one of a large number of different spindle speeds without in any manner affecting the feed mechanism of the machine. This is the most important gain to be had in a motor-driven machine over that of the belt drive, as it means the possibility of the correct peripheral speed for each tooling operation and therefore increased output.

The machine is controlled by means of a push-button for both starting and stopping. Directly back of the large motor is a panel upon which are mounted accelerating units for both motors, an overload relay coil for each motor, and the automatic main switch. On account of the fact that all the electrical equipment is wired as a unit, one push-button controls the starting and stopping of both motors; and an overload on either motor instantly stops the entire machine. No fuses are required in any part of the apparatus. Referring to Fig. 2, at the extreme right-hand end of this view may be seen the speed control apparatus. This is a cast-iron box A containing thirteen levers, eight of which are for the purpose of regulating the speed of the variable motor; three are for controlling the direction of rotation, either forward, reverse or stop; and two are for shifting a clutch by means of a double-acting solenoid. Directly above the speed box is a cam drum B upon which are mounted small adjustable cams which operate the levers in the speed box A.

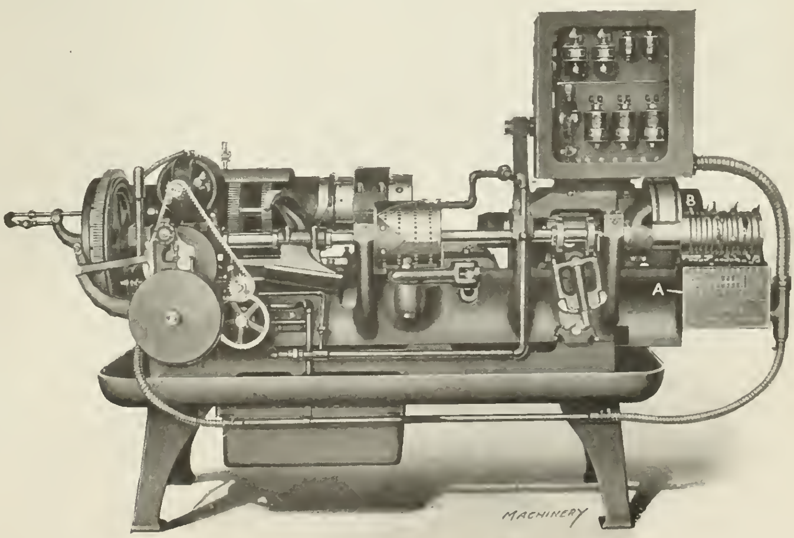


Fig. 2. Opposite Side of Machine, showing Arrangement of Automatic Speed Control

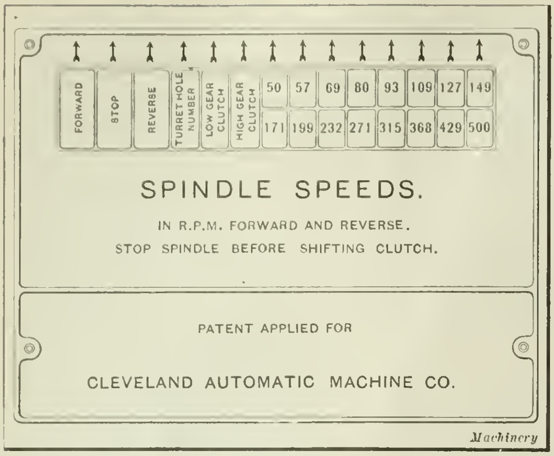


Fig. 3. Plate on Speed Control Apparatus that serves as Guide in setting Cams

Fig. 3 is a diagram showing exactly what may be obtained by means of the mechanism just described. The arrows at the top of Fig. 3 point directly to the cams above them on the machine, showing which cam should be used to obtain any one of the speeds or direction indicated. The speeds which are obtainable on the 2-inch machine are here indicated, and it will be noted that there are sixteen different speeds from the lowest, which is 50 revolutions per minute, to the highest, which is 500 revolutions per minute, and that these speeds step up in regular progression. All these speeds may be used in either direction or the spindle may be stopped dead if desired for any purpose, all this being done without in any way interfering with the feed control of the machine. Any one of the entire range of speeds in either direction may be thrown into engagement at any time, as the act of tripping in any speed automatically throws out the speed which was previously engaged, and no harm can come at any time by accidentally engaging two or more speed levers at the same time.

Fig. 4 is a speed curve plotted according to the speeds shown in Fig. 3; and a diagram of the spindle drive is also shown at the left-hand side of Fig. 4. Table I shows available surface speeds in feet per minute on bar stock of ½ to 2½ inches diameter. The enormous range of surface speeds obtainable on one size of machine, such as is here shown, will be readily appreciated. Fig. 5 is a diagram of the cam drum *B*, Fig. 2. This drum is graduated into five different spaces which are numbered from 1 to 5, as indicated. These spaces on the cam drum correspond to the numbers of the tool holes in the turret of the machine, so that in setting up the operator can tell at a glance the relative position on the cam drum which would give the desired spindle speed at the time any one of the turret tools came into operation. In the illustration accompanying Table II is shown a piece made from 2-inch hexagon cold-rolled steel, finished complete as shown on this machine; the total time was three minutes, forty-five seconds. Another piece is shown at *B* made from 1½-inch square cold-rolled steel. The time for making this piece was one minute, forty-five seconds; and the operations on this piece were as shown in the table.

Referring to Fig. 1, it will be noted that this machine is so designed that the electrical apparatus is out of the operator's way, and also that it cannot be damaged by the large quantity of oil and chips which are always closely associated with the operation of automatic machines. The push-button *A*, Fig. 1, which entirely controls the starting and stopping of the machine, is in a convenient location and is of a type which is indestructible. All the electric wiring is enclosed in conduits, part of which are flexible in order to allow of adjustment of the position of the motors to obtain the correct tension on the silent driving chains.

With this machine an operator has adjustable spindle speeds and also adjustable feeds for all tools, without the necessity of making any special cams for any work within the range of the machine. There is nothing difficult about making any of the cam adjustments, and all cams are readily accessible. This is one of the great points of the Cleveland automatic, making it possible to change over quickly and easily from one job to another, and always be sure of obtaining the correct speeds needed for every tooling operation, whether the lots to be run out are small or large.

Notes on Tooling

When using a forming tool on the cross-slide a very high rate of peripheral speed may be used while hogging off the stock, and when almost down to size the speed and feed may be momentarily lowered, which will have the effect of producing a smooth forming cut. In the case of forming into square or hexagon stock, a slow spindle speed may be used while the corners of the stock are being removed by the forming tool, and when the tool gets past the flats on the stock the peripheral speed can be increased to any extent desired. The possibility of so regulating the spindle speed for certain conditions is of great value. In threading with a tap or die, a very low peripheral speed and powerful drive is instantly available, and at the end of the threading operation the spindle may be reversed at high speed to back off the tap or die quickly. The line voltage may vary ± 20 per cent without in any manner affecting the relative speed necessary between

TABLE I. AVAILABLE SURFACE SPEEDS IN FEET PER MINUTE

Diameter of Stock, Inches	Speed of Spindle in Revolutions per Minute for Controller Positions															
	50	57	69	80	93	109	127	149	171	199	232	271	315	368	429	500
½	....	....	....	....	....	14.3	16.5	19.5	22.4	26.1	30.4	35.5	41.5	48.2	56.3	65.5
1	....	14.9	18.1	21.0	24.4	28.5	33.3	39.0	44.8	52.2	60.8	71.0	82.8	96.5	112.5	131.0
1½	19.6	22.4	27.2	31.4	36.4	42.9	49.9	58.6	67.2	78.3	91.3	106.6	124.2	144.6	168.9	196.5
2	26.2	29.9	36.2	42.0	47.2	57.1	66.5	78.2	89.6	104.2	121.5	142.0	165.5	193.0	225.0	262.0
2½	32.7	37.3	45.2	52.4	60.9	71.5	83.2	97.5	112.0	130.5	152.0	177.5	207.0	241.0	281.0	328.0

Machinery

NOTE: Metbod of selecting spindle speed which ebould be used to obtain surface speed in feet per minute for any diameter required $\text{R.P.M.} = \frac{S \times 3.819}{D}$. S = surface speed in feet per minute. D = diameter of stock.

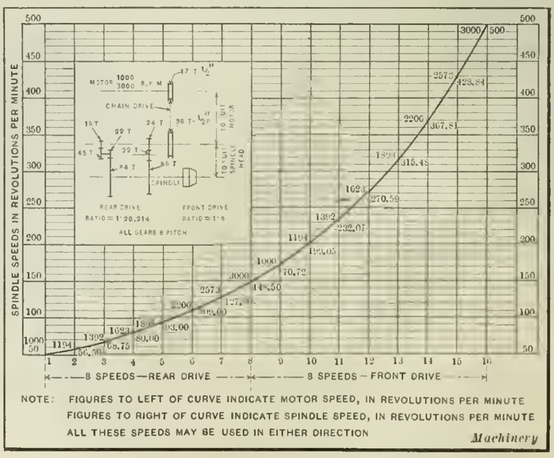


Fig. 4. Spindle Speed Curves and Diagram showing Arrangement of Geared Drive

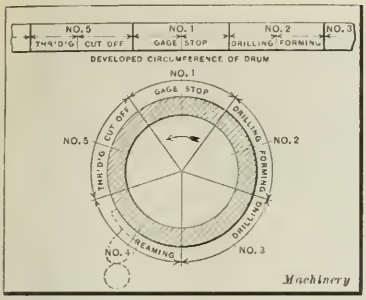


Fig. 5. Divisions on Controller Drum, showing Positions of Tools and Cross-section through Drum

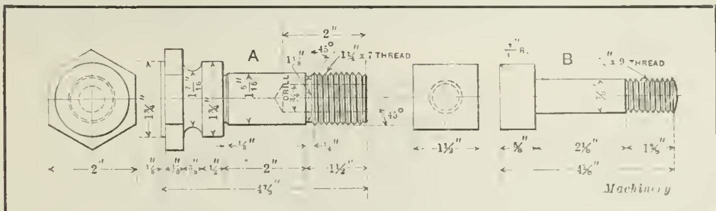
the threading tool, which is controlled by the small pilot motor, and the spindle, which is controlled by the large variable-speed motor. This is accomplished by means of a special adjustment of the electrical apparatus.

For drilling operations, excellent results are obtained with this machine on account of the fact that, regardless of the diameter of the drill, a speed may always be picked out that will be just right. Similarly, for removing stock with a box-tool, an enormous gain in time is made by using a very high peripheral speed. The same holds good with reaming operations. In any case, a speed may always be selected to suit the kind of material or the amount of stock desired to be removed and still produce a fine finish. For operations such as cross-drilling, the spindle may be instantly stopped dead and held there for any desired length of time. On account of the ease with which the spindle may be stopped and started at any moment, it is stopped for feeding the bar through to the gage stop when desired.

The cutting-off operation, which usually consumes much time and is to a great extent a source of trouble, is accomplished with ease and quickness on this machine, and a good job is always obtained. The reason for this is that the peripheral speed at the point of the cutting tool is held practically constant at all times. This is accomplished by throwing in one speed after another as the cut-off tool approaches the center of the work, increasing the spindle speed step by step until the work is cut off. By this means the cutting off can be accomplished very much more quickly than is possible when the spindle speed is held constant during the entire cutting-off operation. The machine may be equipped with motors for either 110- or 220-volt direct current.

This combination of an adjustable speed control which enables the speed to be varied during the performance of any one operation or between successive operations, makes an unusually efficient means of handling automatic screw machine work when combined with the adjustable feed control which is a regular feature of all Cleveland automatics. As most readers of MACHINERY know, the rate of feed on these machines is governed by cams on a feed control drum, two of these cams being provided for each tool on the machine. By making a suitable setting of the cams, the rate of feed may be made uniform for the entire operation performed by a given tool or the cams may be set at different angles on the drum in order to obtain a change of feed during the performance of the operation. Combining the automatic adjustable speed control with this feed control has provided an equipment particularly well suited for handling all classes of work.

TABLE II. EXAMPLES OF WORK FOR WHICH SPEED VARIATION IS PARTICULARLY BENEFICIAL AND OPERATIONS INVOLVED IN PRODUCING PIECE B



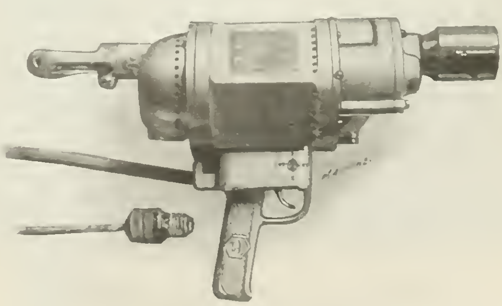
Operation	Time in Seconds	Revolutions per Minute	Feed, Inch per Revolution	Surface Speed, Feet per Minute	Amperes at 110 Volts
Milling	60	308	0.012	0.120	28
Forming	Formed during milling	190–308	0.006	60–160	32
Threading	12	90	.....	21	8
Cutting off	14	308–500	0.006	120	28
Idle movement	19	......	.....	......	4
Total	1 minute 45 seconds				

BLACK & DECKER ELECTRIC DRILL

The important feature of a portable electric drill which is now being made by the Black & Decker Mfg. Co., Baltimore, Md., is the provision of a pistol grip and trigger switch control, which is said to greatly reduce the liability of breaking small drills. On this tool, the switch is operated by the index finger of one hand without requiring the grip on the handle to be released; as a result, the operator is able to maintain a steady "aim" at all times, and when the drill breaks through he can cut off the power without the slightest wavering of the tool or sagging of the weight which is likely to cause a small drill to break. Furthermore, the drill is so shaped and the weight distributed with relation to the position of the grip, that the tool is easy to handle and control. The tool is also made as light as possible, still maintaining the necessary amount of strength and rigidity.

The housings are cast from aluminum alloy, and gears are cut from solid blanks of chrome-vanadium steel and heat-treated to give them long life and freedom from breakage while in service. The chuck spindle is hardened and ground, and runs in a bronze bushing, the end thrust being taken care of by a ball thrust bearing. The motor is of the so-called universal type, adapted for use on either alternating- or direct-current circuits, and 110- or 220-volt motors can be supplied, according to the requirements of the user. A forced draft ventilating system provides for carrying a considerable overload without damage to the windings; and the spindle is ground to size and runs in Norma ball bearings.

The commutator and brushes are readily accessible by removing four screws which enable the top of the cover to be slipped off. The cover does not carry the armature shaft bearing, this bearing and the brushes being carried by an inner spider which is protected from external injury or strain. If so desired, the drill may run while the cover is removed to enable the operation of the brushes and commutator to be inspected. When so desired, a breast plate can be furnished for use in place of the rear grip. It was previously stated that these drills are equipped with motors for use on either 110- or 220-volt circuits; and drills with these styles of motors are made in two sizes having capacities for drilling holes from 0 to 3/4 inch in diameter and from 0 to 1/2 inch in diameter.



Black & Decker Electric Drill with Pistol Grip and Trigger Switch Control

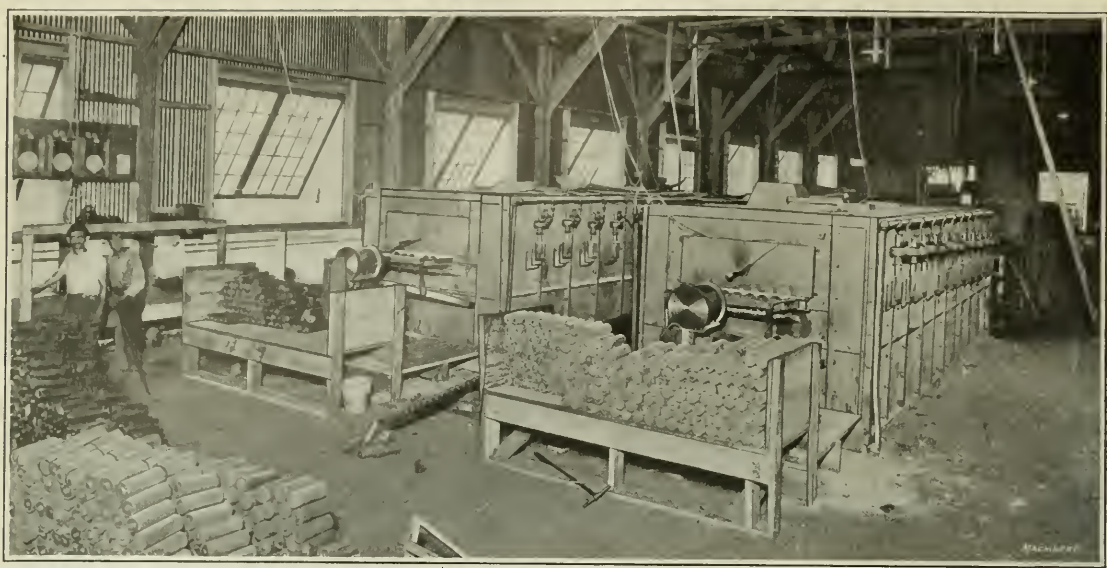


Fig. 1. Charging End of Hardening Furnaces with Pushers in Place. One Tempering Furnace can be seen at Extreme Right, with Oil Quenching Tank at Front. Control Pulpit is shown at Left of Hardening Furnaces

SURFACE COMBUSTION SHELL HEAT-TREATING FURNACES

These furnaces are used for hardening and tempering shells. They are fired by the Surface Combustion Co.'s high-pressure system, in which gas at a pressure of 25 pounds per square inch is made to inspirate the required amount of air for its complete combustion. The furnaces are arranged in units consisting of one hardening and one tempering furnace, and each unit has a capacity for heat-treating 5000 shells in twenty-four hours. Each unit consumes 3300 cubic feet of gas per hour, and the remarkably high efficiency of 32 per cent is obtained, this efficiency representing the percentage ratio of the heat actually absorbed by the work to the total amount of heat in the fuel. It is possible to arrange the inspirator so that complete combustion is obtained, but in order to prevent scaling the work and burning out the feed chutes of the furnaces, it is found advisable to operate them with a slightly reducing atmosphere—carbon monoxide being present to the extent of from 0.3 to 0.5 per cent.

For use in heat-treating shells in the plant of the Eddystone Ammunition Corporation, Eddystone, Pa., the Surface Combustion Co., Wilbur Ave. near Sunswick St., Long Island City, N. Y., has designed and installed the furnaces illustrated and described herewith. The installation consists of three hardening and three tempering furnaces, one hardening and one tempering furnace being under construction at the present time, while two furnaces of each type are in operation. Each furnace is approximately 22 feet long by 8 feet wide by 7 feet high, and they are arranged in units consisting of one hardening and one tempering furnace. Each unit is designed to turn out 5000 shells in a twenty-hour working day, so that full capacity from the installation of three units would be 15,000 shells in twenty hours.

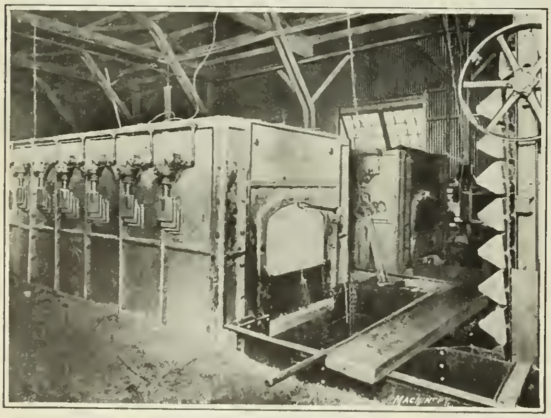


Fig. 2. Discharge End of Hardening Furnaces. Hot Shells pushed out into Oil Quenching Tank and carried by Conveyor to Drain Tables, then fed into Tempering Furnaces

The furnaces are fired by the Surface Combustion Co.'s high-pressure system, a process or system whereby gas under pressure is made to inspirate all the air necessary for complete and perfect combustion, maintaining automatically constant-mixture proportions and eliminating all motors, blowers and air piping. It is a one-pipe system, and is capable of very accurate control from a central control pulpit. Added to these advantages are the features of surface combustion proper. 580 B. T. U. gas (a mixture of water and coal gas) is supplied by the Philadelphia Suburban Gas & Electric Co. of Chester, Pa. This gas is delivered and metered under a pressure of 25 pounds per square inch. The gas is metered by a rotary pressure meter and a Bailey flow meter. The furnaces are operating at an average efficiency of 32 per cent—a remarkable furnace efficiency. Furnace efficiency means the percentage of available heat units in the fuel consumed which are actually absorbed by the work being done, in this case heating steel.

Each unit (one hardening and one tempering furnace) consumes an average of 3300 cubic feet of gas per hour, turning out 240 shells per hour. Therefore when all these units are running at capacity, 9900 cubic feet of gas per hour is consumed, and for a day of twenty-four hours, 237,000 cubic feet of gas, and for 300 such days approximately 71,000,000 cubic feet of gas. While shells are only turned out during twenty hours, the furnaces are kept hot the entire twenty-four hours. Cost of gas in this case is based on a sliding scale rate. The approximate average rate for this work is forty-three cents per thousand cubic feet. The hardening is done at an average temperature of 1500 degrees F. and the tempering (or drawing) at an average of 1100 degrees F. Each shell is in each furnace for a period of approximately one hour. The shells are 3 inches in diameter, and are approximately 8½ inches long; they vary in weight from 8 to 11 pounds.

Running through each furnace are eight steel angles which act as troughs to carry the shells. An air cylinder with an arm attached to the piston rod acts as a pusher; and a man stands in front of the furnace and feeds shells into the angle troughs. Every two minutes the pusher pushes the shells ahead the length of a shell. This causes eight shells to discharge into the oil quenching bath located at the discharge

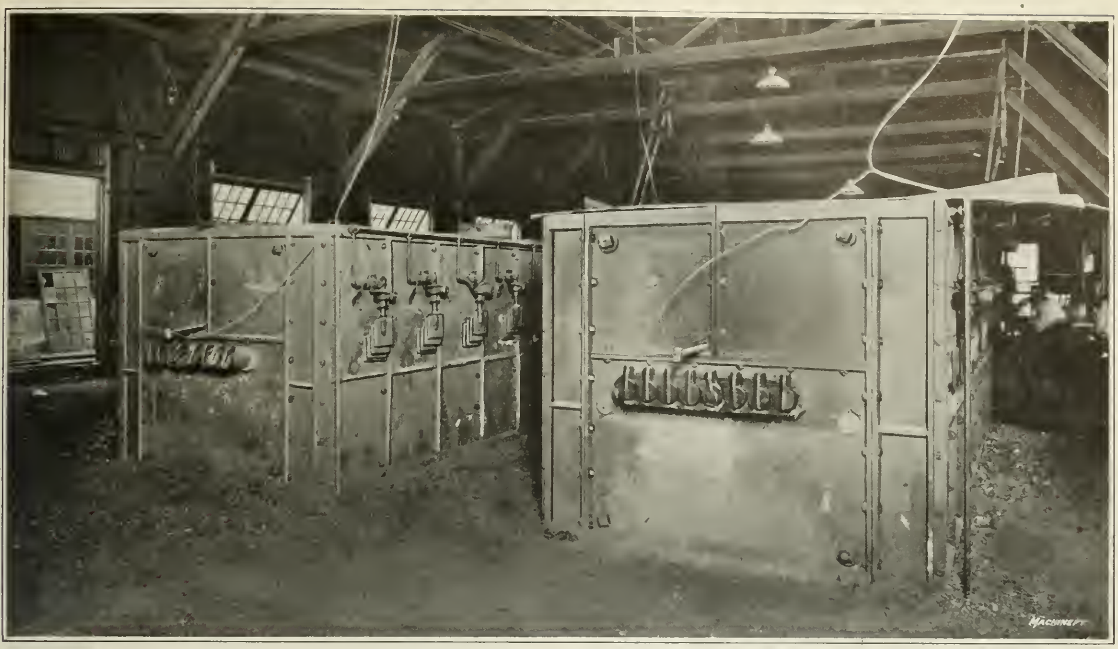


Fig. 3. Discharge End of Tempering Furnace. Shells are pushed out through Tubes which have Hinged Covers to exclude Air, shown at Front of Furnaces

end of the hardening furnaces, from which they are taken when sufficiently cool and fed into the tempering furnaces in exactly the same manner. The furnaces are on a slight slope.

All the furnaces are controlled from a central control pulpit. Each furnace is controlled by a single valve which regulates the pressure supplied, the maximum pressure being 25 pounds per square inch and the minimum 5 pounds per square inch. The average operating pressure is 15 pounds per square inch. All pyrometers, both indicating and recording, are also located in this pulpit, which allows one man to easily operate all the furnaces. This feature also allows much more accurate and careful control, as evidenced by the practically straight line pyrometer charts which are secured daily. There is also located in this pulpit the electric "flasher," which times the charging operation. This machine flashes a red light in front of each furnace every two minutes, which is the signal for the men to operate the pushers. The furnace operator in the control pulpit, each shift, receives his temperature and time instructions, and is able to follow these instructions with the greatest accuracy without moving a step. This pulpit is the "brains" and heart of the heat-treating building, clock, bells, etc., all being located there.

The furnaces are encased in cast-iron casings, tied together by heavy tie-rods and mounted on concrete foundations. The heavy firebrick linings are backed up by "Sil-O-Cel," giving plenty of insulation. This cuts down the radiation losses and protects the operators from the heat. In hot weather this is a point which is greatly appreciated by them. The furnaces are made as air-tight as possible, and to prevent cold air leaking in, which would produce an oxidizing effect and by its cooling action lower the furnace efficiency, a slight furnace back pressure is maintained. The furnaces are so designed as to develop and utilize the maximum amount of radiant heat. The flues are arranged so as to distribute the hot gases uniformly and to release them at the lowest possible temperature. The hardening furnaces are equipped with twenty-two high-pressure burners, and the tempering furnaces with eighteen burners. All piping is laid in conduits having removable covers, thereby eliminating all overhead work. To give an idea of the simplicity of the system, the largest pipe used is a 2-inch size. Each burner is fed by a ½-inch pipe from a 1-inch manifold.

Frequent flue gas analysis has shown oxygen = 0.0, carbon monoxide = 0.0, and an average of 15.2 carbon dioxide. This shows that the heat is generated with 100 per cent efficiency, having no excess air or unburned gases. For the purpose of minimizing the scaling of the shells and to lengthen the life of the angle troughs, the furnace is operated with a slightly reducing atmosphere—carbon monoxide reading between 0.3 and 0.5 per cent. This is done to be on the safe side, as an oxidizing atmosphere would be very injurious in this operation. The "surface combustion" principle was described in the May, 1915, number of MACHINERY in an article entitled "Surface Combustion Appliances."

"ROULSTED" ENGINE LATHE

The "Roulsted" 20-inch engine lathe illustrated and described herewith is built by the Waterville Iron Works, Waterville, Me.; and Hill, Clarke & Co., Inc., 156 Oliver St., Boston, Mass., have the sales agency for this machine. The lathe is equipped with a three-step cone pulley and double back-gears, and it has a semi-quick-change gear-box. Figs. 1 and 2 show a lathe equipped with a compound rest and with a turret toolpost, respectively; either of these equipments may be furnished according to the requirements of the shop in which the lathe is to be used.

The bed is cross-webbed at intervals of 2 feet and the ways are of the V-type. The headstock is bolted to the bed in a

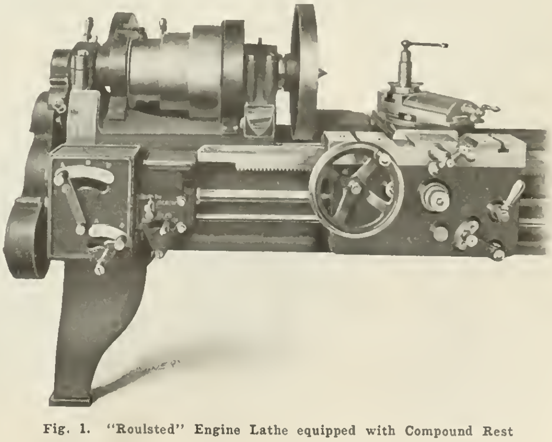


Fig. 1. "Roulsted" Engine Lathe equipped with Compound Rest

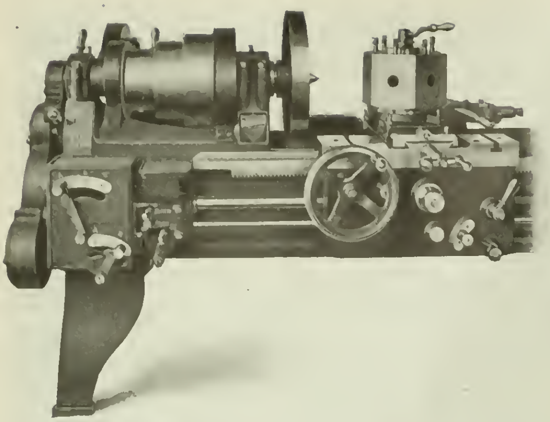


Fig. 2. "Roulsted" Engine Lathe equipped with Turret Toolpost

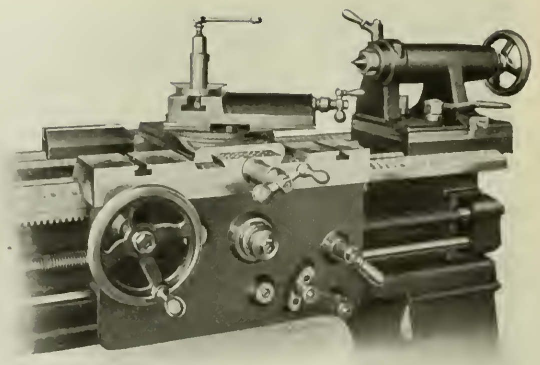


Fig. 3. Tailstock End of "Roulsted" Engine Lathe

way which secures absolute rigidity; and the hollow spindle is made of high-carbon crucible steel, forged and heat-treated, with the hole bored from the solid metal and reamed to size. The outside of the spindle is turned and ground, and the spindle is carried in bronze bearings which are scraped and fitted to both the headstock and spindle. End thrust is supported by a fiber washer, and the spindle is secured against end play by an adjusting nut at the end, which is also used in making compensation for wear. This construction maintains a positive position of the spindle under the heaviest service. An all-steel tumbler gear reverse is provided in the headstock for cutting left-hand threads or for changing the feed; and all gears are thoroughly guarded to avoid accidents to operators or damage to the gearing.

The carriage has a full length bearing on the vees and is gibbed front and back, and provided with a locking screw. The cross vees and bridge are wide and heavy, and the compound rest is graduated in degrees and securely gibbed. The apron is of the double-plate type which provides ample bearings at both ends of all shafts; it is firmly bolted and doweled to the carriage. All pinion shafts are made of steel and are integral with the gears, which are cut from solid blanks. A locking device is provided which makes it impossible to engage the feed-rod and lead-screw at the same time. An apron reverse is provided for all feeds which may be operated independently of the reverse screw in the headstock. The carriage has friction feed and the cross-feed screw is graduated to read to 0.001 inch.

The tailstock usually furnished with the lathe provides for setting the compound rest at right angles when the carriage and tailstock are used close together on the bed. The spindle and screw are accurately fitted, and the tailstock can be set over and clamped to the bed in any position for taper turning operations. The semi-quick-change gear-box has all steel gears which afford a wide range of feed; and special means are provided for disconnecting the lead-screw and feed-rod from the gear-box while the lathe is running. Change-gears are provided to enable either extra fine or coarse thread or rates of speeds to be obtained. Regular equipment furnished with the machine includes a two-speed double friction countershaft, although a one-speed countershaft with a high-speed reverse may also be employed with satisfactory results; in addition, the standard equipment includes a full set of change-gears, large and small faceplates, toolpost ring and wedge, steadyrest and wrenches.

The principal dimensions of this lathe are as follows: swing over bed, 21 inches; swing over carriage, 14 inches; swing over steadyrest, 8 inches; capacity between centers for 8-foot bed, 3 feet, 9 inches; diameter of hole through spindle, 2 1/16 inches; width of driving belt, 4 inches; ratio of double back-gears, 10 to 1 and 3½ to 1; available spindle speeds, 7 to 285 revolutions per minute; available gear feed, 6 to 90 per inch; available range of threads which may be cut, 2 to 30 per inch, including 4½ and 11½ threads per inch; maximum travel of compound rest, 5½ inches; diameter of tailstock spindle, 2⅞ inches; travel of tailstock spindle, 8 inches; size of tools used, ⅞ by 1½ inch; weight of machine with 8-foot bed, 4100 pounds; and weight per additional foot of bed, 230 pounds.

PUTNAM ENGINE LATHE

The 22-inch engine lathe illustrated and described herewith is a recent product of the Putnam Machine Co., Fitchburg, Mass.; and Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York City, are the sales agents. It will be apparent from the illustrations that this machine is equipped with a standard carriage and compound rest, tailstock and steadyrest; or that a turret may be provided on the carriage. In other respects, the two machines are identical.

The machines are driven by a three-step cone pulley and double back-gears; and they have universal feed, *i. e.*, gear, screw and belt feed combined, operated instantaneously without the necessity of removing the feed belt or changing gears. The spindle is made of forged open-hearth steel, and is supported in bearings provided with self-oiling bronze boxes which maintain the precision of the spindle and faceplate, and help to preserve true alignment of the live and dead centers. The lead-screw is made of special steel and great care is taken to obtain a high degree of accuracy in cutting the thread. The feed rack is made from a forged steel bar and is securely anchored to the bed; it is 1⅛ inch face width and the teeth are 0.524 inch pitch.

The tailstock has a liberal bearing on the ways and is held in alignment with the head by a vee at the rear of the bed, the front bearing being flat. The joint between the tailstock base and top is accurately scraped and a wide tongue is

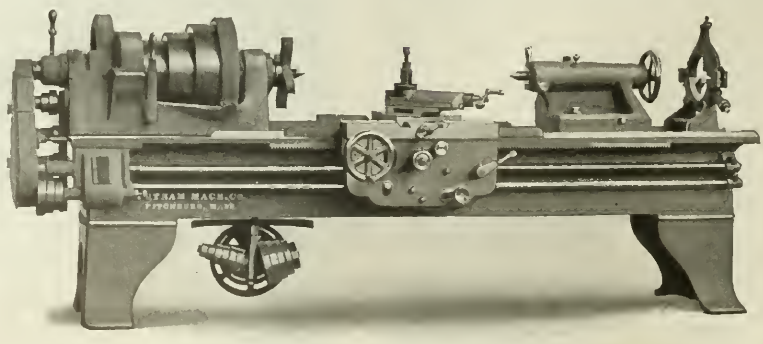


Fig. 1. Putnam 22-inch Engine Lathe with Compound Rest, Tailstock and Back Rest

fitted into a groove in the tailstock base to keep the spindle in perfect alignment with the head spindle. Provision for setting over the tailstock is made by means of a screw and nut. The carriage has bearings 30½ inches long on the outside raised ways, in addition to which it has a bearing on the front inside flat way. All bearing surfaces are scraped to a perfect fit, and the carriage is gibbed both front and rear. The compound rest is fitted with a tool-block for carrying tools ⅞ by 1¼ inch in size. The apron is an improved design provided with large, powerful friction for lateral feed and an eccentric stud gear for cross feed. An automatic safety device is provided, making it impossible to engage the lead-screw and feed-rod at the same time. All feeds are reversed and controlled at the apron. The screw nut is lined with babbitt and is 5¾ inches long; it is operated by a cam plate. The range for screw cutting through individual change-gears is from 1 to 16 threads per inch.

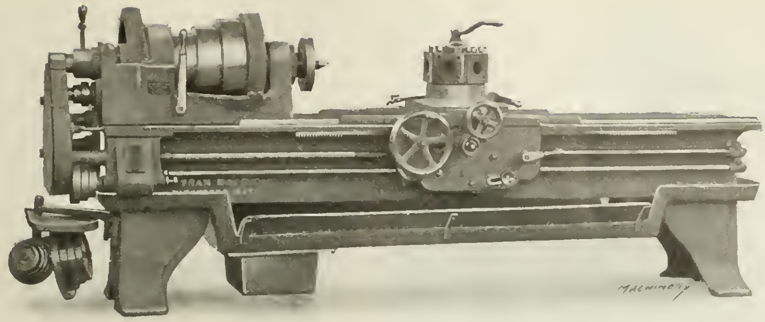


Fig. 2. Putnam 22-inch Lathe with Heavy Turret on Special Carriage

The regular equipment furnished with the machine includes one set of tool steel centers, a dog faceplate fitted to the nose of the spindle, a large standard circular faceplate, an adjustable three-jaw back rest, a countershaft with two friction pulleys and wrenches. The swing over the ways is 22½ inches; swing over carriage, 13¾ inches; swing over compound rest, 13¾ inches; distance between centers for 10-foot bed, 5 feet; cone pulley diameters, 11, 14 and 17 inches by 4¼ inches face width; available spindle speeds, 7, 10.8, 16.8, 25.4, 39.3, 60.8, 90.5, 140 and 216 revolutions per minute; size of front spindle bearing, 4⅛ by 8⅛ inches; size of rear spindle bearing, 3 by 5⅛ inches; diameter of tailstock spindle, 2 15/16 inches; and weight of machine with 7-foot bed, 4100 pounds.

BRIDGEFORD PLAIN TURNING MACHINE

The 27-inch by-12-foot plain turning machine illustrated and described herewith is a recent product of the Bridgeford Machine Tool Works, 235 Mill St., Rochester, N. Y. The machine takes 6 feet between centers, and swings 13½ inches over the carriage and 27 inches over the ways. Three instantaneous changes of spindle speeds are obtained through sliding hardened steel gears, and four instantaneous changes of feed through cut steel gears. The main driving gear is 6½ inches face width. Both the speed and feed change-gears run in oil. All main bearings on the machine are lined with bronze and are self-oiling; the front spindle bearing is 6 by 9 inches in size; and the rear spindle bearing, 5 by 7½ inches.

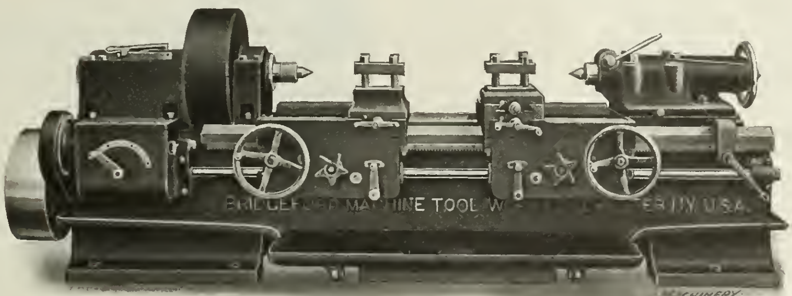


Fig. 1. Front View of Bridgeford 27-inch Plain Turning Machine

This lathe is especially adapted for performing the outside turning operation on 8-, 9.2- and 12-inch shells, and it will be seen that two carriages are provided. The carriage nearest the headstock is used for turning the straight wall of the shell, while the one at the tailstock end is used for forming the nose, this carriage being run in conjunction with a radius attachment which is shown in the back view of the machine, Fig. 2. A hollow spindle is provided so that an air chuck may be easily attached; and the machine has ample strength to safely transmit thirty horsepower. On a speed test in turning 8-inch shells, one user of this machine rough-turned a shell of this size in 4½ minutes. The weight of the machine is 15,000 pounds.

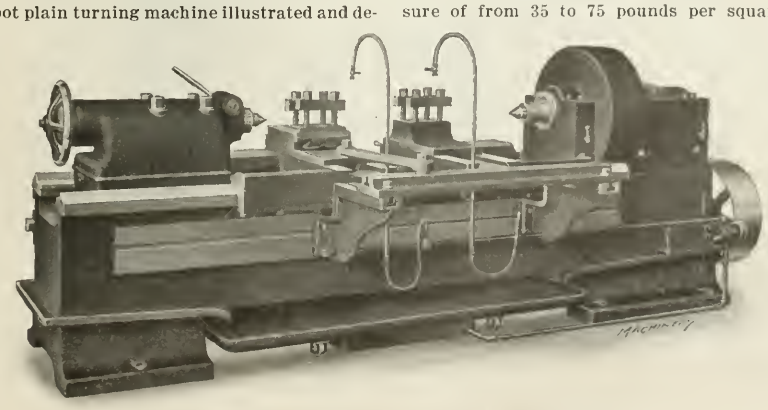


Fig. 2. Opposite Side of Bridgeford Plain Turning Machine shown in Fig. 1

"SPRACO" PAINT GUN

The "Spraco" paint gun recently placed on the market by the Spray Engineering Co., 93 Federal St., Boston, Mass., is a hand tool for use in applying all kinds of liquid protective coatings to various classes of work. The complete equipment consists of the paint gun proper, which is connected by a flexible hose to a portable unit containing the paint tank, air dryer and strainer, pressure control attachment and pressure gage. After the portable control head has been adjusted to meet the conditions of air pressure, thickness of paint, etc., the operator has complete control of the outfit by means of a trigger on the paint gun. The unit is furnished complete, ready for attachment by a single hose connection to the compressed air supply which should have a pressure of from 35 to 75 pounds per square inch, according to the nature of the paint used and the degree of finish desired. The equipment is adapted for use in shops or in the field, and may be adjusted for spraying the higher grades of varnish or lacquer as well as heavy asphaltum and structural paints, producing finely finished surfaces without streaks.

Fig. 1. Complete Portable Outfit for Use with "Spraco" Paint Gun for spraying Paint

There are but two adjustments required in operating the "Spraco" gun, *i. e.*, the round cap at the nose which screws out or in to regulate the amount of paint delivered by the gun, and the knurled stem at the rear which screws out or in to control the amount of air that is used. These adjustments only have to be made once to regulate the proportion of air and paint required for any class of work; then the control trigger acts on both the air and paint, regulating the amount of paint delivered from zero up to the full amount for which the adjustment has been set.

The control head is an important feature of the apparatus, and consists of a complete unit comprising the following parts: (1) A pressure gage showing the air pressure on the main supply line, and also on the paint in the tank. (2) An adjustable reducing valve by which pressure on the paint may be varied at will so that the action of the gun is made independent of the position of the tank, and any form of paint or other material may be fed to the gun at suitable pressure; this adjustable reducing valve also permits of using any pressure less than the main line pressure, which is essential where very high air supply pressures are maintained. (3) A complete air strainer and filter by which a supply of dry, clean air may be obtained; and this filter may be readily inspected and cleaned without the use of tools. The complete control unit is especially designed for use with the standard portable equipment. It may be used separately when connection is made with a paint barrel, tank or other container.

The pressure tank is designed to withstand full air pressure if necessary, and is made of galvanized iron riveted together. A filling plug in the base permits of filling or emptying the tank without disturbing the control head. Connection with the air system is made by a rubber hose provided with a heavy braid covering, while a flexible metal hose is commonly employed for delivering the paint supply to the gun. Special forms of this hose can be provided if required. Where paint or other materials which do not injure rubber are used, a hose similar to the air hose will be found satisfactory. For shop use the control head and pressure regulator are non-essential, unless very heavy paint is being used; and under such condition the gun may be connected directly to the air pressure line, using an air regulator if the supply pressure is excessive or if the air is not dry and clean. The paint is placed in a tank suspended above the work and is supplied to the gun by gravity. A suitable paint tank with block and tackle for suspension can be furnished with the gun if so desired. The air regulator may be supplied with a filter, pressure gage and reducing valve, providing a complete air controlling apparatus in a single unit.

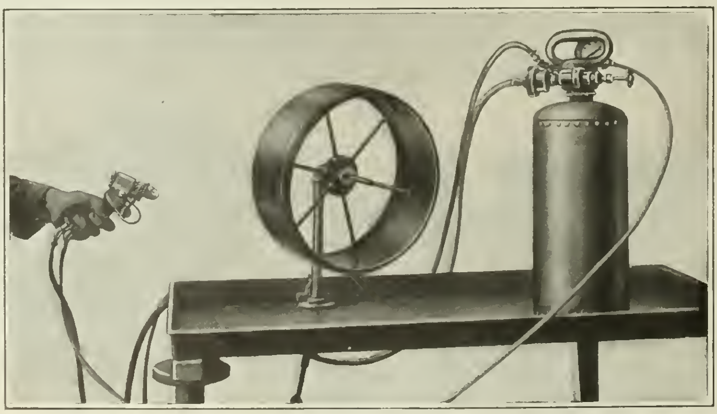
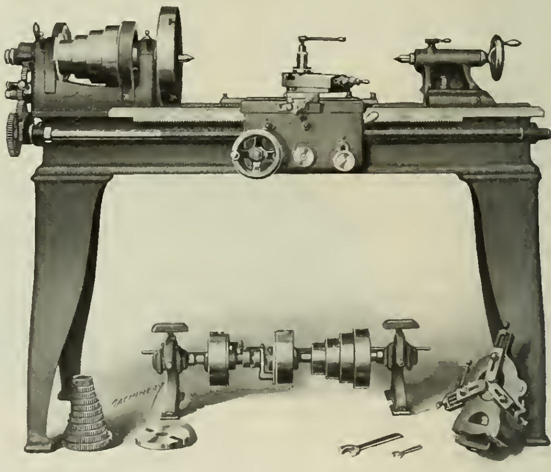


Fig. 2. "Spraco" Paint Gun in Use painting a Pulley

Advantages claimed for this apparatus are that the time required to paint work is reduced from 50 to 75 per cent; that the gun makes it possible to reach surfaces that could not otherwise be thoroughly covered; that it is easily operated and adjusted without the use of tools and is free from delicate parts; that the design is simple and the construction sufficiently rugged to withstand hard service; and that the total weight of the gun is only a little over one pound.

VERNON 11-INCH LATHE

The Vernon Machine Co., Inc., Worcester, Mass., is now building the 11-inch lathe shown in the accompanying illustration.



Vernon Machine Co.'s 11-inch Lathe

The machine is driven by a four-step cone pulley and single back-gears, thus providing eight changes of spindle speed. The spindle is made of high-carbon steel and finished to size by grinding; it is carried in bronze-lined bearings which have ample oiling facilities and means of compensation for wear. The end thrust of the spindle is supported by a step bolted to the end of the headstock. The tailstock is of the offset type which allows the compound rest to be set parallel to the bed; in addition, the tailstock can be set off center to provide for the performance of taper turning operations.

The carriage has a very stiff bridge and long bearings on the vees; it is securely gibbed to the bed and the compound rest is adequately supported by it. The apron is

bolted to the carriage and all gears in the apron are liberally proportioned for the loads they are required to carry. Positive geared feed is supplied with each lathe and the number of changes that are available is limited only by the number of change-gears obtained for use with the lathe. The regular equipment furnished with each machine includes large and small faceplates, center- and follow-rests, a countershaft and the necessary wrenches for making all adjustments.

The principal dimensions are as follows: diameter of hole through spindle, $\frac{7}{8}$ inch; swing over ways, $12\frac{1}{8}$ inches; swing over compound rest, $7\frac{1}{2}$ inches; distance between centers for 5-foot bed, 33 inches; change-gears provided for cutting 4 to 36 threads per inch; width of driving belt, $1\frac{3}{4}$ inch; and weight of machine with 5-foot bed, 775 pounds.

LANGELIER MOTOR VALVE SLEEVE MULTIPLE DRILLING MACHINE

For use in drilling at one operation the twelve $\frac{1}{8}$-inch oil holes in the outer sleeve of a Willys-Overland motor valve, the Langelier Mfg. Co., Providence, R. I., designed the multiple drilling machine which is illustrated and described herewith. A similar machine was built for use in drilling four $\frac{1}{8}$-inch holes in the inner sleeve, and the output of each machine is $3\frac{1}{2}$ sleeves per minute, or 2100 per day. The machines are of exactly the same design except that one is equipped with twelve drill spindles while the other has only four spindles.

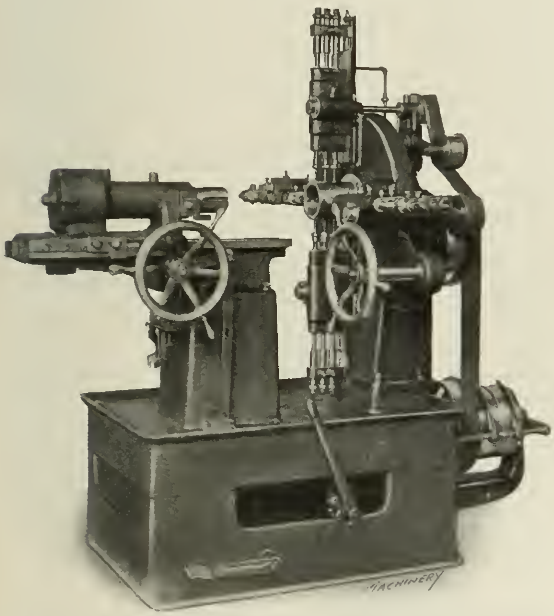


Fig. 1. Langelier Multiple-spindle Machine for drilling Motor Valve Sleeves

Fig. 3 shows a cross-sectional view through the drill jig on the machine for drilling the outer sleeve, in which the work is shown in the drilling position. Referring to this illustration in connection with the following description, the method of operating the machine will be clearly understood. Sleeve A is held and located in the drilling position by an internal expanding arbor B mounted on tailstock C which slides upon ways in line with the axis of the machine. Expanding arbor B is opened or closed automatically by means of compressed air; the construction consists of a split sleeve that is attached directly to the piston in the compressed air cylinder; and inside this sleeve there is a fixed arbor D with a tapered end, that is attached to the cylinder head. A slight travel of the sleeve on this tapered portion of the fixed arbor causes the sleeve to expand and hold the work securely, extra movement being avoided by a stop collar on the sleeve and tapered arbor.

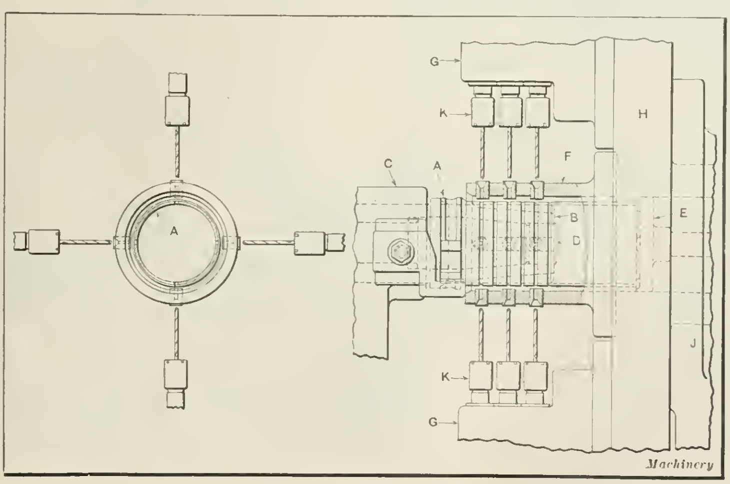


Fig. 3. Section through Drill Jig showing Arrangement of Work-holding Arbor

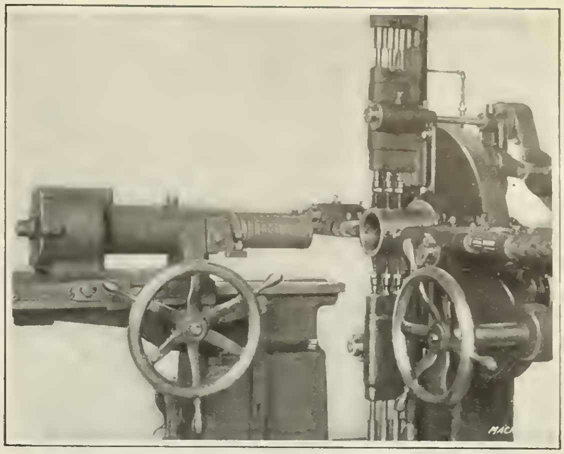


Fig. 2. Close View of Mechanism with Drilled Sleeve on Arbor after being withdrawn from Jig

Admission of air to the cylinder is controlled by a small piston valve that is attached to the tailstock C at the rear and operated by contact with a fixed stop attached to the tailstock slide. The tailstock is shown in its outer or loading position in Fig. 1, movement of the tailstock slide being secured by means of the handwheel at the front of the machine. The drilling position is obtained by the sleeve to be drilled coming into contact with a stop E located inside drill jig F; this stop can be adjusted at the left-hand end of the machine. The tailstock is also automatically locked when in a drilling position and is unlocked by the foot-treadle shown at the front of the bed; this lock is adjustable and can be set to suit the requirements of the work being drilled.

Drilling heads G are located radially 90 degrees apart upon a circular faceplate H that is mounted on column J attached to the bed of the machine. Drilling spindles K are driven by spiral gears, the drivers extending to the rear and having pulleys on their ends. The thrust is taken up by ball thrust bearings. Feed of the drill spindles is operated by a handwheel at the right-hand side of the machine, which has a spur gear connection to a rim gear located inside and concentrically with faceplate H. The rim gear carries a segment feed cam for each head, that has roller contact with the feed yoke of each drill head. These yokes have a clamp connection to the sleeve on the outer end of the drilling spindles, and this clamp connection provides ready means of adjusting the feeding position of the drill spindles.

The drill spindles are driven by pulleys which receive power from an endless belt; the belt, in turn, is driven by two large drivers which are geared to the main driving pulley. The main pulley is driven by belt from a tight and loose pulley drive attached to the bed of the machine. The belt is shifted by the hand-lever located on the bed of the machine. The drilling jig has a compressed air arrangement that blows out chips. The drill speed is 2500 revolutions per minute and the tight and loose pulleys are run at 446 revolutions per minute; floor space occupied is 4 feet by 6 feet, 1¾ inches; height of machine is 5 feet, 9 inches; and net weight, 3500 pounds.

SILVER GANG DRILLS

The Silver Mfg. Co., Salem, Ohio, is now manufacturing gang drills of the type shown in the accompanying illustration with two, three and four spindles. These machines are made in four styles with plain lever feed, lever and wheel feed, power feed and automatic stop, and back-gearing. It will be seen that there is a separate column and table for each spin-

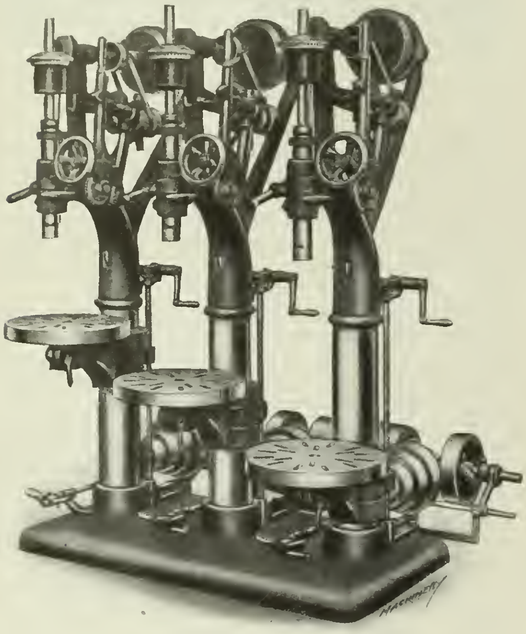


Fig. 1. Silver Three-spindle Gang Drill

dle; the countershaft is driven by a single belt, and an individual belt drive is provided for each drill of the gang. Each machine has one friction tapping attachment, and each spindle may be equipped independently of the others.

The countershaft has the driving pulley placed at the center, while clutches transmit power to the cone pulleys provided for driving independent spindles. This makes it possible to operate all spindles at the same time or to operate any one spindle independently of the others. The principal dimensions of the machine are as follows: height, 68¼ inches; diameter of column, 5½ inches; diameter of round table, 16 inches; size of square table, 16½ by 16½ inches; diameter of spindle, 1⅜ inch; vertical travel of spindle, 10 inches; vertical travel of table, 16 inches; distance from column to center of table, 10¼ inches; distance from spindle to base, 41⅛ inches; distance from spindle to table, 26⅝ inches; distance between spindles, center to center, 18 inches; diameter of crown gear, 5 3/16 inches; diameter of bevel pinion, 3⅜ inches; diameter of large pulley on cone, 9¼ inches;

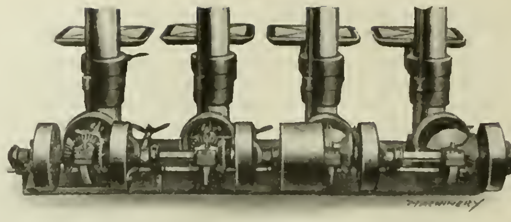


Fig. 2. Countershaft on Silver Four-spindle Gang Drill

diameter of small pulley on cone, 4 inches; width of cone pulley belt, 2 inches; floor space occupied, including countershaft, 41½ by 42½ inches for two-spindle machine; 41½ by 60 inches for three-spindle machine; and 41½ by 78 inches for four-spindle machine.

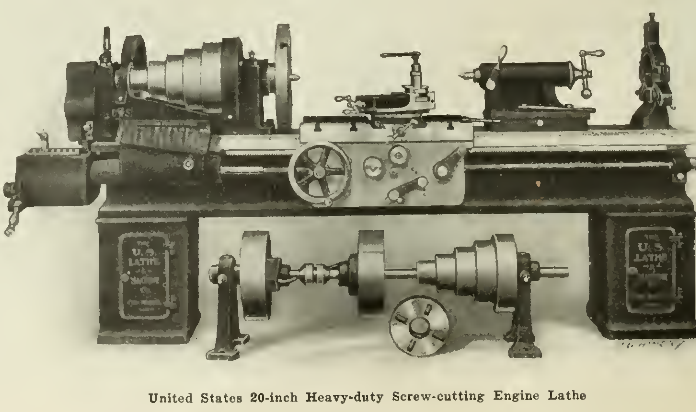
UNITED STATES ENGINE LATHE

The United States Lathe & Machine Co., Cincinnati, Ohio, is now building the 20-inch heavy-duty screw-cutting engine lathe illustrated in connection with the following description. It will be seen that this machine is driven by a five-step cone pulley from which power is transmitted through single back-gears; and a quick-change gear-box provides for cutting from 1 to 32 threads per inch, including 11½ threads per inch. It will be noticed that the quick change in gears locks downward, thereby preventing the lever from working loose. The back-gear lever is of a positive locking type and is easily operated.

The tailstock is provided with an easily accessible lever at the front, and a very short movement of this lever instantly releases or securely locks the spindle against the top, thereby retaining an accurate center position. The legs are of the cabinet type affording a convenient place for the storage of tools, etc. Regular equipment furnished with the machine includes large and small faceplates, a center-rest, complete countershaft equipment and the necessary wrenches for making all adjustments. Extra equipments which may be furnished include a taper turning attachment for turning tapers up to 4⅛ inches per foot, which travels with the lathe carriage and is available from center to center; a center-rest; and an 8-, 10- or 12-inch follow-rest. The United States Lathe & Machine Co. will also build this lathe in a double back-geared type; and it is planned to build larger lathes of the same design.

METALWOOD SHELL BANDING PRESSES

The accompanying illustrations show two machines which constitute recent additions to the line of hydraulic presses built by the Metalwood Mfg. Co., Leib and Wight Sts., Detroit, Mich. The press shown in Fig. 1 is for use in compressing copper bands onto shells from 6 to 12 inches. This is the familiar form of equipment in which six rams operated by hydraulic pressure from a pump or accumulator converge onto the copper band and force the metal to flow into the band seat.



United States 20-inch Heavy-duty Screw-cutting Engine Lathe

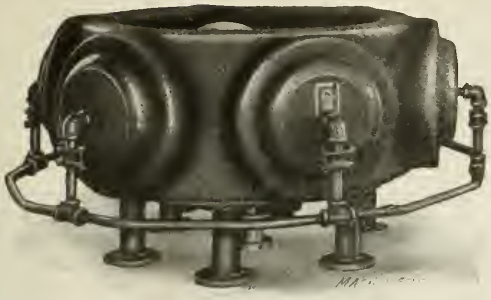


Fig. 1. Metalwood Shell Banding Press for Shells from 6- to 12-inch Sizes

The machine shown in Fig. 2 was developed for banding British Mark IV and V shells. It will be seen that this press is used in connection with a knock-out plug that is placed in the base of the press to protect the shell from distortion or collapse during the banding operation. This press is operated from an accumulator under a pressure of 2500 pounds per square inch. The speed of the ram, pressure, and return movement of the ram are controlled by a Metalwood single-lever quick-operating valve. The press is constructed entirely of steel and has a constant pressure pull back from the accumulator line.

In operation, the shell is placed in the die on the revolving table which is supported on ball bearings. The arbor is

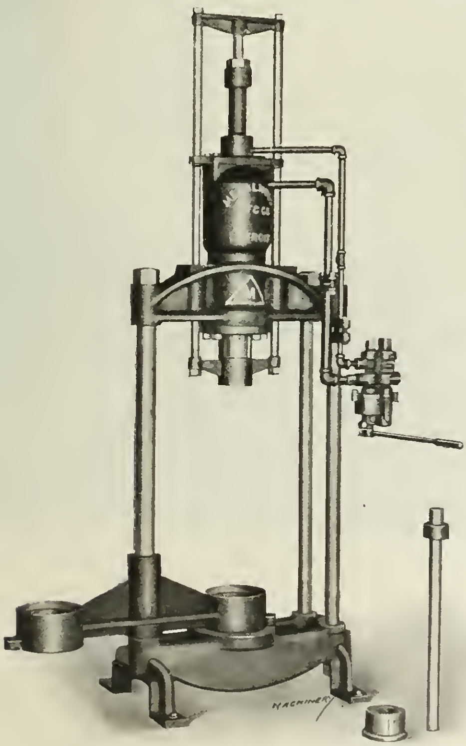


Fig. 2. Metalwood Vertical Shell Banding Press for British Mark IV and V Shells

dropped into the nose of the shell, after which the table is swung around to bring the arbor and shell into position under the ram, where the table is held by a latch which is operated by foot-treadle for release. When the ram descends, the shell is forced down through the die which results in compressing the copper band into its seat in the shell. While the operation of pressing one shell is going on at one end of the table, the other end of the table is unloaded, after which another shell is put in position in the die ready to be swung around to the operating position.

FRASER INTERNAL AND SURFACE GRINDING ATTACHMENTS

In the August number of MACHINERY, a description was published of the universal grinding machine built by the Warren F. Fraser Co., Freeport St., Boston, Mass. Mention was made of the fact that the machine is adapted for performing internal and surface grinding operations, and that the capacities for

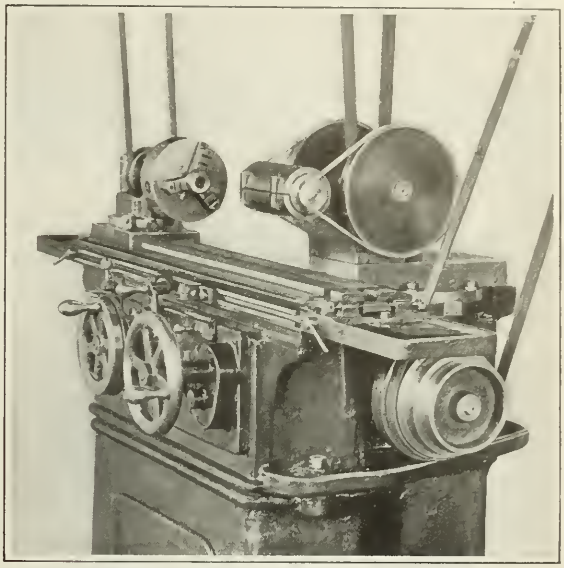


Fig. 1. Fraser Universal Grinding Machine set up for Internal Grinding

work of this kind are for internal grinding in pieces up to 8 inches in diameter, and for surface grinding on work 20 inches in length by 5 inches in width. At the time this article was published, illustrations of the internal and surface grinding attachments were not available, and these equipments are shown in the accompanying illustrations.

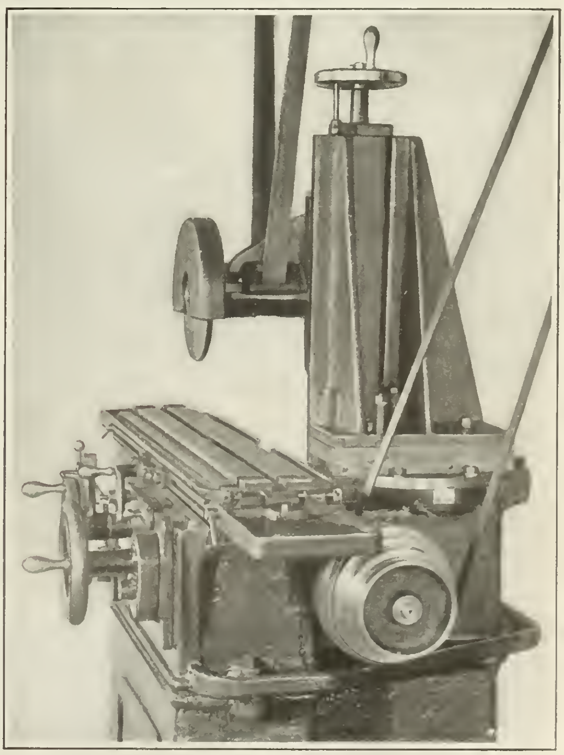
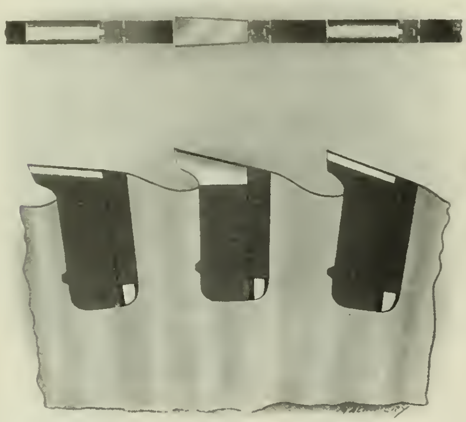


Fig. 2. Fraser Universal Grinding Machine set up for Surface Grinding

SIMONDS INSERTED-TOOTH METAL SAWS

The Simonds Mfg. Co., Fitchburg, Mass., is now manufacturing inserted-tooth metal cutting saws of the type shown in the accompanying illustration. The plate or body of the saw is made of high-carbon steel which is carefully heat-treated and flattened without hammering; the inserted teeth are made of high-speed steel, and the projection at the front holds the bottom of each tooth firmly on the plate so that the tooth cannot work up or down. This makes it unnecessary to drive the wedge in so hard as to disturb the tension or distort the saw plate in any way. Referring to the plan view, it will be seen that alternate teeth are oval and square at the point. The oval teeth are slightly higher than the square teeth, and this allows them to cut a channel in front of the square teeth which



Simonds Inserted-tooth Metal Saw with Alternate Teeth Oval and Square

results in breaking the chips into three pieces and allows them to clear more freely. It also avoids trouble from the material becoming welded to the face of the teeth and at the side of the saw. These saws are made in three sizes, known as Nos. 0, 1 and 2, respectively, and they are made to fit any type of arbor-driven machine.

PUTNAM 42-INCH ENGINE LATHE

In the September, 1915, number of MACHINERY, mention was made of a 42-inch heavy-duty engine lathe, especially adapted for machining large forgings. This machine was built by the Putnam Machine Co., Fitchburg, Mass., and recently this firm has built machines of similar design but with certain modifications to adapt them for turning and boring operations on large gun forgings.

It will be seen that the lathe is equipped with a geared head and direct-connected motor drive. The arrangement of the

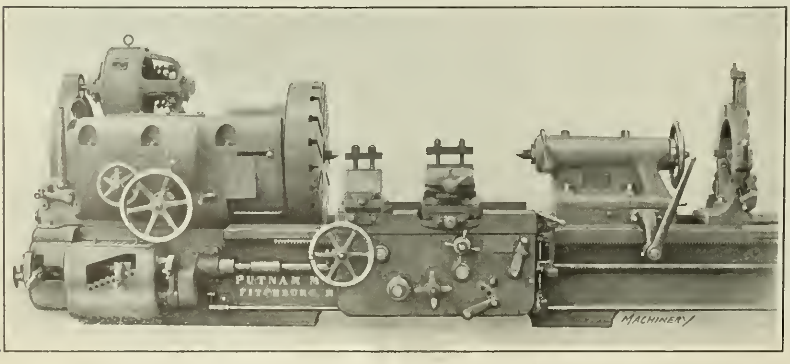


Fig. 1. Putnam 42-inch Engine Lathe for machining Gun Forgings

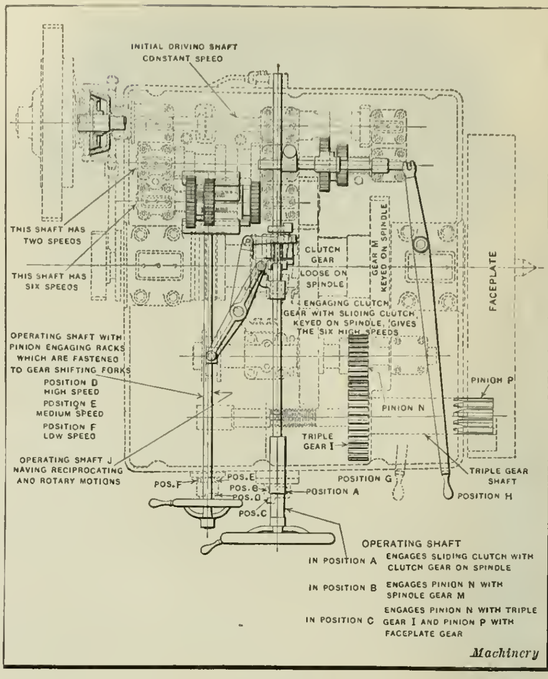


Fig. 2. Arrangement of Gearing in Head of Putnam 42-inch Lathe

gearing in the head is shown in Fig. 2. Eighteen changes of speed are provided by this mechanism, which are in geometrical progression and cover a range of 3.04 to 178.3 revolutions per minute. It will be seen that the sliding gears at

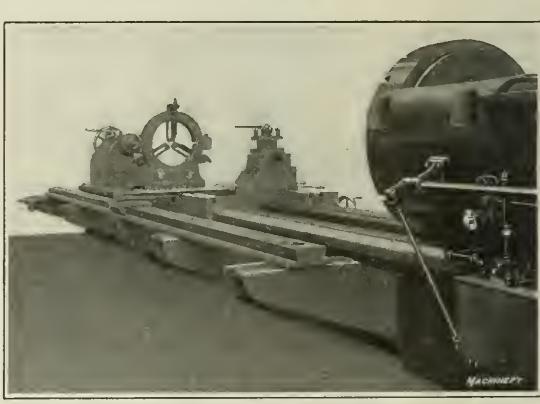


Fig. 3. Taper Attachment which has Range of Entire Distance between Centers

the back of the headstock furnish six changes of speed, and any of these speeds may be transmitted to the spindle by engaging the clutch which provides for securing the first spindle gear, which otherwise runs free on the spindle. Six more changes of speed are provided by allowing the first spindle gear to run free, thus transmitting the drive through back-gears to the second spindle gear. The remaining six changes of speed are provided by transmitting the drive through gearing in the position shown in the illustration, connection being made in this case with the gear teeth in the faceplate. A feature of the headstock design is that all shafts and gears are placed horizontally in the headstock casting proper, and they are on the same plane and not in the upper half or cover, so that easy access may be had to all

parts of the headstock. All bearings are capped, making it an easy matter to remove any shaft in case of necessity. Fig. 3 shows a rear view of the machine and clearly illustrates the arrangement of the taper attachment. No disconnection of any part is necessary in order to engage or disengage the attachment. It can be used for turning outside or boring inside work, where a taper is required, and owing to the fact that it is bolted to the carriage with which it travels, the taper attachment is available for the entire distance between centers. The principal dimensions of this machine are as follows: swing over ways, 43½ inches; swing over compound rest, 32½ inches; swing over taper attachment, 29¾ inches; maximum distance between centers for 19-foot bed, 10 feet, 11 inches; diameter of hole in spindle, 2⅛ inches; length of carriage on bed, 48 inches; range of longitudinal feeds, 0.28 to 0.02 inch; range of cross-feeds, 0.28 to 0.02 inch; travel of tailstock spindle, 19 inches; range of taper attachment, up to 10 degrees, or 4 inches per foot; maximum opening in center-rest, 18⅜ inches; and weight of machine with 19-foot bed, 29,000 pounds.

RADIAL ROLLER BEARINGS

For use on heavy motor vehicles, heavy machinery and journals subject to severe loads, the Ball & Roller Bearing Co., Danbury, Conn., has introduced the radial roller bearings which form the subject of this description. These bearings are suitable for use under a wide range of speeds, and are found particularly useful for application where space is so limited that there is not room for a radial ball bearing sufficiently strong for the load. These bearings are furnished in the two types illustrated herewith, one of which is a so-called full roller type, while the other is provided with a roll separator. In each case, the inner race is channeled to form a groove or track for the rollers, while the outer race is a straight cylinder, so that the rollers are free to take up their correct position in the outer race. The separator or roller cage is made of bronze cast metal, carefully machined on all surfaces and designed to float freely with the rollers. In order to secure satisfactory service from these bearings, it is said to be essential for the tracks or paths of the rollers in the inner and outer races to be perfectly parallel with each other, and as a result accurate machining is absolutely necessary.

Fig. 1. Radial Roller Bearing with Separator

Fig. 2. Roller Bearing without Separator

It will be obvious from the illustrations that side thrust can under no conditions be imposed upon these bearings, even to locate a shaft endwise. Both the inner and outer races may be made press fits, shoulders being frequently provided to locate them in their respective positions; but care should be taken when this is done to see that the bearing is not unduly tightened. Where end thrust exists, ball thrust bearings or roller thrust bearings must be provided to take the thrust load. Owing to their high carrying capacity, these radial bearings are suitable for use where the conditions of service are very severe; and they can be employed in place of large, plain bearings, which would, of necessity, have to be carefully fitted and scraped. If there is no end thrust other than end location of a shaft, plain thrust collars are often sufficient to meet requirements.

The limits of accuracy to which these bearings are ground, both as regards bore and outside diameter of the rings, is within 0.0003 inch minus or 0.0002 inch plus the specified size. The thickness of the rings is ground to standard dimensions with a limit of 0.005 inch in either direction. So far as lubrication is concerned, radial roller bearings should be treated in precisely the same way as ball bearings and the same lubricants may be used, except in the case of very high speeds, when a mineral oil will be found to give better satisfaction. In this respect, radial roller bearings have the same advantage as ball bearings in that they only require the renewal of lubricant at long intervals. To protect them from dust and moisture is absolutely essential, and a suitable method of guarding against this is to bring the housing down within 0.004 inch of the shaft and provide grooves which form oil pockets, into which the grease finds its way and makes a more or less perfect shield against the admission of moisture or dirt.

NEW MACHINERY AND TOOLS NOTES

Endless Fabric Belt: Victor Endless Belt Co., Camden, N. J. An endless fabric belt which is oil-proof and waterproof, and especially adapted for high-speed drives on short center distances. It is claimed that these belts are stronger than leather belts of the same width and thickness.

Universal Machine Tool: J. L. Kunz Machinery Co., Milwaukee, Wis. A machine designed for use in small shops where the amount of one kind of work to be done is not sufficient to warrant the purchase of a single-purpose machine. The machine may be adapted for the performance of milling, keyseating, gear-cutting and kindred operations.

Motor-driven Grinder: Ransom Mfg. Co., Oshkosh, Wis. A machine known as the No. 35 grinder which is equipped with two wheels 18 by 3 inches. These wheels are protected by guards constructed of tank steel, and are fitted with glass eye shields. The spindle of the machine is started or stopped by the operation of a foot-treadle at the front of the grinder.

Lubricant Pump: C. F. Roper & Co., Hopedale, Mass. This company is now building one-way and reversing lubricant pumps in three sizes which have capacities of 8, 16 and 46 quarts per minute when running at 500 revolutions. The design is very similar to that of pumps of this company's manufacture which were referred to in the May number of MACHINERY.

Tool-holder: H. P. Parrock, General Mauager, Lumen Bearing Co., Buffalo, N. Y. A tool-holder in which the bit is machined to a size slightly larger than a slot cut in the shank of the tool; to secure the bit in place, the shank is heated so that the groove expands sufficiently to allow the bit to be dropped into place; and when the shank cools, the contraction of the metal causes it to secure a firm grip on the cutter.

High-speed Steel-tipped Drill: Campbell Mfg. Co., 3715 Wentworth Ave., Chicago, Ill. This company is now manufacturing a line of drills with inserted high-speed steel tips. The tips are easily inserted or removed, and seven different sizes of tips are furnished with each size of shank. Either straight or fluted shanks may be used, according to the requirements of the work. The tips are about 2 inches in length.

Shear and Rod Cutter: In the July number of MACHINERY a description was published of the No. 2 shear and rod cutter built by W. M. & C. F. Tucker, Hartford, Conn. This machine was of the floor type, but to meet the requirements of shops where a considerable amount of light work is to be done, the same machine has been built in a bench type adapted for handling smaller work. In other respects, the design of both machines is the same.

Geared-head Lathe: Phoenix Mfg. Co., Eau Claire, Wis. A lathe in which the headstock is cast integral with the bed, and in which the spindle is driven through duplex worms and worm-wheels of widely varying range with sliding gears to obtain the required range of speed. The lathe swings 21½ inches over the ways and 14 inches over the carriage; capacity between centers for a 10-foot bed is 5 feet, 1 inch; and weight of machine is 5750 pounds.

Engine Lathe: Axelson Machine Co., Los Angeles, Cal. A 16-inch engine lathe driven by a four-step cone pulley and single back-gears. The swing over the bed is 17½ inches, and over the carriage, 10½ inches; the back-gear ratio is 9.6 to 1; the available speeds range from 6.67 to 350 revolutions per minute; and there are thirty-two changes of feed provided by a quick-change gear-box. With a 6-foot bed, the weight of the machine is 2400 pounds.

Belt Tension Machine: Tabor Mfg. Co., Philadelphia, Pa. A machine for use in applying tension to new belts or belts which have been repaired, preparatory to placing them on the pulleys. The machine consists of a pulley or drum over which the belt is placed and secured at each end by clamps. The bed is graduated to facilitate setting the clamps for any length of belt that is required to be tensioned, and means are furnished for applying tension to the belt.

Dynamic Balancing Machine: Dynamic Balancing Machine Co., Philadelphia, Pa. In the September, 1915, number of MACHINERY a description was published of the dynamic bal-

ancing machine which had just been placed on the market by the Dynamic Balancing Machine Co. at that time. Recently a small machine has been introduced for use in balancing small motor armatures, couplings, etc. The principle of operation is the same as that of the larger machine.

Power Press Clutch: Campbell Mfg. Co., 3715 Wentworth Ave., Chicago, Ill. In the operation of power presses, the average speed of the flywheel is from 80 to 200 revolutions per minute, but the application of this new clutch makes it possible to employ speeds ranging from 80 to 1000 revolutions per minute. When the clutch is used on other types of machinery, it will operate satisfactorily and positively at speeds ranging from 500 to 5000 revolutions per minute.

Gage Standards: Wismach & Co., 1513 Richard St., Milwaukee, Wis. These are block gages with parallel lapped opposite sides; they vary in thickness by specific increments, given in fractions of inches or millimeters, and two or more blocks can be wrung together to obtain what is practically a solid gage of any required size. Holders are provided for the blocks when they are used for external measuring or for measuring holes with two half-round members furnished for that purpose.

Portable Electric Tools: Standard Electric Tool Co., Cincinnati, Ohio. This company has added to its line a combination drilling and polishing machine; when used for polishing, the wheel arbor is interchanged with the drill chuck. The tools are driven by a one-half horsepower motor adapted for use on 220 volts, 50 cycle, three-phase circuit, which runs at 950 revolutions per minute. The feed reduction is obtained through a gear-box at the lower end of the motor case, which provides a reduction of 4 to 1.

Car Wheel Lathe: Niles Tool Works Co., Hamilton, Ohio. An unusually heavy car wheel lathe which is provided with central driving gears and pinions of the herringbone type. The wheels are rolled onto the lathe on a short hinged track which makes connection with the shop track, and an elevating device is provided for aligning the work with the tailstocks. For wheels on axles with outside journals, collapsible bushings fitting over the journals and tapered to fit the tailstock spindle are provided for use on the machine.

Plain Grinder: Ram Engineering Co., Richmond, Ind. A 10- by 31-inch plain horizontal grinding machine which has capacity for handling a large range of work. The cross-feed is operated by a screw with a graduated collar, and a special form of nut is provided which takes up all backlash. The table is also operated by a screw with a graduated collar and is furnished with adjustable stops. The machine may be provided with additional accessories, such as universal headstock, table for taper grinding, internal grinding attachment, faceplate, steadyrest, etc.

Riveting Machine: Vulcan Engineering Sales Co., 2059 Elston Ave., Chicago, Ill. A riveting machine built by the Hanna Engineering Works, for which the Vulcan Engineering Sales Co. has the sales agency. This is a pneumatic riveting machine, and in general respects the design is similar to that of the pneumatic riveter of this company's manufacture described in MACHINERY for March. The former machine was intended for riveting latticed columns, while the present machine has been developed to meet the requirements of riveting operations on automobile and similar work.

Engine Lathe: Oliver Machinery Co., Coldbrook and Clancy Sts., Grand Rapids, Mich. An 18-inch lathe designed for taking heavy cuts at high speed. A feature is that all parts of the lathe are jig machined, so that replacement parts may be substituted without the necessity of doing any fitting in the shop. The lathe is driven by a three-step cone pulley and double back-gears; and a quick-change gear-box is provided in which thirty-two changes of feed may be obtained by operating two levers. A taper attachment is provided which has a capacity for turning tapers up to 4 inches per foot.

Motor-driven Grinder: Standard Machine & Electric Co., Indianapolis, Ind. This machine may be equipped with a motor for connection with either alternating- or direct-current circuits. The spindle carries two grinding wheels which may be 1½ by 12 inches or 2 by 12 inches in size. The wheel spindle runs in ball bearings, and the wheels are enclosed to provide for the safety of the operator. An exhaust system is an integral part of the machine, and is driven by the same motor which drives the grinding spindle. The driving motor is started or stopped by means of a foot-treadle at the front of the machine.

Automatic Screw Machine: Fitchburg Automatic Machine Works, Fitchburg, Mass. A four-spindle machine known as the "Radical" automatic, which combines a number of interesting features. In working out the design, particular attention has been given to the development of a rigid construction and a design which is as simple as possible. The claim is made that this machine contains only six hundred parts, while other machines of similar design have approximately twice this number of parts. At the present time the "Radical" automatic is built in two sizes which have capacities for work up to 1 and 1¼ inch in diameter; but it is planned to build three other sizes having capacities for work up to 9/16, 1 1/2 and 2 inches in diameter.

FOREIGN TRUST LAWS

LAWS REGULATING COMBINATIONS, MONOPOLIES, AND PATENTS IN GREAT BRITAIN, CANADA, AUSTRALIA NEW ZEALAND AND GERMANY

During the past two years the factors governing and influencing the development of foreign trade have been carefully studied by both the American manufacturer and the commercial bodies of this nation. One result of this study has been the discovery that the trade of the European countries has been promoted largely through the cooperation of the producers, manufacturers, exporters and bankers, and that these have had the cooperation of the state. The present indications are that at the close of the war nations will cooperate to meet the competition of groups of nations. As the United States stands alone among the commercial nations of the world, its trade can be built up and held only by the cooperation of its exporters and manufactnrers. For this reason the Webb bill recently introduced in Congress authorizes the cooperation of American exporters. In order that the American exporter may know the conditions against which he must work, the Department of Commerce has issued a bulletin entitled "Trust Laws and Unfair Competition," from which the following abstracts have been made:

Chief Justice White, in the Standard Oil case, said that the public outcry against monopolies was due to the power that a monopoly gave to one to fix the price and thereby injure the public, to limit the production, and to allow a deterioration of the article. He then said that so far as the necessities of life were concerned, laws were passed prohibiting individuals to deal under circumstances and conditions that created a presumption that the dealings were not simply the honest exertion of one's right to contract for his own benefit unaccompanied by a wrongful motive to injure others, but were the consequence of a contract or a course of dealing of such a character as to give rise to the presumption of an intent to injure others through the means, for instance, of a monopolistic increase in prices.

The laws that regulate the formation of combinations, etc., however, vary widely in various countries. The monopolies granted by the English Crown became so numerous and obnoxious that in 1601 many of them were abolished by Parliament, and in 1640 the most of them were declared void. At present the only law in England affecting combinations to control the market is the common law. According to this, any member of the community is entitled to carry on any trade or business he chooses, and in such manner as he thinks most desirable in his own interests; and inasmuch as every right connotes an obligation, no one can lawfully interfere with another in the free exercise of his trade or business unless there exists some just cause or excuse for such interference.

In common law no contract was ever an offence merely because it was in restraint of trade. To make such a contract or combination unlawful, it must amount to a criminal conspiracy, as the right of an individual to carry on his business in the manner that he deems best in his own interests involves the right to combine with others in a common course of action.

The policy of the English law is to encourage competition, but it apparently places no serious obstacles to combination. In the interpretation of contracts of sale of property and business, the English courts, in recent years, have given them a more liberal construction than have the courts of the United States in those cases in which the common law has been applied, and have been willing to aid the enforcement of contracts of combinations in restraint of trade or to control the market that in the United States would have been declared against the public policy.

Canadian Trust and Patent Laws

In Canada action may be brought against a trust under statutes in the criminal code, or the customs, patent and inland revenue laws, or the Combines Investigation Act. According to the criminal code, it is unlawful:

> To unduly limit the facilities for transporting, producing, manufacturing, supplying, storing, or dealing in any article or commodity; to restrain or injure trade or commerce in relation to any such article or commodity; to unduly prevent, limit, or lessen the manufacture or production of any such article or commodity, or to prevent or lessen competition in the same.

. The patent law provides that if a patentee does not meet the reasonable requirements of the public in regard to patented article, compulsory licenses may be issued for its manufacture. If a patentee should refuse to comply with an order to grant a license, the patent may be declared void. The customs law provides that if the governor in council should find that there is a combination of manufacturers or dealers of any article that is injurious to the consumers, he may remove or reduce the duty on the article, in order to give the consumers the benefit of reasonable competition.

According to the Combines Investigation Act, if six citizens believe that a combination is in restraint of trade, they may bring action and cause a board to be appointed. Should this board find that the alleged condition exists, it may cause the removal or reduction of customs duties, the revocation of letters patent, and criminal prosecution. The only proceedings brought under this act were against the United Shoe Machinery Co. of Canada, when it was found that the leases of this company unduly restricted competition in the manufacture, sale, etc., of shoe machinery.

Australian and New Zealand Laws

The Australian Industries Preservation Act aims especially at the repression of monopolies and the prevention of dumping. It forbids contracts and combinations that will affect adversely the commerce of Australia and other countries or among the different states. But any person may defend his act by showing that the restraint was not to the detriment of the public or that the restraint is not unreasonable. Any person who monopolizes or attempts or conspires to monopolize commerce with other countries or among the states is guilty of an indictable offense. Instead of proceeding by indictment, however, the attorney-general may bring a civil action for the recovery of the fines imposed, without jury trial. The refusal to deal with a person, except under disadvantageous conditions, because such person deals with some other person or with persons not belonging to a commercial trust, is an offense in certain cases. A person may, however, declare the fact and purposes of the contract or combination to the attorney-general, and await his decision. Any proceedings brought against him before he receives the attorney-general's decision will not hold.

The patent laws provide for the granting of compulsory licenses and the revocation of letters of patent. Among other things, the patentee is held to be at fault if he has failed to grant licenses so that the demand for the patented article is not fully met, or the establishment of any new trade or industry in Australia is unfairly prejudiced. Patentees are forbidden to insert clauses in their leases, etc., restricting the other parties to the use of the article patented.

The Interstate Commission has very broad powers over all things connected with trade. In its first annual report it stated that a combination existed among the printers of Victoria, by which those in the association were given preferential treatment in the purchase of supplies. The commission found that while the combination may not have been illegal, it was contrary to the intention of Parliament, when it passed the Industries Preservation Act, because it caused the non-combination printers to purchase their supplies abroad. The chief commissioner suggested that the protective duties be remitted in such cases.

New Zealand has no general laws forbidding trusts. The two more important ones are restricted to agricultural implements, coal, meat, flour, etc. They prohibit the giving of rebates and make any person who conspires to monopolize the demand or supply of goods guilty of an offense, if such monopoly is contrary to the public interest. These laws declare that a commercial trust is any association having as one of its objects controlling or influencing the supply or demand or price of any goods in New Zealand or elsewhere, or creating or maintaining a monopoly in the supply or demand of goods. In one case the court said: "If the monopoly or control sought to be obtained can only be obtained by breaches of the law it is of such a nature as to be contrary to the public interest, although if it could have been obtained without breaches of the law it might not have been contrary to the public interest."

According to the New Zealand law, the governor may cause licenses to be granted if he is convinced that the patent is not being worked in New Zealand, that the reasonable requirements of the people cannot be supplied, or that any person is prevented from working or using to the best advantage an invention of which he is possessed.

Germany's Trust Laws

Germany's civil code, like England's common law, provides that "the pursuit of an industry is permitted to everyone, in so far as exceptions or limitations are not imposed or permitted in this law." This provision, though, permits combinations to exist. The Imperial Court has said:

> If in any branch of industry the prices of products sink too low and if the thriving operation of the industry is thereby made impossible or endangered, the crisis which occurs is destructive not only for individuals, but for the social economy in general, and it lies, therefore, in the interest of the whole community that unduly low prices shall not permanently exist. . . . Agreements of the kind under consideration can therefore be questioned from the standpoint of the protection of the general interest through the freedom of industry.

The Imperial Court has held that a book dealers' combination that fixed rebates and discounts was lawful, and the highest court of Bavaria has held that a combination of tile manufacturers that fixed prices and limited production was not against good morals, but rather both a valid and a prudent business arrangement. The civil code, however, says:

> Whoever in business affairs, for the purpose of competition, commits acts which are repugnant to good morals may be subject to an action to desist therefrom and to pay damages.

In the case of potash, spirits, beer, matches, and a few other industries, the laws have been so framed that combinations are favored. The general purpose of the potash laws is to regulate production and prices so that there will not be an excessive competition between producers nor very high prices for the consumers. This condition was created to conserve the supply of the material and prevent its exhaustion by wasteful mining or selling methods. Low prices in the domestic market are established by a direct fixing of price, and export sales are generally made at higher prices, though the export prices are not uniform. These laws, however, have failed in preventing unfair competition or the multiplication of mines.

Both Germany and the individual states have laws forbidding the formation of combinations for bidding on the public contracts. Combinations that restrain trade can also be punished by the provisions of the penal code. For instance, the Imperial Court condemned a combination of powder manufacturers that refused to supply dealers who would not patronize it exclusively, and who also threatened to discontinue the supply of a customer who had purchased goods from a competitor. This code also imposes penalties on those who exploit the necessity, thoughtlessness, or inexperience of another in order to obtain for themselves or a third party a pecuniary advantage that is greatly disproportionate to the service rendered.

Because of the conditions found to exist between a tobacco firm and a British American company, it is said that the following section was to be added to the penal code just before the outbreak of the war:

> Participation in a society whose existence, constitution, or purpose shall be kept secret from the government or in which is promised obedience to an unknown superior or unconditional obedience to a known superior makes the members punishable with imprisonment up to six months and the promoters and leaders of the society with imprisonment from one month to one year.

D. E. J.

* * *

Don't run the diamond across the wheel rapidly if you wish a good smooth finish, as such a procedure will cause the wheel to be imperfectly trued, and mottle marks are likely to appear on the work. On the other hand, don't run the diamond too slowly across the wheel if you wish the surface broken up so that it will cut freely and quickly.—*Grits and Grinds.*

PERSONALS

C. K. Cairns, formerly with the American Tool Works Co., Cincinnati, Ohio, has resigned, to become sales manager of the Cincinnati Pulley Machinery Co. of Cincinnati, manufacturer of the "Avey" drilling machines.

Henry H. Powell has been appointed manager of the buying department of William P. Bonbright & Co., Inc., 14 Wall St., New York City, taking effect September 1. Mr. Powell has been associated with N. W. Halsey & Co. in a similar capacity for ten years.

Merritt H. Barnes, formerly of the Boston office of the Prentiss Tool & Supply Co., now Henry Prentiss & Co., Inc., New York City, machine tool dealer, has been transferred to the Scranton office of the company. Mr. Barnes will cover the territory formerly handled by S. N. McFadden, resigned.

Frank G. Bolles, formerly manager of the publication *International Trade*, of Chicago, has been made vice-president of R. Martens & Co., Inc., New York City, and Petrograd, Russia, and will be in immediate charge of the subsidiary Russia Trade Corporation of America, recently formed. This concern will handle all kinds of general merchandise.

OBITUARIES

John H. Allen, president of the John F. Allen Co., New York City, maker of the original Allen riveting machine, died at his summer home at Kattskill Bay, Lake George, N. Y., aged fifty-seven years. Mr. Allen succeeded his father, who founded the business some forty-five years ago.

R. J. Collins, who for the past twelve years was connected with the Cataract Refining & Mfg. Co., Buffalo, N. Y., died at his home in Buffalo July 20. Mr. Collins was sales manager of the cutting compound department for the past six years, and had many friends among the machine tool builders throughout the country. He was well liked because of his attractive personality and genial qualities.

Charles Kirchhoff, for many years editor-in-chief of the *Iron Age*, died July 22 at his summer home near Asbury Park, N. J., aged sixty-three years. Mr. Kirchhoff enjoyed the friendship of many prominent men in mining and metal trade circles. He was elected president of the American Institute of Mining Engineers in 1898. He took a great interest in the industrial safety movement, and was a charter member of the American Museum of Safety and one of its vice-presidents.

COMING EVENTS

September 5-8.—Annual convention of the Traveling Engineers' Association at Chicago, Ill. W. O. Thompson, secretary, New York Central Car Shops, E. Buffalo, N. Y.

September 11-16.—Annual convention of the American Foundrymen's Association and the American Institute of Metals, Cleveland, Ohio, in the Cleveland Coliseum. A. O. Backert, secretary-treasurer, American Foundrymen's Association, Cleveland, Ohio.

September 11-16.—Exhibition of machines, equipments and supplies for the foundry and allied industries in conjunction with the annual conventions of the American Foundrymen's Association and American Institute of Metals, at Cleveland, Ohio, in the Coliseum. C. E. Hoyt, manager, 1949 W. Madison St., Chicago, Ill.

September 25-30.—Second National Exposition of Chemical Industries, Grand Central Palace, New York City.

September 27-30.—Annual convention of the American Electrochemical Society in New York City. One of the sessions will be devoted to made-in-America products of the electric furnace and electric cell, including copper, aluminum, abrasives, bleach, etc.

September 28.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

September 28-30.—Meeting of the American Electrochemical Society at Grand Central Palace, New York City. Secretary, J. Malcomb Muir, 239 W. 39th St., New York City.

October 11-21.—New York Electrical Exposition in the Grand Central Palace, New York City. Arthur Miller, director, Irving Place and 15th St., New York City.

October 24-25.—Annual convention of National Machine Tool Builders' Association, Hotel Astor, New York City, headquarters. Charles E. Hildreth, general manager, Worcester, Mass.

SOCIETIES, SCHOOLS AND COLLEGES

Columbia University, New York City. Bulletin announcing classes in extension teaching.

University of Utah, Salt Lake City. Bulletin of the University of Utah, with lists of students and calendar for 1916-1917.

Carnegie Institute of Technology, Pittsburg, Pa. General catalogue for 1915-1916. Of special interest in this field is the School of Applied Industries, which offers three-year courses in building construction, machine construction, general equipment and installation and printing; and one-year courses in machine shop work, patternmaking, foundry, forging, plumbing, electric wiring, sheet metal working, bricklaying and masonry, mechanical drafting, carpentry and printing. Four-year and two-year evening courses in the same trades are also given.

New York University, New York City. Announcement of the courses of study in the School of Commerce, Accounts and Finance of the New York University. The bulletin contains an article on foreign trade, entitled "American Commerce on the Offensive—Men Needed." The School of Commerce, Accounts and Finance has organized a department of instruction which aims to give students the training necessary for success in foreign trade. Those interested may address inquiries to Major B. Foster, secretary of the New York University School of Commerce, Accounts and Finance, Washington Square E., New York City.

NEW BOOKS AND PAMPHLETS

Standards for Electric Service. Circular No. 56 of the Bureau of Standards. 262 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C.

Correction of Echoes and Reverberations in the Auditorium, University of Illinois. By F. R. Watson and James M. White. 20 pages, 6 by 9 inches. Published by the University of Illinois, Engineering Experiment Station, Urbana, Ill., as Bulletin 87.

Electrical Tables and Engineering Data. By Henry C. Horstmann and Victor H. Tousley. 331 pages, 4¼ by 6½ inches. Illustrated. Published by Frederick J. Drake & Co., Chicago, Ill.

This collection of electrical data is arranged in alphabetical order, and its scope is limited to practical information likely to be needed by the working electrician. The alphabetical arrangement is supplemented by an index to tables, of which there are 132.

The Slide Rule. By Charles N. Pickworth. 124 pages, 5 by 7 inches. 39 illustrations. Published by the D. Van Nostrand Co., New York City. Price, $1.

This is the fourteenth edition of Pickworth's well-known practical manual for the use of the slide rule. This edition has been revised where necessary, and the contents have been further extended to include a section dealing with the solution of algebraic equations by the slide rule. This is probably one of the most complete and thorough treatises on the manifold applications of the slide rule available.

Fundamentals of a Cost System for Manufacturers. 31 pages, 6 by 9 inches. Published by the Federal Trade Commission, Washington, D. C.

The Federal Trade Commission has found that a great number of manufacturers, particularly the smaller ones, have no adequate system for determining their costs, and therefore price their goods arbitrarily. It is evident that there must be improvement in this direction before competition can be placed upon a sound economic basis. With the object of aiding in the improvement of business generally, the commission has endeavored in this pamphlet to show briefly the importance of accurate manufacturing costs and the fundamental principles underlying them.

Industrial Arithmetic. By Nelson L. Roray. 154 pages, 5 by 7½ inches. 85 illustrations. Published by Blakiston's Son & Co., Philadelphia, Pa. Price, 75 cents.

The manuscript of this book has been used for about thirty different classes under several teachers in the Industrial Department of the Dickinson High School, Jersey City, N. J., during the past five years, and the success obtained in its use has prompted the author to publish it in book form. The book should be especially suitable for trade schools and similar institutions, where a teacher is present to guide the work. For home study the instruction matter is probably somewhat too abbreviated, and needs the supplementary instruction of a teacher. For school work, however, the book is unusually complete, and contains a great number of exercises which will force the student to memorize the rules and principles by constant repetition.

Instruction Book on Oxy-acetylene Welding and Cutting. By H. Sidney Smith and A. F. Brennan. 45 pages, 6 by 9 inches. Illustrated. Published by the Prest-O-Lite Co., Inc., Indianapolis, Ind. Price, 50 cents.

This pamphlet is the fourth edition of the instruction book published by the company to help users of "Prest-O-Lite" oxy-acetylene welding and cutting apparatus get best results. It treats of the nature of oxygen and acetylene gases, and of the necessary qualifications of the operator. The construction of the torch is described and the management of the acetylene regulator. Illustrations show the correct welding flame and how the joint should be prepared for welding. Preheating, reheating and annealing are discussed. The book contains in a small compass a large amount of valuable, instructive matter for those using oxy-acetylene welding and cutting apparatus.

Electric Wiring Diagrams and Switchboards. By Newton Harrison. 330 pages, 4½ by 6½ inches. 120 illustrations. Published by Norman W. Henley Publishing Co., New York City. Price, $1.50.

This is the second edition of a work first published in 1906, which has just been revised; data on transformers and measuring instruments have been added. Practical every-day problems in wiring are presented, and only arithmetic is employed in the computations. A simple explanation is given of Ohm's law with reference to the wiring for direct and alternating currents. The simple circuit is developed with positions of mains, feeders and branches, and their treatment as a part of a wiring plan and their employment in house wiring are clearly illustrated. The book is bound in flexible covers and is well suited to the needs of electricians.

The Use of the Slide Rule. By Allan R. Cullimore. 36 pages, 6 by 9 inches. Illustrated. Published by Keuffel & Esser Co., Hoboken, N. J. Price, 50 cents.

The author of this manual is dean of the College of Industrial Science of Toledo University, and undertook its preparation after recognizing the need of a book to meet the requirements of students taking engineering and industrial courses. The text is based upon sets of notes which were developed for use in classes consisting of engineering students and men possessing more or less practical experience. This book is not in any sense a complete treatise, its aim being to assist the slide-rule user to develop his own ideas rather than to give empirical rules for the use of this instrument. Such rules as have been given are for the purpose of training the students in the development of processes, and the author does not recommend that they be committed to memory.

Five-figure Mathematical Tables. By E. Chappell. 320 pages, 6 by 9 inches. Published by D. Van Nostrand Co., New York City. Price, $2.

This is an entirely new collection of logarithm and similar tables, introducing, in addition to the ordinary logarithm tables, tables of what the author terms "cologs," "illogs" (anti-logarithms), "lologs" (logarithms of logarithms), and "illologs" (anti-lologs). In addition, of course, there are the usual tables of natural trigonometrical functions and their logarithms. In the preface the author calls attention to the fact that the sciences of electricity and thermo-dynamics present fundamental differences with regard to the mathematical expressions appearing in them, as compared with those in the older sciences of mathematics and mechanics, one fundamental difference being that in the newer sciences numbers are frequently raised to fractional powers. Consequently, the logarithm tables of the past, which are especially useful when numbers are raised only to simple powers, cannot be said to reduce the calculations of these new sciences to the simplest possible forms. It is for processes of involution and evolution involving fractional indices that the tables of so-called "lologs" and "illologs" have been calculated. The "lolog," or logarithm of a logarithm, enables the value of an expression such as $1.765^{1.29}$ to be found by simply finding the logarithm of 1.29, adding to it the "lolog" of 1.765, and finding the number corresponding to the "lolog" thus obtained, or, still simpler, finding the "illolog" of the sum. The book gives explicit directions for the use of these various tables, which probably will be found useful to many who have a great deal of engineering calculation to do, involving the raising of numbers to fractional powers. A suggestion that might be made is that a book of this kind, which is frequently referred to and which contains not less than six different classes of tables, should be provided with some kind of thumb index or other means for rapidly finding the class of tables which the user wants at the moment.

NEW CATALOGUES AND CIRCULARS

Richard W. Jefferis Co., Camden, N. J. Folder illustrating and describing Jefferis pressed steel lockers, wardrobes, bins and shelving for modern factory equipment.

Keuffel & Esser Co., 127 Fulton St., New York City. Price list revised to July 1, 1916, superseding the prices listed in the thirty-fifth edition of the Keuffel & Esser general catalogue.

International Machine Tool Co., Indianapolis, Ind. Circular of the "Libby" heavy-duty turret lathe in railroad shops, showing typical locomotive work which the "Libby" lathe handles efficiently.

Electric Controller & Mfg. Co., Cleveland, Ohio. Revised price sheet for E. C. & M. automatic motor starters with angle iron mounting and separate resistors, for non-reversing direct-current motors.

Link-Belt Co., Chicago, Ill. Book 275, containing revised list prices of link-belt, sprocket wheels, traction wheels, gears and malleable iron elevator buckets. These prices supersede those given in catalogue 110.

United States Lathe & Machine Co., Cincinnati, Ohio. Leaflet descriptive of the United States 20-inch heavy-duty screw cutting engine lathe with quick-change gear device, five-step cone and single back-gears.

Bunting Brass & Bronze Co., 748 Spencer St., Toledo, Ohio. 1916 catalogue, covering brass and bronze bearing bushings, cored bars for repair work, etc., giving a complete list of dimensions and prices. The book is attractively bound in flexible cloth.

Cadwell-Vernon Co., Inc., 15 Foote Ave., Jamestown, N. Y. Catalogue of rolling machines for forming sheet metal beading, tubing, etc.; made in four sizes for handling stock from 0.005 up to 0.065 inch thick, 6 inches wide. Larger machines are built to order.

Precision Instrument Co., E. Fort and Beaubien Sts., Detroit, Mich. Leaflet advertising the product of this company, which includes CO_2 recorders, SO_2 recorders, recording gages, indicating gages, draft gages, coal calorimeters, gas calorimeters, boiler testers, water meters, etc.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 3033 describing "Imperial" type "XPV" duplex steam-driven air compressors; form 4122, illustrating and describing the "Leyner" drill sharpener; and form 9024, treating of steam condensing plants of the Beyer barometric type.

Vernon Machine Co., Worcester, Mass. Circular of an eleven-inch, four-step cone pulley engine lathe. The dimensions of the headstock and spindle and the general construction are such that the lathe is suited to a wide range of manufacturing work within its capacity. Weight with five-foot bed, 775 pounds.

Phoenix Mfg. Co., Eau Claire, Wis. Catalogue of Conradson engine lathes, covering geared-head engine lathes, geared-head projectile lathes, and geared-head special lathes, giving illustrations of each type, together with brief specifications. Sectional drawings showing the construction of the geared head are included.

Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletins treating of the "Spraco" system for cooling condensing water, the Vaughan flow meter, and cooling water for ice plants. These bulletins describe in detail the various devices dealt with, and are of especial interest to power plant owners and operators.

Ball & Roller Bearing Co., Danbury, Conn. Catalogue 8 on ball thrust bearings, roller thrust bearings, journal roller bearings, annular roller bearings, anti-friction bearings and cylindrical rollers, giving dimensions and prices. Tables of allowable loads on chrome steel balls and conversion tables giving millimeter equivalents of fractional inches and decimal equivalents of fractional inches are included.

New Departure Mfg. Co., Bristol, Conn. Sheets 71 FE to 74 FE for loose-leaf binder, illustrating and describing rotary screw water lifting mechanism, isolated electric lighting plant, ball bearings for gasoline locomotive friction drive, and ball bearings in bench milling machines. A revised price list and description of New Departure double-row, single-row, radax and magneto type ball bearings has been issued.

Foxboro Co., Foxboro, Mass. Bulletin 104, illustrating and describing the Foxboro line of indicating and recording thermometers. The bulletin describes clearly the actuating principles and the many marked improvements which have been embodied in the design. Information has been given and arranged in such a way as to make it easy for the prospective customer to pick out a thermometer that will exactly meet his requirements.

Hauck Mfg. Co., 140 Livingston St., Brooklyn, N. Y. Bulletin 69, showing foundry burners for cupola lighting, ladle heating and skin-drying molds. Several new features have been incorporated in the Hauck compressed air and hand pump burners for foundry service, which are illustrated and described in this bulletin. A special foundry outfit equipped with interchangeable burners and nozzles is illustrated on page 7.

Austin Co., Cleveland, Ohio. Bulletin illustrating examples of manufacturing buildings that have been erected by the Austin system in thirty to sixty days from the time of starting work. Standardized cross-sections and bay widths are employed, which means that the structural steel required can be held ready in fabricating plants, and all other materials held in stock or under order. This plan equalizes production and makes possible the erection of first-class buildings at low cost and in quick time.

Foote Bros. Gear & Machine Co., 210-220 N. Carpenter St., Chicago, Ill. General catalogue 12 of spur, bevel, miter, spiral, worm and internal gears, tractor gears, traction engine gears, heavy-duty hardened gears, rawhide pinions, and cut steel racks. The catalogue comprises 384 pages, 5½ by 8 inches, and is substantially bound. In addition to the price list of gears and machinery listed, a considerable amount of valuable technical information relating to gearing, the strength of gear teeth, etc., is included.

Hilliard Clutch & Machinery Co., Elmira, N. Y. Catalogue C of Hilliard friction clutches and friction cut-off couplings, illustrating and giving dimensions of the Hilliard line of clutches, including two of the latest developments—double disk clutches and ball bearing sleeve clutches. The ball bearing sleeve clutch illustrated is the Chapman ball bearing sleeve in combination with the Hilliard clutch mechanism. The company has, however, completed a standard design which will permit the use of any annular bearing in connection with the clutch sleeves.

Cutler-Hammer Mfg. Co., Milwaukee, Wis. Two-color, eight-page folder illustrating and describing Cutler-Hammer machine tool controllers, which was distributed to master mechanics and master car builders at the annual June convention at Atlantic City. The folder describes machine tool controllers in three classes, as plain starting, speed setting and speed regulating controllers. Five pages of the folder are devoted to large illustrations of Cutler-Hammer machine tool controllers installed on various machine tools, and one illustration shows one of several hundred controllers now in use in the new plant of the River Furnace Co. at Cleveland, Ohio.

Greenfield Tap & Die Corporation, Greenfield, Mass. Bulletin containing a detailed description of the Greenfield "gun" tap. The characteristics of this tap are shown by a severe test to which it was subjected by a user. The tool was used to tap a safe door made of five plates of steel welded together. Three of the plates were chrome-vanadium and two open-hearth steel. The company claims that from twenty-five to twenty-eight holes was the life when a high-speed steel tap was used on this job. A "gun" tap made of carbon steel tapped thirty-six holes before it was necessary to sharpen it. The book also contains tables giving sizes and prices of the "gun" taps in stock.

Link-Belt Co., Chicago, Ill., is issuing a book entitled "Personal Reminiscences of James Mapes Dodge," written by Charles Piez, president of the Link-Belt Co. The book contains an interesting account of the life of James Mapes Dodge, who had such an important part in American invention and engineering and in the development and success of the Link-Belt Co. The first part of the book deals with the development of the conveying and coal-storage business, in which Mr. Dodge took an active part. The second part of the book discusses Mr. Dodge's work in connection with the Taylor system of scientific management, and his wise adaptation of this system to the needs of the Link-Belt Co. Mr. Dodge's inventions in the power and transmission field are well known by all mechanical men.

S. K. F. Ball Bearing Co., Hartford, Conn. Booklet entitled "Better Electric Motors Equipped with S. K. F. Ball Bearings." This booklet, which is in the nature of a short treatise on the use of ball bearings in electric motors, is copiously illustrated and the matter is attractively arranged. It points out how the efficiency and the power factor of a motor are improved by the use of ball bearings because the air gap may be reduced without danger of the armature wearing down and being stripped by contact with the pole pieces. Some of the topics of special interest treated are "How Maintenance Charges are Reduced 66 per cent," "Motor Lengths Shortened 10 to 27 per cent," "A Discussion of Bearing Sizes," "Discussion of Gear Drive Motors," "Applications of Motors to Machine Tools," etc.

Lodge & Shipley Machine Tool Co., Cincinnati, Ohio. Catalogue of lathes, showing details of construction of threading and feed gearing, carriage, apron, tailstock, taper attachment, draw-in chuck and collets, relieving attachment, double-nose spindle, diameter stops, etc. The first general section is devoted to 14-inch, 16-inch, 18-inch, 20-inch, 22-inch, 24-inch, 27-inch, 30-inch, 36-inch, three-step cone double back-geared lathes, which are illustrated and specifications given. The selective head lathes are made in sizes of 16-inch, 18-inch, 20-inch, 22-inch, 24-inch, 27-inch, 36-inch, 42-inch and 48-inch swing. Examples of these are illustrated and data are given for all sizes. The catalogue includes examples of multiple diameter turned shafts, giving dimensions, material and time required to turn complete.

TRADE NOTES

Beaman & Smith Co., Providence, R. I., has completed a four-story reinforced concrete addition to its factory. This addition covers a floor space of 40 by 150 feet, and will be used for offices, drafting-room and pattern shop.

Abrasive Machine Tool Co., Providence, R. I., has built a factory in East Providence for the manufacture of grinding machines. The building is of reinforced concrete, one story high, 50 by 150 feet, with an L 20 by 30 feet, and is expected to be ready for occupancy October 1.

Link-Belt Co., Chicago, Ill., is enlarging its malleable foundry at Indianapolis to meet the increased demand for link-belt. The foundry extension will be one story high, 70 by 275 feet, with a wing 107 by 140 feet. It will house the company's fifth melting furnace and will provide space for sixty molders.

Grayson Tool Co., Indianapolis, Ind., has removed to its new factory at Charleston, W. Va. The factory is a modern shop, 200 by 175 feet, and will employ about 100 men. The firm will do contract work, make gages and manufacture and market the Grayson single, duplex and triplex full automatic surface grinders.

Diamond Power Specialty Co., Detroit, Mich., announces that its estimate of sales of "Diamond" soot blowers for the year beginning August 1, 1916, will be sufficient to equip 1,000,000 horsepower of boilers annually. The Diamond soot blowers are provided with insuluminum parts that are subjected to high temperature. This alloy has heat-resisting qualities far superior to iron and steel.

Prentiss Tool & Supply Co., 149 Broadway, New York City, dealer in machine tools and metal-working machinery, has been incorporated under the name of Henry Prentiss & Co., Inc. The new corporation will succeed to the business and properties of the old, but, with the exception of the name, there will be no change, the officers, directors, general organization and business policy remaining the same as heretofore.

Transmission Ball Bearing Co., 32 Wells St., Buffalo, N. Y., has found it necessary, owing to the rapidly increasing demand for Chapman ball bearings, to build and equip a factory having a capacity of three or four times the present output. The company is now in the market for machinery and equipment to handle a complete line of shafting bearings and loose pulley bushings, as well as machinery for manufacturing the "Universal" elevating truck.

Wismach & Co., 1513 Richard St., Milwaukee, Wis., are making rectangular gage standards such as have formerly been imported exclusively. These gage standards are hardened by a special process, and their measuring surfaces are distanced as indicated on each gage, within limits of 0.00001 inch. They are made in standard sets, but they are also furnished in sets of any desirable combination, varying by fractions of inches as well as of millimeters.

R. Martens & Co., Inc., 24 State St., New York City, announces that the original purpose of limiting its operations to the mechanical lines of industry will be strictly adhered to, but in order to conserve the enormous opportunity for non-mechanical lines, it has created a subsidiary company under the name of Russia Trade Corporation of America. The new concern will have a complete business organization, and its general offices will be in the Maritime Bldg., 8-10 Bridge St., New York City.

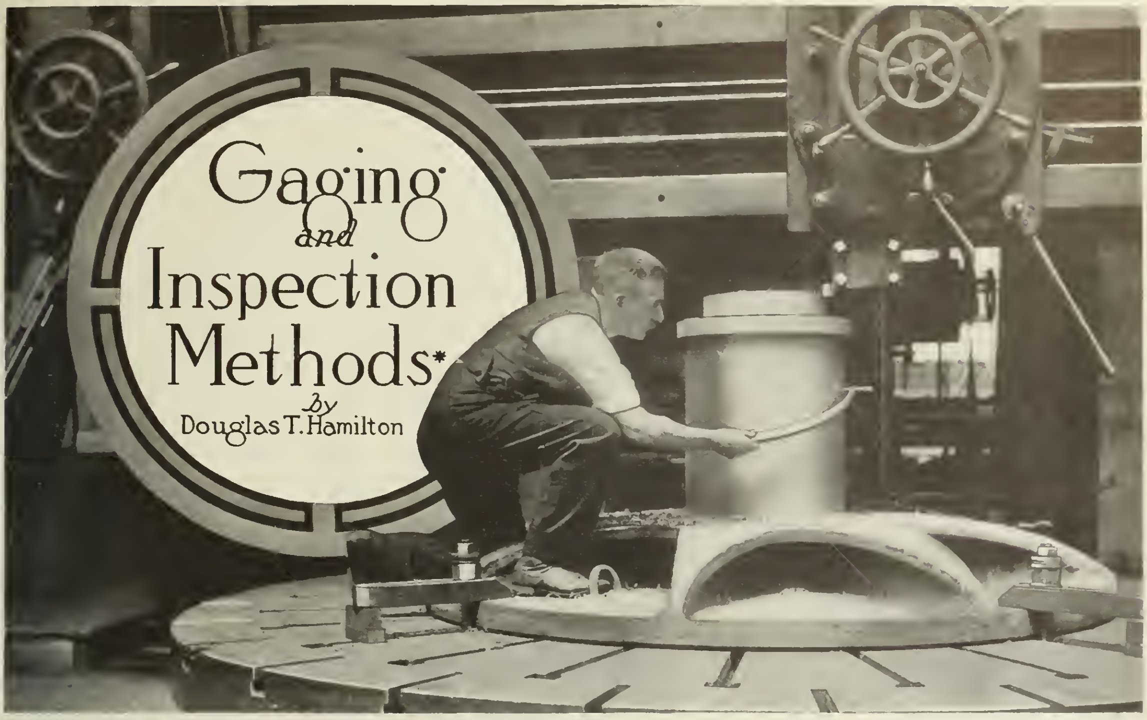
Hyatt Roller Bearing Co., Newark, N. J., has given the name of industrial department to its commercial sales division located in Newark with the factory. The company feels that the time is rapidly approaching when the industrial world will appreciate the economy of anti-friction bearings, as have the automobile builders. For that reason, the industrial department will be prepared to meet conditions and advise regarding the use of anti-friction bearings for lineshaft boxes, industrial trucks, mine cars, machine tools, electric motors, cement machinery, cranes and trolleys, textile machinery, blowers, fans and conveyors, etc.

Ph. Van Ommeren Corporation, 42 Broadway, New York City, has recently entered the New York shipping field as a branch of the business of the old Dutch shipping house of Ph. Van Ommeren, which was established in Rotterdam, Holland, nearly a century ago, and which now has branches all over the world. The American branch is incorporated under the laws of the state of New York, and the management will be in the hands of William H. Scholz, who for the past two years has been attached to the American legation at the Hague, acting as commercial adviser. The New York office is fully equipped for handling shipments to all parts of the world.

Philadelphia Brass Co., 917 Crozer Bldg., Philadelphia, Pa., has been incorporated with a capital of $101,000 for the manufacture of brass rods, extruded shapes and seamless tubes. The company has purchased a seventeen-acre tract at Downingtown, Pa., near Philadelphia, on which the plant will be erected, and it will start on day and night shifts to fill orders on hand as soon as erected. The directors are: C. C. Anthony, Lewis Burnham, Henry T. Coates, Jr., J. Lloyd Coates, Carl B. Ely, E. B. McCarthy and Walter S. Johnston; and the officers are: Henry T. Coates, Jr., president; William E. Chickering, secretary and treasurer; Walter S. Johnston, general sales manager.

CLASSIFIED AND WANT ADVERTISEMENTS

Will be found on page 285 of this issue and will be run in the same relative position in future.



The importance of gages and inspection methods in modern interchangeable manufacturing is generally recognized, and at this time, when manufacturing industries are rapidly expanding, a review of gages and gaging methods is especially timely. The limit system is the foundation or basis of interchangeable manufacturing, and in these articles the author has undertaken to make clear the matter of limits, allowances and tolerances. Various types of gages are used to illustrate. The article takes up the developments of interchangeable manufacture, the limit system, advantages of the limit system, difference between allowance, tolerance and limit, setting manufacturing limits on interchangeable parts, various methods of establishing a system of limits, simple method of establishing manufacturing limits, allowances for various classes of fits, establishing allowances and tolerances for various classes of fits, and various methods of presenting manufacturing limits on drawings. Very little data are available on the life of gages, and in this article, references are given to records which indicate the probable life of gages on certain classes of work and material, and the advantages to be obtained by giving manufacturing tolerances on gages to provide for wear. These data are of much value to those who have to estimate on large quantities of work, such as munitions and shells that are made in great quantities.

PREVIOUS to the adoption of gages and inspection fixtures, the component parts of mechanisms were made by fitting one to another. As an illustration, we will take a gasoline engine and assume that the cylinders were finished by reaming. The pistons would be made approximately to size by caliper measurements and then fitted to the bore of the cylinders, the cylinders acting as a gage. In this way, of course, the production of interchangeable parts is difficult if not impossible. The question of having each part alike within given limits, however, has not always been considered practical or necessary, and the first application of the interchangeable system was adopted in the production of rifles, as will be described later.

In the past few years the subject of gaging and inspection methods has received considerable attention. This has been due more particularly to the desire to reduce manufacturing costs rather than to have all parts made interchangeable. For instance, in the manufacture of the modern automobile, which is one of the many examples of interchangeable manufacture, it makes very little difference to the purchaser, generally speaking, whether the parts are interchangeable or not, but it does make a great difference to the manufacturer who is desirous of reducing his manufacturing costs to a minimum. In order to accomplish this it is necessary to employ efficient gaging and inspection methods, so that the time spent by the operator in measuring the work will be greatly reduced.

It has also been clearly demonstrated in plants where the interchangeable system has been properly applied that a poorer grade of mechanics can be employed and still turn out interchangeable parts. It requires the services of a first-class mechanic to make a number of parts exactly alike, without a gaging system, but a poor mechanic can make a large number of parts exactly the same—within the required limits—and much cheaper, with a proper gaging and inspection system. Hence, the chief advantage gained by interchangeable manufacture is not that all parts are made alike, but that production costs are greatly reduced.

* For articles on gages and gaging previously published in MACHINERY, see "Fixed Caliper Gages in Manufacturing," May, 1916; "Plug and Ring Gage Allowances," January, 1916; "Limit Gage with Ball Contact Points," January, 1916; "High-explosive Shell Cartridge Cases," December, 1915; "Interchangeability," August, 1915; "Rogers Taper-end Plug Gages," July, 1915; "Ames Test Gage," June, 1915; "Taft-Peirce Tool-room Specialties," June, 1915; "Thread Tool Gages," June, 1915; "How We Came to Have the Micrometer Caliper," June, 1915; "B. & S. Machinists' Small Tools," May, 1915; "Shrapnel and Shrapnel Manufacture—Gaging Shrapnel Shells," April, 1915; "Slocomb Bench Micrometer," March, 1915; "Limit Gage for Measuring Recessed Work," January, 1915; "Slocomb Direct-reading Micrometer," December, 1914; "Thread Measuring Tool," November, 1914; "Precision Method of Measuring Angles," October, 1914; "Checking a Cam-shaft with the Dial Indicator," August, 1914; "A Dial Comparometer," August, 1914; "One-wire System for Measuring Threads," July, 1914; "A Gage Limit System for General Work," June, 1914; "The Use of Gages," June, 1914; "Gage for U. S. S. Thread Tools," April, 1914; "Gaging Watch Escapements," February, 1914; "Test Gages for Automobile Cylinders," January, 1914; "Measuring the Flat on U. S. and Acme Thread Tools," July, 1913; "Atlas Ball Gages," May, 1913; "A 'Three Point' Micrometer and Its Use," May, 1913; "Fixtures and Gages used in Manufacturing the Multigraph," April, 1913; "Measuring Screw Threads by Means of Micrometers," January, 1913; "Ashcroft Thickness Gage for Sheet Materials," November, 1912; "Making New Departure Ball Bearings," November, 1912; "Limits on Gearing," October, 1912; "A Ball Race Gage," July, 1912; "Watch Movement Manufacture," June, 1912; "Device for Testing and Measuring Gears," April, 1912; "Taps and Tapping," April, 1912; "The Manufacture of Steel Balls," April, 1912; "Table of Allowances and Limits," April, 1912; "The Ross Rifle and Its Manufacture," January, 1912; "Plant Inside Micrometer Caliper," November, 1910; "A System of Gages for Small Parts," November, 1910; "Locating Work by the Button Method," October, 1910; "Height Gages for Inspecting," September, 1910; "Depth Gage with Indicator Attachment," September, 1910; "Accurate Gage Work in the Bench Lathe," May, 1910; "Ball Point vs. Anvil Type Thread Micrometers," March, 1910; "An Electric Surface Gage," November, 1909; "The Manufacture of Gages," September, 1909; "Compact Form of Dial Indicator," August, 1909; "Gages for Accurately Sizing Bevel Gear Blanks," March, 1909; "Device for Testing Truth of Cut Gears," January, 1909; "Keyway Gaging in Shafts and Hubs," December, 1908; "Gage for Testing the Planing of a Turret Machine Bed," September, 1908; "Sensitive Indicating Micrometer," September, 1908; "Pack-hardening Gages," June, 1908; "Making Thread Gages," February, 1908; "Micrometer Attachment for Reading Ten-thousandths," February, 1908; "German Bevel Gear Testing Device," February, 1908; "Testing the Lead of Taps and Screws," January, 1908; "Dial Gages for Accurate Measurements," December, 1907; "Radius Micrometer," "Measuring Screw Thread Diameters," and "Wells Bros. Standard and Limit Gages," September, 1907; "Micrometer Heads for Special Gages," September, 1900; "Gages for Bicycle Work," June, 1900.

† Associate Editor of MACHINERY.

In the following article, the fundamental principles governing the setting of limits and tolerances, application of standard and special gages, inspection fixtures, etc., for various classes of work will be dealt with in detail. In addition, systems of handling work in the most up-to-date plants in the country will be described in order to illustrate some of the fundamental principles of interchangeable manufacture. The methods of making some of the principal types of gages, such as plain cylindrical, plug, snap and thread gages, and other inspection tools, taking up machining, hardening, lapping, etc., will also be described.

Development of Interchangeable Manufacture

The original idea of making parts interchangeable is credited to Eli Whitney, a manufacturer of Whitneyville, Conn., a small town just outside New Haven. Mr. Whitney first applied this principle to the production of firearms for the United States government, with the object of being able to replace broken parts of firearms with new ones when in the field. In 1798 Mr. Whitney was given a contract for firearms which were produced on the interchangeable basis. The lock of these firearms was made by employing hardened templets to which the parts were accurately filed. About the same time Simeon North adopted the principle of interchangeable manufacture in the production of army pistols, and from the year 1800 on great strides were made in this direction.

The first complete system of interchangeable manufacture is credited to Elisha K. Root, a New England mechanic, who made a complete system of jigs, fixtures, tools and gages for use in the Colt Armory at Springfield. It has been stated that interchangeable parts were made in France as early as 1717, but that the system was not a success. In 1785, however, a mechanic by the name of Le Blanc made rifles on this basis. The method was not generally adopted, however. In the plant of Sharp, Roberts & Co., Manchester, England, an interchangeable system was adopted in 1825, in which templets and gages were used extensively. The greatest advances in the application of this method of production, however, have been made in the United States, and as has been previously mentioned, the chief advantage gained has been in the gradual reduction of production costs. A reduction has been effected in some cases in spite of the increase in the cost of materials and labor, as has been clearly demonstrated in the Ford Motor Co.'s plant in Detroit.

The Limit System

The limit system which forms the basis of interchangeable manufacture is applied in a variety of ways in various manufacturing plants. In some cases the limit system, as generally understood, is not applied in its entirety. For instance, parts which must go together are made with certain allowances, but no tolerances are given to take care of unavoidable errors in the manufacture of parts. This cannot be called a limit system, because no limits are allowed. Consequently, a great deal more time and money is spent in making the parts than would be the case if the complete system were adopted. In cases where the limit system is not adopted, the parts are made to direct measurement, using standard measuring tools, and unless great care is taken and experienced workmen employed, considerable fitting and assembling is necessary. With a complete system of gaging and inspection, this fitting and assembling is practically, if not entirely done away with, and manufacturing costs are thereby greatly reduced. The advantages of the limit system are not always thoroughly appreciated, and in the following an endeavor will be made to explain some of the chief reasons why this system should be adopted where it is desired to produce parts cheaply as well as interchangeably.

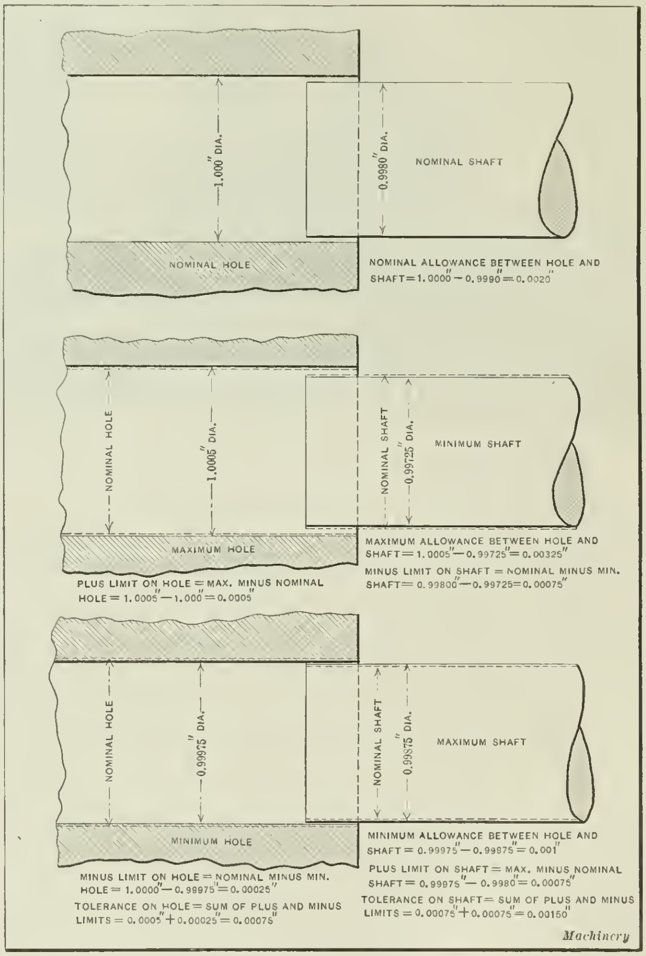


Fig. 1. Diagram illustrating Difference between the Terms Allowance, Tolerance and Limit

Advantages of the Limit System

The adoption of a limit system and the practice of working to limit gages has many advantages. In the first place, it makes an interchangeable product possible and eliminates the necessity of depending on the judgment of the workman; and probably what is of still more importance, it reduces the amount of spoiled work to a minimum. The initial cost required to install the system in some cases is heavy, but when it is considered that a properly worked out limit system greatly reduces inspection and manufacturing costs, it will be seen that the advantages to be gained will much more than offset the cost involved.

In adopting a limit system for ordinary work, it is necessary to take either the hole or the shaft as a standard. When holes are finished by grinding, it makes little difference which is decided upon. When the hole in the work is finished by reaming or other set tools, and can be duplicated in size with reasonable commercial accuracy, it is advisable to adopt the hole as a basis. There are, of course, exceptions to all rules, and in some cases manufacturers using considerable cold-rolled steel shafting find that it is preferable to use the shaft as a basis instead of the hole. As a general rule, however, the hole basis should be adopted.

Difference Between Allowance, Tolerance and Limit

The terms "allowance," "tolerance" and "limit" are frequently used interchangeably, although as a matter of fact they represent different quantities.

Allowance is the difference between the diameter of the shaft and the hole to allow for various classes of fits, such as drive, push, running, force, etc.

TABLE I. TOLERANCES FOR STANDARD HOLES (NEWALL ENGINEERING CO.)

Nominal Diameters, Inches	0—½	9/16—1	1 1/16—2	2 1/16—3	3 1/16—4	4 1/16—5	5 1/16—6	6 1/16—7	7 1/16—8	8 1/16—9	9 1/16—10	10 1/16—11	11 1/16—12
Class A													
Max. Limit	+0.00025	+0.00050	+0.00075	+0.00100	+0.00100	+0.00100	+0.00150	+0.00150	+0.00175	+0.00175	+0.00175	+0.00200	+0.00200
Min. Limit	—0.00025	—0.00025	—0.00025	—0.00050	—0.00050	—0.00050	—0.00050	—0.00075	—0.00075	—0.00100	—0.00100	—0.00100	—0.00100
Tolerance	0.00050	0.00075	0.00100	0.00150	0.00150	0.00150	0.00200	0.00225	0.00250	0.00275	0.00275	0.00300	0.00300
Class B													
Max. Limit	+0.00050	+0.00075	+0.00100	+0.00125	+0.00150	+0.00175	+0.00200	+0.00225	+0.00225	+0.00250	+0.00250	+0.00275	+0.00275
Min. Limit	—0.00050	—0.00050	—0.00050	—0.00075	—0.00075	—0.00075	—0.00100	—0.00100	—0.00125	—0.00125	—0.00125	—0.00125	—0.00150
Tolerance	0.00100	0.00125	0.00150	0.00200	0.00225	0.00250	0.00300	0.00325	0.00350	0.00375	0.00375	0.00400	0.00425

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Tolerance is the difference between the maximum and minimum diameters of either the shaft or the hole necessary to tolerate unavoidable imperfections in workmanship.

Limit is the amount set above or below the nominal diameters of the shaft or the hole in order to limit the amount of error that can be tolerated.

For example, suppose it is necessary to make a shaft with a good running fit in a bushing, as illustrated in an exaggerated form by the three detailed views in Fig. 1. The difference between the nominal diameters of the shaft and hole is 0.002 inch, which is known as the allowance. The limits on the diameters of the hole and shaft, respectively, are — 0.00025 inch, + 0.0005 inch, and ± 0.00075 inch, so that the tolerance on the hole is 0.00075 inch, and on the shaft, 0.0015 inch. For nominal hole of 1 inch and shaft of 0.998 inch, this gives a maximum hole of 1.0005 inch and a minimum shaft of 0.99725 inch, a difference of 0.00325 inch; and a minimum hole of 0.99975 inch and a maximum shaft of 0.99875 inch, a difference of 0.001 inch. From this it will be seen that the "set" allowance between the shaft and hole is what is desired, but seldom obtained.

Setting Manufacturing Limits on Interchangeable Parts

The setting of limits on work which must be made interchangeable is of vital importance to the present-day manufacturer. It is a subject which does not receive the consideration that it deserves. Many manufacturers set the limits much closer than is absolutely necessary to obtain interchangeability. When a part does not need to be made closer than to ± 0.003 inch, this limit should be tolerated. Where greater accuracy is necessary the limits, of course, should be closer. In doing this, no unnecessary time is spent in making parts to closer limits than the conditions actually demand.

For instance, many manufacturers specify the length of a shaft in fractions of an inch and do not give any limits, with the result that the toolmaker or mechanic endeavors to bring the parts exactly to the size mentioned. This is a short-sighted policy, especially where 1/64 inch more or less than the size given on the drawings would make no practical difference in the efficiency of the machine. Take also, for instance, gages, jigs, fixtures or other special tools used in the production of interchangeable parts. It is the practice of some concerns not to give any manufacturing limits on these tools, specify-

TABLE II. TOLERANCES FOR RUNNING FITS (NEWALL ENGINEERING CO.)

Nominal Diameters, Inches	0—½	9/16—1	1 1/16—2	2 1/16—3	3 1/16—4	4 1/16—5	5 1/16—6	6 1/16—7	7 1/16—8	8 1/16—9	9 1/16—10	10 1/16—11	11 1/16—12
Class R													
Max. Limit	—0.00200	—0.00275	—0.00350	—0.00425	—0.00500	—0.00575	—0.00650	—0.00675	—0.00700	—0.00750	—0.00800	—0.00825	—0.00850
Min. Limit	—0.00100	—0.00125	—0.00175	—0.00200	—0.00250	—0.00300	—0.00350	—0.00350	—0.00350	—0.00375	—0.00400	—0.00400	—0.00425
Tolerance	0.00100	0.00150	0.00175	0.00225	0.00250	0.00275	0.00300	0.00325	0.00350	0.00375	0.00400	0.00425	0.00425
Class S													
Max. Limit	—0.00125	—0.00200	—0.00250	—0.00300	—0.00350	—0.00400	—0.00450	—0.00475	—0.00500	—0.00550	—0.00575	—0.00600	—0.00625
Min. Limit	—0.00075	—0.00100	—0.00125	—0.00150	—0.00200	—0.00225	—0.00250	—0.00275	—0.00275	—0.00300	—0.00325	—0.00325	—0.00350
Tolerance	0.00050	0.00100	0.00125	0.00150	0.00150	0.00175	0.00200	0.00200	0.00225	0.00250	0.00250	0.00275	0.00275
Class T													
Max. Limit	—0.00075	—0.00125	—0.00150	—0.00200	—0.00225	—0.00250	—0.00275	—0.00275	—0.00300	—0.00300	—0.00325	—0.00350	—0.00350
Min. Limit	—0.00050	—0.00075	—0.00075	—0.00100	—0.00100	—0.00125	—0.00125	—0.00125	—0.00150	—0.00150	—0.00150	—0.00175	—0.00175
Tolerance	0.00025	0.00050	0.00075	0.00100	0.00125	0.00125	0.00150	0.00150	0.00150	0.00150	0.00175	0.00175	0.00175

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TABLE III. TOLERANCES FOR PUSH, DRIVING AND FORCE FITS (NEWALL ENGINEERING CO.)

Nominal Diameters, Inches	0—½	9/16—1	1 1/16—2	2 1/16—3	3 1/16—4	4 1/16—5	5 1/16—6	6 1/16—7	7 1/16—8	8 1/16—9	9 1/16—10	10 1/16—11	11 1/16—12
Push Fits—Class P													
Max. Limit	—0.00075	—0.00075	—0.00075	—0.0010	—0.0010	—0.0010	—0.0010	—0.00125	—0.00150	—0.00150	—0.00200	—0.00200	—0.00200
Min. Limit	—0.00025	—0.00025	—0.00025	—0.0005	—0.0005	—0.0005	—0.0005	—0.00050	—0.00050	—0.00050	—0.00075	—0.00075	—0.00075
Tolerance	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00075	0.00100	0.00100	0.00125	0.00125	0.00125
Driving Fits—Class D													
Max. Limit	+0.00050	+0.00100	+0.00150	+0.00250	+0.00300	+0.00350	+0.00400	+0.00450	+0.00500	+0.00550	+0.00600	+0.00650	+0.00700
Min. Limit	+0.00025	+0.00075	+0.00100	+0.00150	+0.00200	+0.00250	+0.00300	+0.00300	+0.00350	+0.00400	+0.00450	+0.00450	+0.00500
Tolerance	0.00025	0.00025	0.00050	0.00100	0.00100	0.00100	0.00100	0.00150	0.00150	0.00150	0.00150	0.00200	0.00200
Force Fits—Class F													
Max. Limit	+0.00100	+0.00200	+0.00400	+0.00600	+0.00800	+0.01000	+0.01200	+0.01400	+0.01600	+0.01800	+0.02000	+0.02200	+0.02400
Min. Limit	+0.00050	+0.00150	+0.00300	+0.00450	+0.00600	+0.00800	+0.01000	+0.01200	+0.01400	+0.01600	+0.01800	+0.02000	+0.02200
Tolerance	0.00050	0.00050	0.00100	0.00150	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200

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ing that all dimensions should be exact. Thus much unnecessary time is consumed in making the tools, which even under the most favorable conditions cannot be made exactly alike. Some go so far as to state that a plug or ring gage should be made exact and have no limit of error at all. Those making such a statement only hold themselves up to ridicule, as it is practically impossible to make two parts exact; a slight change in temperature will easily move a plug gage 0.000025 inch. Several large manufacturing concerns have set limits on work produced in the tool-room with satisfactory results, but, of course, an experienced designer or draftsman is required to set limits which are reasonable and consistent with the requirements of the tool being made.

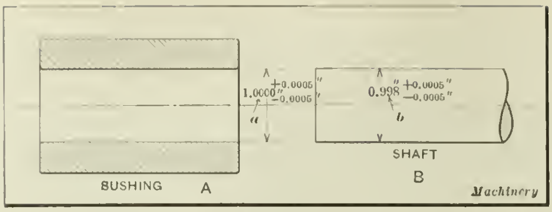


Fig. 2. Diagram illustrating Method of setting Limits for obtaining Running Fit

Various Methods of Establishing a System of Limits

Many methods have been evolved for establishing a system of limits, and careful study of this subject has revealed the fact that practically no two manufacturers use the same system of setting limits or give the same permissible amount of error in manufacturing. In some cases the limits are stated directly on the drawing; in others the size of the part is given in fractions or decimals of an inch, the method of presenting the dimension being an indication of the permissible limit allowed. In some cases it is stated on the drawing that where dimensions are given in fractions of an inch, a tolerance of 1/64 inch above or below the dimension given is permissible. If the dimensions are given to two decimal places, the limit can be $\pm$ 0.005 inch; to three decimal places, $\pm$ 0.0015 inch; to four decimal places, $\pm$ 0.0005 inch; and to five decimal places, $\pm$ 0.0002 inch.

It is a difficult matter to decide upon the permissible error between parts, as this depends entirely on the character of the work and the conditions under which the parts are to operate. For instance, there are different classes of fits desired, such as push, drive, running, slide, force, etc. The variation or allowance between the female and male members depends on several factors, among which might be mentioned: diameter and length of hole, material, speed, load carried, etc. Consequently, no set rules can be established for this work. Several concerns, however, have established limits derived from practice, which with proper judgment can be used to good advantage. One system which has been adopted by the Newall Engineering Co. of England is given in Tables I to III, inclusive.

Simple Method of Establishing Manufacturing Limits

There are several questions to be decided in setting limits on parts which must go together. Ignoring, for the present, the method used in making the parts, which, of course, is an important matter, the two points which should be settled are, first, permissible maximum and minimum allowances between the shaft and hole; and second, manufacturing limits or tolerance on the hole. When these two points have been satisfactorily decided upon, it is a simple matter to establish limits on both the hole and shaft.

As an illustration, assume that it is necessary to obtain a running fit between the shaft and bushing shown in Fig. 2, and that the hole in the bushing is to be produced by reaming. The first question to decide is the maximum and minimum allowances. In this particular case we will say that the maximum allowance is 0.003 inch and the minimum 0.001 inch. The next question to decide is the permissible tolerance on the hole. As a standard reamer cuts slightly over size, we will make the hole as shown in Fig. 2, 1.000 inch $\pm$ 0.0005 inch. This gives a tolerance on the hole of 0.001 inch. Now, to set the limits for the shaft, we subtract from the nominal diameter of the hole, or 1.000 inch, the mean allowance, or 0.002 inch. This gives us a nominal shaft diameter of 0.998 inch. The limits can now be set on the shaft, in a similar manner to the hole, thus giving a manufacturing tolerance of 0.001 inch. By this method of establishing limits, no checking back is necessary and the allowances previously set, of course, are obtained in the product.

Checking back, however, in this case to prove that our assumption is correct, we find that the largest hole is 1.0005 inch and the smallest shaft 0.9975 inch, which gives us an allowance between these two sizes of 0.003 inch — the maximum permissible allowance. The minimum sized hole is 0.9995 inch and the maximum shaft 0.9985 inch, which gives us a difference of 0.001 inch, or the minimum allowance between the hole and the shaft. The manufacturing limits set on the work, of course, do not affect the original established allowances between the parts, and in this way there is no danger of having the minimum hole the same size as the maximum shaft, which is sometimes the case when the manufacturing limits are set in a haphazard manner.

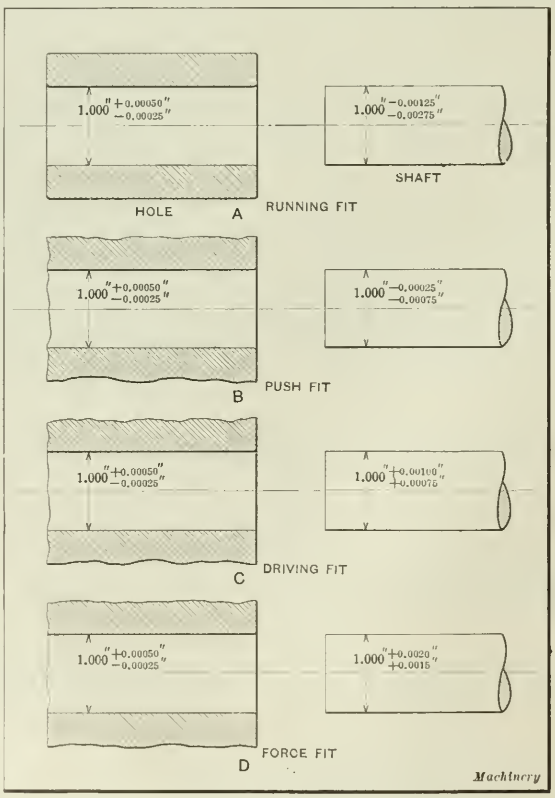


Fig. 3. Diagram illustrating Method of setting Limits for Various Classes of Fits

Allowances for Various Classes of Fits

In order to provide for various classes of fits, such as push, drive, force, etc., it is necessary to make certain allowances between the diameters of the hole and shaft. As the hole basis is taken to be the standard in most cases, the size of the hole, therefore, is the first question to decide. Table I gives two lists of tolerances for standard holes varying from 0 to 12 inches in diameter and known as classes A and B. Class A is preferred by some manufacturers as manufacturing limits, and class B as inspection limits. In using the hole as a basis or standard, the shaft is made to suit the hole, depending on the type of fit desired. In order to make the following description clear, it may be advisable to describe what the different classes of fits mean. The classes of fits used in ordinary practice are as follows: running, push, drive and force fits.

Running Fit.—Running fits are divided into three classes

or grades known as classes R, S, and T. Class R is used principally for engine and other work where easy fits are wanted, and also for shafts running in several bearings or a single bearing of unusual length. Class S is for high speeds and good average machine work, and also for shafts running in a single bearing of ordinary length. Class T is for fine tool work, sliding shafts and similar work. The limits given in Table II for running fits can also be employed for other than revolving fits where it may be advisable or necessary to limit the manufacturing error on the parts.

Push Fit.—Push fits, known as class P, the limits for which are given in Table III, are for shafts that are forced into a hole by hand and that would be free to rotate without seizing, but not free enough to rotate under anything but a very slow speed. Usually there is sufficient friction between the hole and the shaft to prevent free rotation. Push fits are usually employed where one member is fitted into another and then held in place with a key or pin.

Drive Fit.—Drive fits, known as class D, will produce shafts that need to be driven into holes either with a heavy hammer or with a light arbor press, and are distinguished from push fits in that shafts made to the limits given in Table III can be easily driven into a hole, but will not be able to rotate freely.

Force Fit.—Force fits, known as class F, are for shafts which require either hydraulic pressure to force them into the holes, or for those in which the female member must be expanded by heating so as to shrink it onto the shaft.

Establishing Allowances and Tolerances for Various Classes of Fits

The method used in establishing allowances and tolerances for a running fit has been previously described in a general way. We will now take a concrete example, illustrated at *A* in Fig. 3, using the limits of tolerance given in Tables I and II. Assuming the nominal hole to be 1.000 inch diameter and using class A limits, we obtain a hole 1.000 $^{+0.00050}_{-0.00025}$ inch. This gives a manufacturing tolerance of 0.00075 inch. The diameter of the shaft is then made smaller than the hole by making use of the limits given in Table II. Reference to this table will show that the shaft is made $^{-0.00125}_{-0.00275}$ inch less than the nominal hole. This gives a hole and shaft of the following dimensions: maximum hole 1.0005 inch, minimum, 0.99975 inch; maximum shaft 0.99875 inch, minimum, 0.99725 inch. The difference or allowance between the minimum hole and maximum shaft is 0.001 inch, and the difference between the maximum hole and minimum shaft, 0.00325 inch. The tolerance between the maximum and minimum hole is 0.00075 inch, and the tolerance between the maximum and minimum shaft, 0.0015 inch.

In making a shaft which must be a push fit in a hole, the amount of tolerance permissible on the shaft is considerably less than for an ordinary running fit. As indicated at *B* in Fig. 3, the tolerance on the shaft is made with a minimum limit of − 0.00025 inch and a maximum limit of − 0.00075 inch. This allows no theoretical difference between the maximum shaft and minimum hole; in other words, the smallest hole and the largest shaft are of the same dimensions, or 0.99975 inch diameter. The difference between the largest hole and smallest shaft is 0.00125 inch. In this case the ideal allowance desired between the shaft and the hole is 0.00075 inch, which is the difference between the mean dimensions of the hole and the shaft, respectively.

In making a drive fit, it is necessary, of course, to have the shaft slightly larger than the hole, so that the required amount of grip on the shaft will be obtained. As before, the hole is made with plus and minus limits, as shown at *C* in Fig. 3. The shaft is made larger than the hole and has a maximum limit of + 0.001 inch and a minimum limit of + 0.00075 inch. This produces a condition in which the largest hole is 0.0005 inch smaller than the largest shaft, and the smallest hole is 0.00125 inch smaller than the largest shaft. This insures in all cases that the parts will go together with a suitable driving pressure.

The conditions for a force fit are similar to those for a driving fit, with the exception that a greater allowance is made between the diameters of the shaft and hole, respectively, in order to obtain a tighter union between the parts. As shown at *D* in Fig. 3, the shaft is made 1.000 $^{+0.0020}_{+0.0015}$ inch. This gives an allowance between the smallest hole and largest shaft of 0.00225 inch, and a difference between the largest hole and smallest shaft of 0.001 inch.

Various Methods of Presenting Manufacturing Limits on Drawings

In setting manufacturing limits on interchangeable parts, various methods are adopted for expressing the limits of error to be tolerated. Expressions such as plus and minus, low and high, maximum and minimum are commonly used. There are two important points to be observed when setting manufacturing limits on parts. The first is to so set these limits that the operator can clearly understand the drawing, and second, to express them in such a way that the draftsman who checks up the drawing can conveniently tell whether the parts have been properly dimensioned or not.

A practical example which will serve to illustrate this point is shown in Fig. 4. Here a set of gears for the lower part of an automobile transmission is shown in section, and to simplify the problem the shaft *a* is shown supported in two fixed bearings. The four gears *b*, *c*, *d* and *e* are keyed to this shaft and separated by a spacing washer. The washer provides for inaccuracy of parts, and while this practice is not recommended, the example is so simple that it has been used in place of a more complicated one.

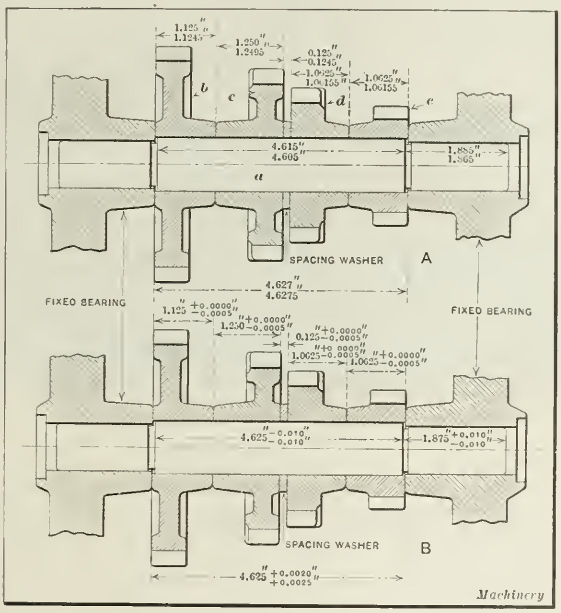


Fig. 4. Diagram illustrating Two Methods of dimensioning Drawings

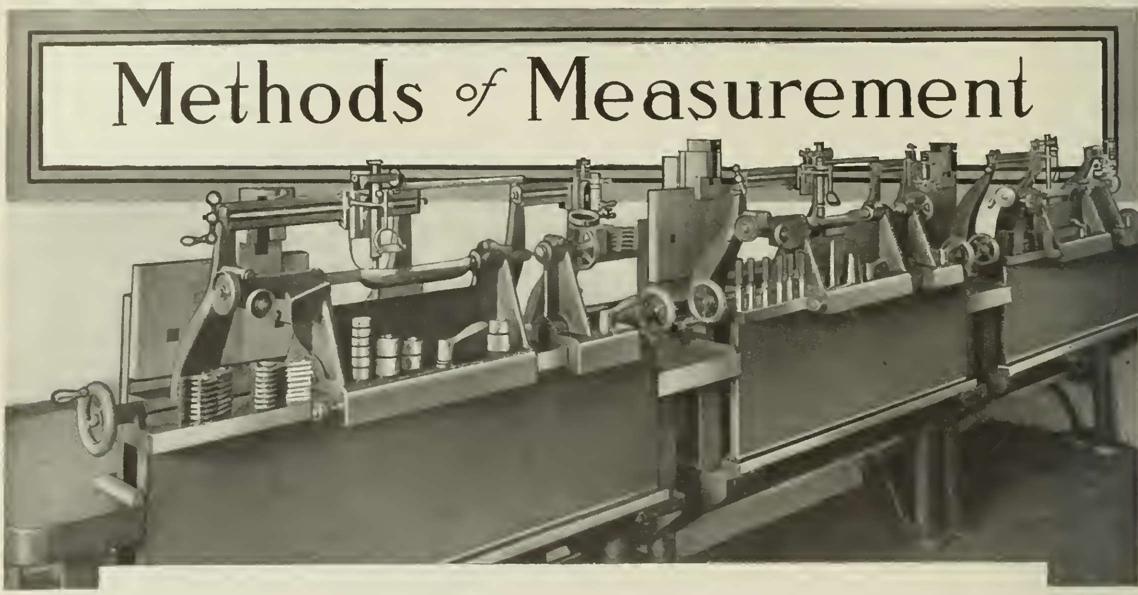
Reference to Fig. 4 will show that two methods are used for dimensioning the parts. As shown at *A*, the minimum and maximum sizes or widths of the gear shoulders are given and the minimum and maximum distances between the bearings. In presenting the dimensions in this manner it makes it extremely difficult for the checker to determine whether any mistakes have been made in dimensioning or not. It requires a careful addition of the different dimensions and then checking to see if the required allowance between all the gear shoulders and bearing faces has been provided. Assuming that the minimum allowance between all the gears and bearing faces is 0.002 inch and the maximum allowance 0.005 inch, the method of setting the limits on the drawing would be as follows:

Inspection will show that there are five parts, so that the total manufacturing limits on the gears should not exceed 0.0025 inch, as a limit also has to be provided for the distance between the bearing faces. In other words, there are six dimensions to take into consideration, allowing a limit of 0.0005 inch on each; this totals 0.003 inch, or the difference between

the maximum and minimum allowances. As soon as this question is settled, it is a simple matter to place the limits on the different parts. For the gears, no plus limits are tolerated and a minus limit on each part of 0.0005 inch is provided. The dimension given on the drawing to represent the distance between the bearing faces is a nominal dimension and is equal to the sum of the gear shoulders and washer. But as a minimum allowance of 0.002 inch is necessary, the minimum distance between the bearing faces would be the nominal dimension, or 4.625 inches + 0.002 inch, and the maximum, 4.625 inches + 0.0025 inch. To show that this is correct, we add the nominal dimensions on the gears and washer, which equals 4.625 inches, as the maximum. The minimum is 4.625 inches — 0.0025 inch, or 4.6225 inches. The maximum distance between the bearing faces is 4.6275 inches, and the minimum, 4.6270 inches. This gives us an allowance between the minimum gear shoulders and maximum bearings of 0.005 inch, and an allowance between the maximum gear shoulders and minimum bearing faces of 0.002 inch.

Inspection of the two methods of presenting these dimensions at *A* and *B* will show that the one illustrated at *B* is by far the simpler from the standpoint of checking up the drawing. It will be seen that at *B* no plus limit is allowed for the gears and no minus limit for the space between the bearings. Hence, the checker can immediately see that these gears are to be made with a running fit between the bearing faces. In the case shown at *A*, this is more difficult to ascertain without actually checking up the different dimensions and ascertaining the allowance between the gear shoulders and bearing surfaces.

Methods of Measurement



IN measuring work, many different appliances are used, the kind of tool depending on the accuracy required. For instance, in ordinary machine work, the bow caliper and scale are used to a large extent for making diameter and length measurements. When the work calls for a greater refinement, the micrometer caliper, vernier caliper, micrometer depth gage, etc., are applied. When still greater accuracy is demanded, standard measuring machines as well as scientific measuring appliances are adopted. For angular measurements, squares, bevel protractors and templets are used. The average mechanic is familiar with the use of the bow caliper, micrometer caliper, vernier, bevel protractor, etc., so that an extended description of these tools is not necessary here. This subject has also been exhaustively dealt with in the pages of MACHINERY. Many mechanics, however, are not familiar with the different types of standard measuring machines used in gage manufacture and the originating of the standards by means of which various tools are checked.

Standard Unit of Length

The international meter is the fundamental metric unit of length in the United States. The original standard is retained by the International Bureau of Weights and Measures, near Paris, France. Several copies of this primary standard were made in 1889 for the United States and other governments under the direction of the International Committee representing the various countries which support the bureau. The Bureau of Standards, Washington, D. C., has two copies of the original meter; one—No. 27—is kept sealed in a metal case in a fireproof vault, and the other—No. 21—is used occasionally to verify the working standards. The legal equivalent of the meter for commercial purposes was fixed by law in 1866 as 39.370788 inches. The United States Bureau of Standards was authorized by executive order, in 1893, to derive the yard from the meter by the use of this relation. Metric length measures tested by this bureau are standardized at 20 degrees C., and standards in the customary units of yards, feet and inches are made to be correct at 62 degrees F.

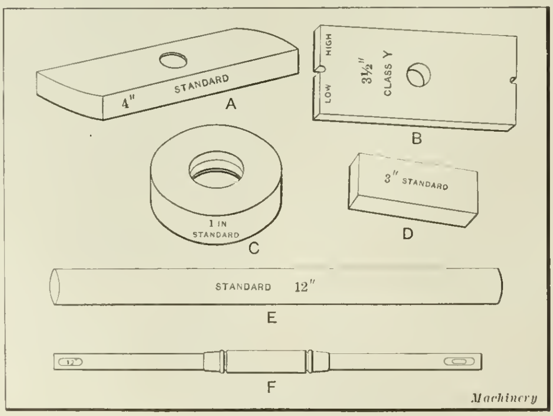


Fig. 5. Standard Reference Blocks, Disks and End Measuring Rods

Reference Standards

In order to check up various measuring instruments, micrometer calipers, standard and special gages, etc., different types of reference rods and blocks have been devised. These are very carefully seasoned and lapped, and are usually supplied in sets vary-

ing from blocks of the thickness of feelers to rods several feet in length. Fig. 5 shows several types of reference blocks, disks and rods. The block shown at *A* is made from steel, hardened and ground, with cylindrical ends, and is used for setting micrometers and other adjustable measuring tools. *B* shows another type of block which is particularly adapted for setting the adjustable points of limit gages. A disk type of standard which is used principally for setting micrometer calipers is shown at *C*, while a standard block used both for setting gages and for general tool-room purposes is shown at *D*. *E* is a standard end-measuring rod, which is made with rounded ends having a section of a true sphere with a diameter equal to that for which the rod is made to measure. These rods are made ⅜ inch diameter for lengths from 3 to 6 inches, and ½ inch diameter for lengths from 6 to 16 inches. *F* shows another type of standard reference rod, which is made from round steel rods, hardened, ground and lapped on the ends. To prevent expansion due to handling when in use, the center portion of the rod is fitted with a sleeve of insulating material.

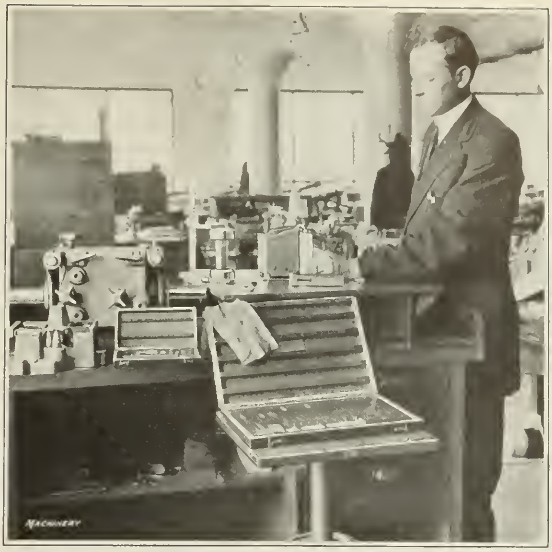


Fig. 6. Johansson Reference Blocks

Johansson Reference Blocks

The Johansson system of reference blocks was originally designed to be used in the tool-room for quickly laying out and checking gages and fixtures. Owing to the extreme accuracy to which these blocks are made, however, they are also used as references, both for manufacturing and inspection purposes. Fig. 6 shows one set of these blocks in use in the inspection department for checking gages and fixtures. The combination consists of a series of rectangular blocks, which are made from "Invar" steel, carefully machined, seasoned, ground and lapped on all sides. The opposite sides of each block are parallel, and the distance between them is equal to the dimension stamped on them within a maximum tolerance of 0.00001 inch. These blocks are supplied in various sets, set No. 1, shown in Fig. 6, comprising eighty-one blocks, divided into four series. The first series contains nine blocks, which vary in thickness from 0.1001 to 0.1009 inch, increasing by 0.0001 inch increments. The second series contains forty-nine blocks, which vary in thickness from 0.101 to 0.149 inch, increasing by 0.001 inch. The third series comprises nineteen blocks, varying in thickness from 0.050 to 0.950 inch, increasing by 0.050 inch increments; and the fourth series consists of four blocks, of 1, 2, 3 and 4 inches. This set gives all the sizes from 0.0500 inch up to 10 inches. When furnished with standard plugs and holder for retaining these blocks, over 100,000 different internal and external gages are obtained. The range can be increased by adding other series of blocks up to 20 inches, and increments in quarter thousandths can be obtained by adding two blocks, 0.10025 and 0.10075 inch.

These blocks are generally used by building them up to obtain the required size, and owing to the almost perfect flatness of the surfaces, they can be wrung together with sufficient pressure so that the total number in the set (eighty-one) can be built up. The contacting surfaces are carefully cleaned with chamois skin, and then the gages are slid over each other with a slight pressure.

To illustrate how these blocks are used in combination to get any desired size, assume that it is necessary to measure 3.3625 inches. This can be made up by using four blocks: 3.000, 0.140, 0.122 and 0.1005 inch. Other combinations can also be used for the size given. These blocks can also be extensively used for setting and checking limit gages. With the set of eighty-one blocks, any limit gage having a tolerance as small as 0.0005 inch, up to about 10 inches, can be checked, and by the addition of the two blocks of 0.10025 and 0.10075 inch, it will be evident that limits as fine as 0.00025 inch can be verified.

Bench Micrometer Caliper

One of the simplest types of measuring instruments, which comprises the principle of the micrometer screw and graduated sleeve, is shown in Fig. 7. This is known as a bench micrometer caliper and is used on the bench for taking fine measurements from 0 to 6 inches. It is provided with two interchangeable measuring heads, the one shown on the instrument being graduated to read to 0.0001 inch directly from the thimble, and the other shown at *A* being provided with a ten-pitch screw and graduated to read to 0.001 inch. The thimbles are 4 inches in diameter, and consequently have coarse graduations, enabling accurate readings to be quickly taken. The adjustable anvil is set by standard reference blocks. The screw on the thimble has a movement of 1 inch.

Principle of Standard Measuring Machines

Standard measuring machines generally comprise both a vernier scale and a micrometer screw and wheel. Usually the vernier scale is attached to the bed of the instrument and is used for setting the headstock bracket carrying one anvil; the headstock also carries the graduated wheel operating the spindle through a screw. There are three important points to consider in designing a measuring machine: first, to produce an accurate screw, vernier and wheel; second, to secure the proper proportions and rigidity of bed; and third, to provide some means of indicating the pressure exerted on work placed between the measuring points.

While all three points are highly important, the third one is probably the most important and the one that should receive the most careful attention. A measuring machine not provided with a pressure indicating device is only of value in the hands of an expert, and it is practically impossible for two men to obtain exactly the same readings. Pressure indicating devices are made in several forms, such as feeler plugs, which drop out from between points when a certain pressure is reached; levels which are inclined at an angle when acted upon by the moving anvil; spring operated plungers,

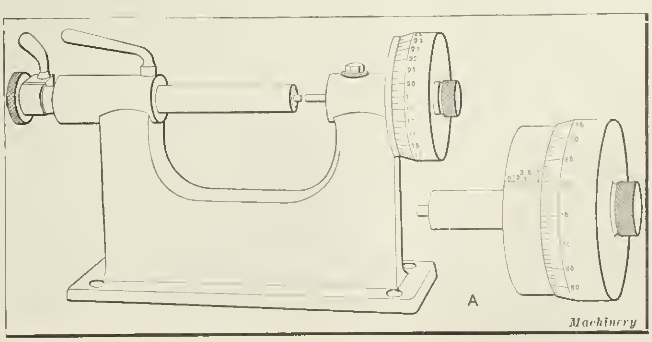


Fig. 7. Bench Type of Measuring Machine

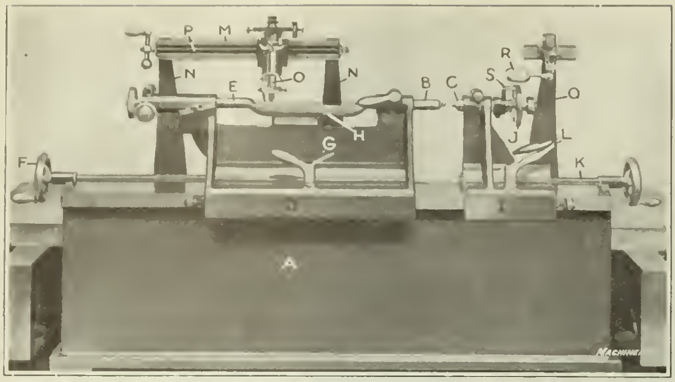


Fig. 8. Brown & Sharpe Measuring Machine

in conjunction with a scale and hair line microscope; and graduated glass tubes up which a colored liquid is forced by the pressure of a diaphragm connected to the movable anvil. These various devices as well as other of the recording and indicating types will be described in connection with several interesting machines in the following.

Brown & Sharpe Measuring Machine

The measuring machine designed and used by the Brown & Sharpe Mfg. Co. for testing the accuracy of standard gages and other tools that must be finished to very accurate dimensions is shown in Fig. 8. This machine belongs to that class of measuring instruments in which the measurement is made by means of a moving scale under a microscope, used in conjunction with a micrometer screw and vernier. The most important feature of this machine is that all measurements are made directly from the scales, and dependence is not placed upon standard test pieces that have been previously measured by other means.

In construction, this measuring instrument consists of a heavy bed *A* made of double I-beam section about 4 feet long and 1½ foot deep. The I-beam section combined with the weight of the bed gives this machine great rigidity to resist any tendency to deflect when the anvils or measuring points *B* and *C* are brought into contact with the piece to be measured. The carriage *D* on the left-hand side of the bed supports bar *E* which carries the graduated scale. This carriage is moved by adjusting screw *F*, and clamped by the handle *G*. Bar *E* is provided with coarse and fine graduations and its central portion, which carries the graduated scale, is cut away, thus placing the scale in a line with the axis of the measuring points. The guide *H* which fits in a slot in the lower surface of the bar holds it rigidly in position.

The carriage *I* on the right-hand end of the machine supports the micrometer adjustment *J*. This carriage is regulated by an adjusting screw *K* and clamped by handles *L*. Measuring points *B* and *C* are integral parts of the cylindrical bar and micrometer screw, respectively. The slide *M*, supported parallel to the bar *E* by the uprights *N*, carries the microscope *O*. Screw *P* is used to adjust the microscope along the slide. Upright *Q* holds the reading microscope *R* that facilitates taking readings with the micrometer vernier.

The scale on the bar *E* is 8 inches long and is attached to a flat surface. It has two lines of graduations, each division being 0.025 inch. One line of graduations, which is easily visible to the naked eye, is used for locating the scale approximately. The other graduations, which are invisible to the naked eye except under favorable light conditions, are used for the exact reading of the scale by means of the microscope *O*. The lines of these graduations are 0.0001 inch wide, being the same width as the hair line of the microscope; thus the two lines can easily be brought to coincide. The machine can be set to measure distances up to 16 inches long.

The micrometer wheel *J* is graduated to read to 0.0001 inch, and the vernier plate *S* used in connection with the wheel, makes it possible to obtain readings as fine as 0.00001 inch. The wear of the micrometer screw amounts to practically nothing, inasmuch as the micrometer readings are only used for short distances and the wheel never moves more than half a turn. The accuracy of this screw is also greatly increased by providing it with a bearing practically equal to its length.

Method of Taking Measurements

To measure an object, slide *D* carrying bar *E* is moved to the right so that the measuring point *B* will touch the micrometer point *C*. The microscope *O* is then set over one line of the scale, generally the zero line, and the slide is moved to the left until the nearest graduation of the required size is reached. This is indicated by bringing the line of the scale under the hair line of the microscope. The slide is then fastened by clamping handle *G*. Readings less than 0.025 inch are indicated by the micrometer screw and dial *J*. The object to be measured is inserted between the measuring points *B* and *C*, and by adjusting the micrometer screw the size can be indicated to 0.00001 inch.

The accuracy of this machine rests fundamentally upon the accurate graduations on the scale and the perfection of the micrometer screw. Among other factors that contribute to the accuracy of the machine are the weight of the bed and the rigidity of the carriages that support the measuring instrument. All bearings and wearing surfaces are scraped accurately to reduce any possible error. The machine is also firmly braced. As an example of the accuracy of this machine, it might be mentioned that a pull of about fifty to seventy-five pounds on the bed directly beneath the measuring points is sufficient to make a plug ¼ inch diameter drop out from between the measuring points. Another test which shows the sensitiveness of the machine is placing the hand on the bed between the slides and holding it there for approximately one minute; the heat of the hand causes the plug to drop from the measuring points. It is estimated that it requires about twenty minutes for the machine to reset itself and overcome the influences exerted by the pull or temperature test.

Pratt & Whitney Standard Measuring Machine

The Pratt & Whitney standard measuring machine shown in Fig. 9 employs what is known as a feeler plug for determining the pressure between the measuring points, thus eliminating the human element. This machine consists of a heavy cast-iron bed provided with ways upon which two heads are mounted. One head *A* is normally fixed to the bed, whereas the other head *B* is adjustable and is located along the bed by means of a powerful microscope *C* and finely divided measuring points *D*, consisting of plugs provided with fine lines that are spaced exactly one inch apart. Each head carries a

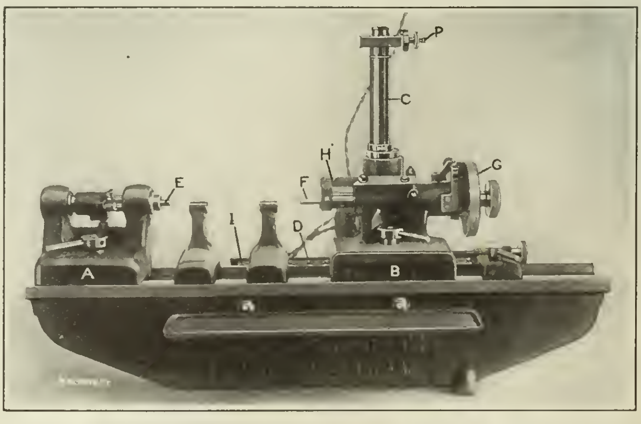


Fig. 9. Pratt & Whitney Measuring Machine

spindle or measuring point E and F, and the parts to be measured are supported between these spindles upon rests, or held in the hand if very small. Measurements up to one inch are obtained by means of a large graduated index wheel G, a scale and pointer at H being provided for approximate setting. This is more clearly shown in Fig. 10, where it will be seen that scale J has twenty-five graduations representing a movement of the spindle of 1.000 inch, and pointer K has a single setting line. For measurements greater than one inch, the sliding head B is set by means of a standard bar I located at the rear of the machine. This bar carries a series of plugs D which are provided with graduations exactly one inch apart and so fine that they are imperceptible to the naked eye. The screw of the sliding head spindle, by means of which the adjustments for fractional parts of an inch are obtained, has twenty-five threads per inch, and the index wheel has 400 graduations. Therefore, each graduation represents 1/400 of 1/25 inch, or 0.0001 inch. These divisions can easily be split up by estimating to at least five points, making possible the reading of accurate measurements to 0.00002 inch with little difficulty.

In order to insure proper contact between the measuring points of the instrument, the machine is provided with an indicating device on the fixed head A. This consists, as shown in Fig. 11, of two auxiliary jaws L and M, between which a small ¼-inch diameter plug N is held by the pressure of a light helical spring which operates the sliding spindle to which one of the jaws is attached. The tension of this spring is so adjusted that when the measuring points are not in contact the jaws will hold the plug N by friction in a horizontal position, as shown to the left in Fig. 11. When the measuring points are in contact with one another or with the work being measured, the tension on this helical spring is slightly reduced and the plug N swings down to a vertical position between the jaws, as shown to the right of the illustration. Should there be an excess pressure between the jaws the plug would drop out. Hence, the contact for all measurements should be just enough to cause plug N to swing down to a vertical position and not drop out. It is estimated that the measurable difference between the faces of the measuring spindles when the feeler plug is in the horizontal and vertical positions is 1/250,000 inch.

In checking a measurement, the machine should first be set to the zero position with the measuring points in contact. This is done by adjusting the screw of the linear scale at the top of the head to zero and setting the pointer of the index wheel G nearly to zero. Then the head is slid along the bed until the measuring faces are almost in contact. For the last adjustment, screw O, Fig. 10, is operated until the feeler plug N, Fig. 11, shows a tendency to move to the horizontal position. The head is now clamped firmly in position and the index wheel adjusted until the plug swings to a vertical position. Then the adjustable index pointer is set to zero and the line in the eye piece of the microscope is set so that it exactly coincides with the zero line of the graduated reference bar I at the rear of the machine. The adjustment of the line in the eye piece is made by means of the screw P. The machine is now set to the zero position, and when adjusting the head for the required measurement, care must be taken not to disturb the eye piece of the microscope. To measure from zero to one inch, the micrometer screw can be used direct, but for a greater dimension the sliding head must be located by means of the microscope so that the line in the microscope is set exactly on the nearest graduation on the plugs on bar I. Assuming that it is necessary to take a measurement of 12.2508 inches, slide the movable head B along the bed until the microscope is brought directly in line with the 12-inch graduation on bar I. The screw is now turned back until the scale and index wheel of the adjustable spindle show a movement of 0.2508 inch. As the pitch of the screw is 1/25 inch, a complete turn of the index wheel equals 0.04 inch. Hence for a movement of 0.2508 inch, the number of turns of the index wheel would be $0.2508 \div 0.040 = 6.27$, or six full turns and 108 divisions. The Pratt & Whitney measuring machines are graduated for English measurements at a standard of 62 degrees F., and in sizes from 12 to 144 inches.

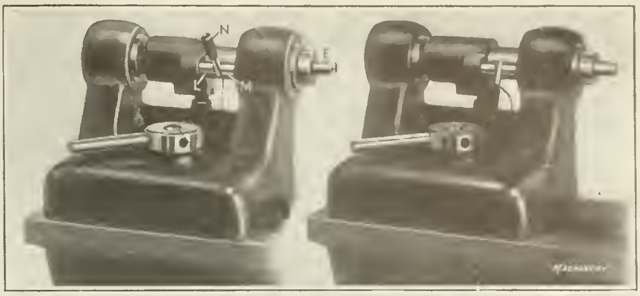


Fig. 11. Close Views of Pratt & Whitney Measuring Machine, showing Position of Feeler Plug before and after taking a Measurement

Slocomb Standard Measuring Machine

The type of measuring machine used by the J. T. Slocomb Co. is shown in Fig. 12. This machine is of comparatively simple construction, and consists of a bed carrying two heads. The heads are of circular section and slide in a V-groove in the bed, and when set in the required position are clamped by a C-clamp, as shown. This machine is used principally for duplicating measurements by using master end measuring rods for setting. The screw has a 40-pitch thread and the dial is 5 inches diameter and reads to 0.0001 inch.

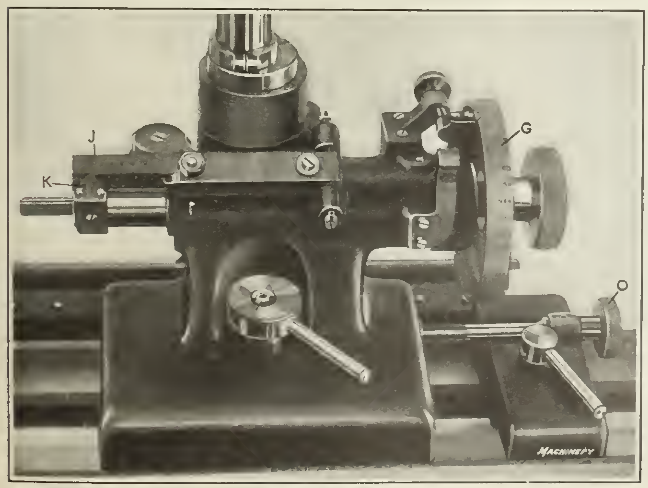


Fig. 10. Close View of Pratt & Whitney Measuring Machine, showing Graduated Wheel and Vernier Scale

The most interesting part of this measuring machine is the device for indicating the pressure exerted between the measuring points. It is a well-known fact that when taking measurements to 0.0001 inch with an ordinary micrometer it is difficult to know just what pressure is being applied on the work; and two inspectors seldom obtain the same reading. This pressure indicating device, which is shown in detail in Fig. 13, eliminates the human factor in taking accurate measurements. In Fig. 13, A represents a section through the tailstock to which the device is attached, and B is the plunger anvil which is retained in bushings. This anvil is made a nice sliding fit in the bushings, and is kept against the front bushing by means of the spring C. The movement of the anvil is limited by means of the pin F driven into the collar and working in an elongated slot in the tailstock A. The rear end of the anvil B is pointed to an angle of 60 degrees and rests against a flat portion on pin E which is retained in the lower end of lever G. Pin E is fulcrumed on two cone-pointed screws, as shown in the view to the left, and its axis is located 1/16 inch below the point of the plunger. The ratio between the short and long arms of the lever is 0.062

Fig. 12. Slocomb Standard Measuring Machine

to 4 inches, so that when anvil *B* moves 0.0001 inch, the top part of lever *G* moves about 0.0064 inch. The top part of lever *G* bears against the plunger of the dial indicator *H*, and the indicator hand moves about 3/8 inch when the plunger or anvil *B* is moved 0.0001 inch. An interesting test made in connection with this instrument showed that the heat from three fingers of the hand applied for a few seconds to a 4-inch end measuring rod, 5/16 inch in diameter, was sufficient to move the hand of the dial indicator 1/4 inch. In testing two pieces with this instrument, the needle will stand at zero when they are of the same length. If the needle moves from zero, it indicates that there is a variation between the length of the two pieces.

Swiss Standard Measuring Machine

A measuring machine which differs somewhat in principle from those previously described is shown in Figs. 14 and 15. This machine is built by the Societé Genevoisé, Geneva, Switzerland, and comprises two hair line microscopes *A* and *B*. Microscope *A* is used for setting movable head *C* when taking measurements of over twenty-five millimeters. This microscope is provided with cross-hairs which are brought in line with the graduated marks on a scale located at the rear of the instrument. This scale is 51 centimeters long and is graduated in millimeters. Microscope *B* is used for determining the position of spring plunger *D*, which governs the pressure exerted on the work. Head *E* is fastened rigidly to the base and carries the stationary anvil *F*, which can be adjusted in case of wear. Spindle *D* is held in a sleeve *H*, the movement of which is controlled by a screw of 1/2 millimeter pitch and which is attached to the graduated wheel *I*. Located behind spindle *D* is a light spring capable of exerting a pressure on the work of one pound per square inch.

In setting the machine for measurements over twenty-five millimeters, head *C* is slid along the bed until both anvils contact with sufficient pressure so that the line on the sliding spindle is exactly central between the two cross-hairs in microscope *B*, the graduated wheel *I* at the same time being set at zero. The head is now moved back to approximately the distance required, using the coarsely graduated brass scale at the rear, and is clamped by handle *K*, Fig. 14. Screw *L* is then adjusted until the cross-hairs in the telescope *A* exactly coincide with the required graduation on the scale at the rear. The machine is now set to the dimension required. To determine the accuracy of the piece being measured, it is located between the measuring points and the position of the line in the movable spindle noted; if this is not exactly in the center of the two cross-hairs in telescope *B*, wheel *I*, which is divided into 500 parts giving direct readings to 0.001 millimeter, is rotated until the line is directly in the center of the two hair lines. The amount that wheel *I* has been moved away from the zero point indicates the amount that the part varies from the required size in thousandths of a millimeter.

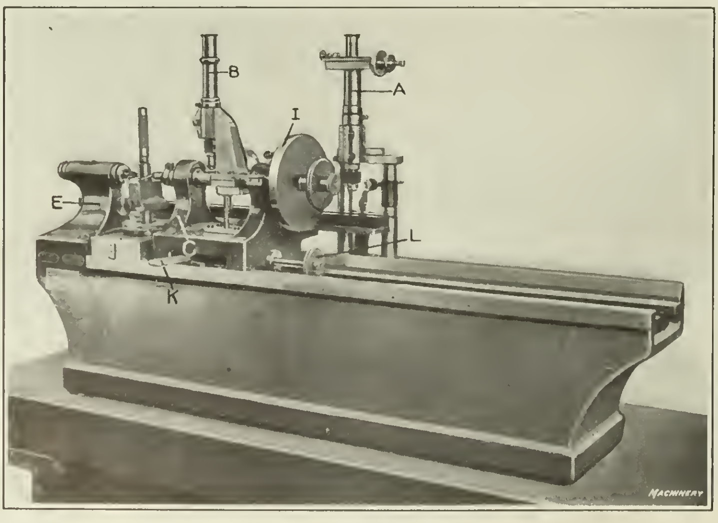


Fig. 14. Swiss Type of Measuring Machine used in Plant of Wells Bros. Co.

Newall Measuring Machine

The measuring machine built by the Newall Engineering Co. of Walthamstow, London, England, is particularly suited for general employment in toolrooms and workshops. It permits of making extremely fine measurements, and is simple in operation. The combined features of the machine are such as to entirely eliminate the possibility of making errors in measuring, and it maintains its accuracy and requires only slight attention for adjustment. As shown in Fig. 16, it consists of a rigidly ribbed bed *A* on which two slides *B* and *C* are mounted. Attached to the bed is a vernier scale *D*, providing for the approximate setting of slide *C*. Slide *C* carries the tail measuring spindle *I* and a

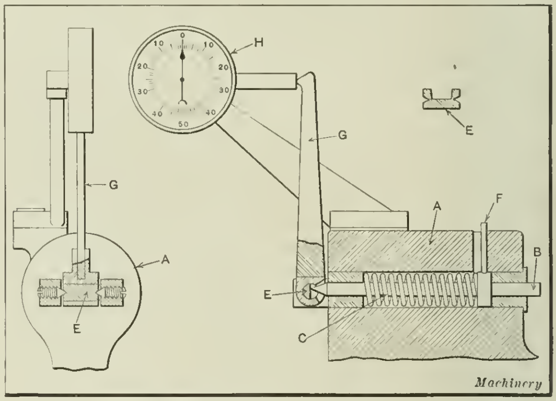


Fig. 13. Diagram showing Pressure Arrangement used on Slocomb Measuring Machine shown in Fig. 12

telescope for setting the position of the slide. In addition, as shown in Fig. 17, it carries an indicating spirit level *E*, which is one of the most interesting features of the machine. When pressure is applied to the measuring anvil through the piece being measured, this spirit level is tilted out of the horizontal plane, due to the backward movement of the anvil; the curvature of the vial gives a movement to the bubble four thousand times the movement of the anvil. This device is so sensitive that the slightest expansion or contraction of the piece being measured, due to varying temperatures, can be detected, and it is more sensitive than the drop plug feeler employed on some of the other measuring machines. The piece to be measured can be supported between the measuring points for any length of time until all parts arrive at an even temperature.

The headstock or slide B carrying the measuring wheel gives readings to 0.00001 inch, the graduations on the measuring wheel F being so arranged that the indicated size can be read in decimals of an inch, the digits appearing in their proper rotation. For example, as shown in Fig. 18, if the size to be read is 0.31254, the first digit 3 is the highest figure disclosed on the left-hand side of the scale carrying the vernier. The second and third digits 1 and 2 are the highest main graduation on the measuring wheel below the zero line on the vernier, and the fourth digit 5 is the highest sub-division on the measuring wheel below the zero line on the vernier, while the fifth digit 4 is that graduation on the vernier in line with any graduation on the measuring wheel.

The measuring spindle has a thread of the buttress form cut especially deep to provide for wear, and has a range of 1 inch. The threaded portion of the screw and nut is equal to three times the length of range stated, so that the wear is even and accuracy of pitch is maintained. An automatic adjustment is also provided which maintains an even tension on the measuring screw by keeping the effective faces of the screw and nut in contact. It obviates backlash and facilitates accurate reading. A knurled nut on the end of the spindle provides for the rapid movement of the measuring screw. This is used until sufficient pressure has been applied through the piece being measured to bring the indicating bubble into motion. For a sensitive movement, a fine adjusting screw is provided which is carried on an arm that can be clamped on the measuring wheel at any point by an eccentric. This screw, the thrust of which is taken against the front horizontal bar, gives the slow motion necessary. The front horizontal bar is also used as a stop when it is desired to compare a number of parts which have been made to close dimensions.

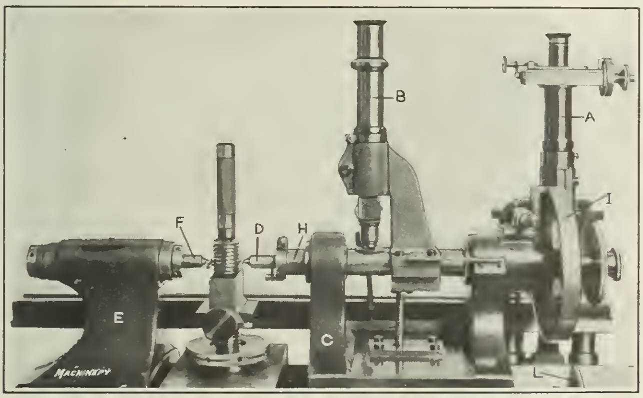


Fig. 15. Close View of Machine in Fig. 14 showing Graduated Wheel and Vernier Scale

Owing to the great difficulty encountered in making the pitch of a screw absolutely accurate for its entire length, a compensator arrangement is provided. This consists of a secondary screw of the same pitch as the measuring screw, cut on the rear end of the spindle. In contact with this screw is a roll held in a lever G, Fig. 17, and mounted in such a manner that any undulation on the crest of this thread imparts through lever G a forward or backward movement to the vernier scale H which is mounted on the vertical arm. In this way any inaccuracies in the pitch of the thread are compensated for.

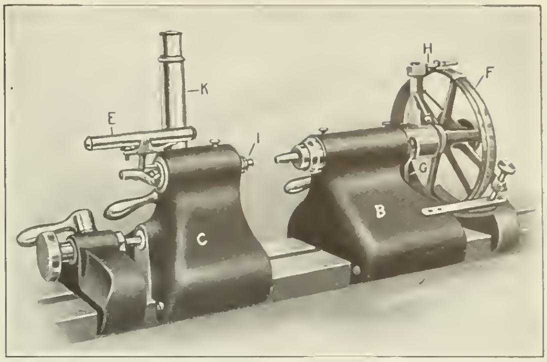


Fig. 17. Close View of Newall Machine showing Spirit Level Indicator and Screw Compensator

Operation of Newall Measuring Machine

In setting this machine, the first step is to ascertain the amount of free movement in the anvil I. This is determined by bringing the headstock B and tailstock C together so that the measuring points may contact, and then observing by rotating the measuring wheel F forward, the number of graduations passed in moving the bubble of the spirit level indicator E from its resting position. A small adjusting screw is provided underneath the rear end of the vial for returning the bubble to the resting position. Assuming that the free movement of this vial is 0.01 inch, the vertical arm carrying the scale H and vernier is swung around to a perpendicular position or inclined a little to the front of the machine if more convenient for the operator's reading and the measuring wheel set to read about 0.01 inch. Before doing this, however, it is necessary to see that the measuring faces of the screw and anvil are perfectly clean and that the headstock and tailstock are securely clamped to the bed. Then the measuring screw is advanced until the indicator bubble again reaches the measuring position and the reading will be somewhere near zero. The vertical arm is then adjusted so as to get the zero graduation on the vernier in direct line with the zero graduation on the measuring wheel, and the machine set at zero. It is advisable, however, to release the measuring screw and advance it again to check this final setting, when any slight inaccuracies may be corrected by a readjustment of the vertical arm. The machine should be so set that it is as free as possible from vibration and also from the effects of frequent changes of temperature. It is essential that it should not be exposed to the direct rays of the sun.

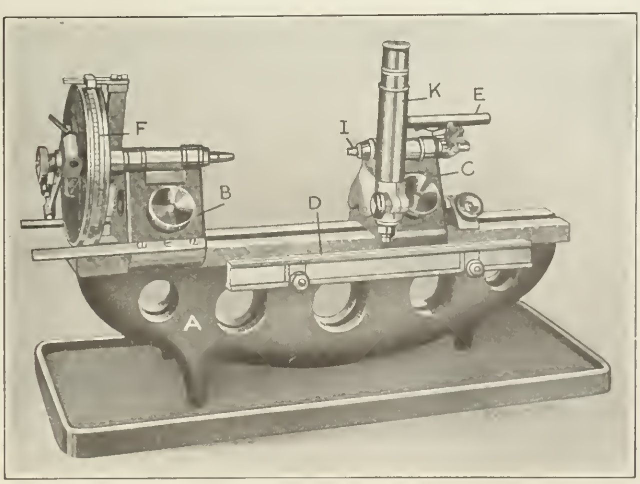


Fig. 16. Newall Standard Type of Measuring Machine

The foregoing description relates to the setting of the machine for measuring pieces up to 1 inch. For measuring pieces over 1 inch and without the use of end measuring rods for setting the machine, the following method should be employed. The tailstock C is moved along the bed to the left; then, through microscope K it is set to the nearest graduation on the rule on the bed below the size to be measured, the headstock being left untouched, as when previously set to the zero point. In all cases of

microscope settings, it is advisable to clamp the tailstock slightly until, by means of the sensitive movement obtained by the fine adjustment slide, the desired line on the rule is perfectly central between and parallel to the two hair lines in the microscope; then the tailstock can be firmly clamped in position. The part to be measured is held in supports between the measuring points, care being first taken to be sure that all points of contact are perfectly clean. Then by advancing the measuring screw in the same way as has previously been described until the bubble of the indicator assumes its central position, the size of the piece is read off on the wheel and vernier. When advancing the measuring screw, the knurled nut on the end of the spindle is turned until sufficient pressure has been applied to start the bubble from its

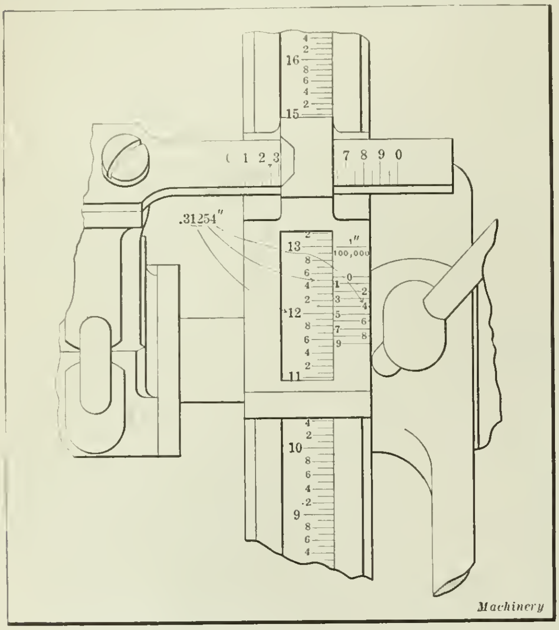


Fig. 18. Diagram illustrating Method of taking Measurements on Newall Measuring Machine

resting position. Then the screw of the fine adjustment arm is turned, moving the bubble slowly to its measuring position, which is the critical point in all operations of setting or measuring. The sub-divisions on the vial of the indicator are intended for comparison only, but their approximate value may be determined by observation and calculation if desired.

Should the alternative method—setting to end measuring rods—be used, a rod of the nearest length to the size to be measured is inserted between the measuring points and the processes described in connection with setting to zero are repeated. The inaccuracy of such end rods must be known, and they should be regularly examined to detect any alterations in length through wear or temperature changes. It is also imperative that all surfaces and working parts of the machine be kept clean and free from oxidization and dust. The lightest possible oil should be used for lubrication, clock oil being preferable, but if this cannot be obtained, paraffine oil should be used on the measuring screw. The accepted mean temperature at which verifications of standards are usually made is 62 degrees F. This is the temperature at which this machine is tested. The rules used on this machine are made in rectangular sections from invar steel, an alloy of nickel steel, which is non-corrosive and practically insusceptible to changes in temperature. This machine will easily measure to 0.000001 inch owing to the extreme sensitiveness of the spirit level indicator.

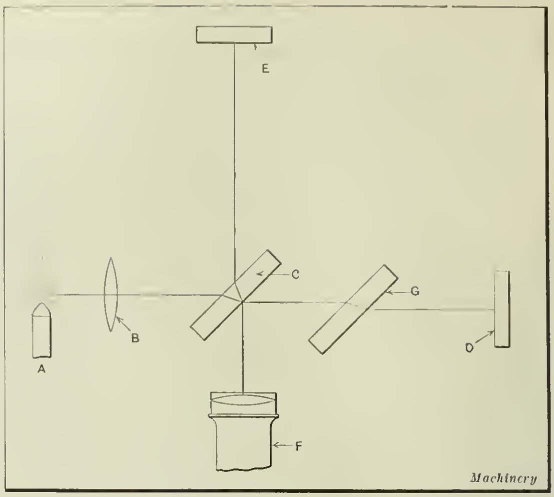


Fig. 19. Diagram illustrating Principle of Interferometer

German Standard Measuring Machine

A measuring machine that is used in the Imperial Laboratory of Technical Tests, Berlin, Germany, and is considered to be absolutely accurate within 0.000004 inch, is shown in Fig. 20. The great precision of this machine is obtained by connecting a movable plunger to a metal diaphragm, which acts upon a colored liquid. This diaphragm is carefully fitted into a cylinder, and connected with the cylinder is a graduated glass tube. The diaphragm is so sensitive that even the expansion of the object being measured caused by touching it with the finger is indicated by the height of the liquid. As far as possible, the temperature of the room is kept at 68 degrees F., and a thermometer forms a necessary part of the instrument. For gaging the work, an adjustable stand is used which is raised to hold the work, if cylindrical, with its axis in perfect alignment with the measuring jaws of the machine. The instrument, in addition, carries a graduated wheel about 10 inches in diameter.

Method of Operating

The chief use of this machine is to compare parts which must be made to standards, and it is therefore not provided with a vernier scale. The method of using it is as follows: The standard test piece with which the parts are to be compared, is brought into contact with screw *A* and plunger *B*,

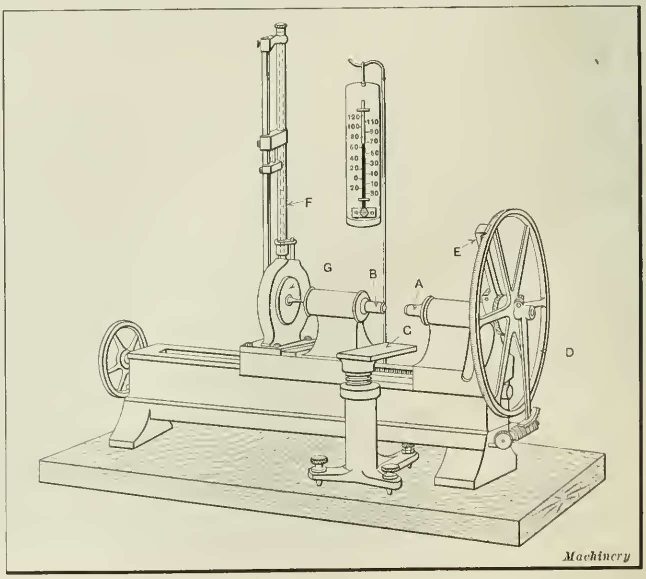


Fig. 20. German Type of Measuring Machine, capable of taking extremely Close Measurements

being supported by stand *C*. Graduated wheel *D* is then set with its zero mark in line with the zero mark on arm *E*, and the height of the liquid in tube *F* is noted. The standard is then removed and the piece to be compared with it substituted. If the difference between the two pieces is minute, the most accurate method of determining it is by the height of the colored liquid, which is so graduated that a difference in diameters is easily calculated. It is highly essential in making accurate measurements that the pieces being measured be of the same temperature as the machine, and hence they should be allowed to remain between the measuring points until this condition is obtained.

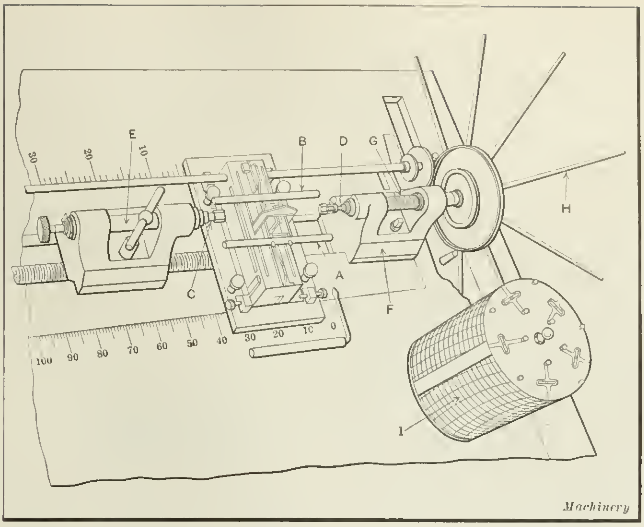


Fig. 21. Hartman's Automatic Comparator

The Hartman Automatic Comparator

The Hartman automatic comparator which is used by the International Bureau of Weights and Measures, France, is employed chiefly for comparing gages, and is not particularly adapted to originating measurements. It was built to insure exactness in the size of gages of the same type which were made by different firms, and is employed largely for testing gages used in gun manufacture. Referring to Fig. 21, which shows a diagram illustrating the principle upon which this machine is constructed, it will be noticed that two end measuring rods *A* and *B* are being compared and are placed between the anvils *C* and *D*. The anvil *C* is held stationary in the tailstock spindle *E*, and the tailstock is free to slide along the base, which is graduated for a length of 1120 millimeters (44 inches). The anvil *D* can be moved backward or forward in the head *F* by means of the left-handed screw *G*, which has a pitch of 1 millimeter (0.039 inch). The rotation of this screw, instead of being noted on a graduated sleeve, is measured by the position of the arms *H* which pass in front of the graduated chart *I*.

The length of these arms is such that they describe a circle of 2 meters (6½ feet) in circumference, while the screw connected with the head makes one revolution and travels a distance of 0.039 inch. The multiplication of the movement of the handles as compared with that of the screw is one to two thousand. By dividing a portion of the circle on the chart into one thousand parts of 2 millimeters each (0.078 inch), when one of the arms has moved that distance—2 millimeters—the surface of the screw will have moved 0.000039 inch.

In comparing the two end measuring gages *A* and *B*, they are placed automatically, alternately between the anvils *C* and *D*, and their lengths registered on the chart *I* by the arms which prick a hole as they pass. The difference between the location of these marks gives exactly the difference between the length of the rods in microns. This instrument is entirely automatic in its operation. The wheel carrying the arms is rotated by a motor which has been greatly reduced in speed. The gages to be measured and supported are held in carriers which operate automatically.

The Interferometer

The interferometer is strictly a laboratory measuring instrument, and while it is indispensable for laboratory use in the checking of standards, it is of little practical value to the average manufacturing establishment. The chief reason for this is that this instrument measures with a degree of accuracy which is much greater than would be necessary in the average manufacturing plant. The interferometer is used for measuring very small distances and angles in terms of wave lengths of light. It has also many other uses which have not a machine shop application. It furnishes the most accurate known method for testing the uniformity of a screw or the perfection of a straightedge, and makes use of the phenomenon known as the interference of light. Light travels in waves, and a simple illustration of this is to compare a light wave to a rope which is fastened at one end and moved up and down rapidly at the other. In the movement of the rope, the distance from the highest part of one wave to the highest part of the next would be a wave length, and the distance which the rope moves up or down from its middle position would be called its amplitude. In the case of light vibrations, the amplitude determines the intensity of the light and the wave length determines the color. For example, light waves which are about 0.00003 inch long appear to the eye as red. The wave length of red light is therefore 0.00003 inch. The wave length of yellow light is about 0.000023, blue light 0.000018 inch, whereas white light is made up of wave lengths

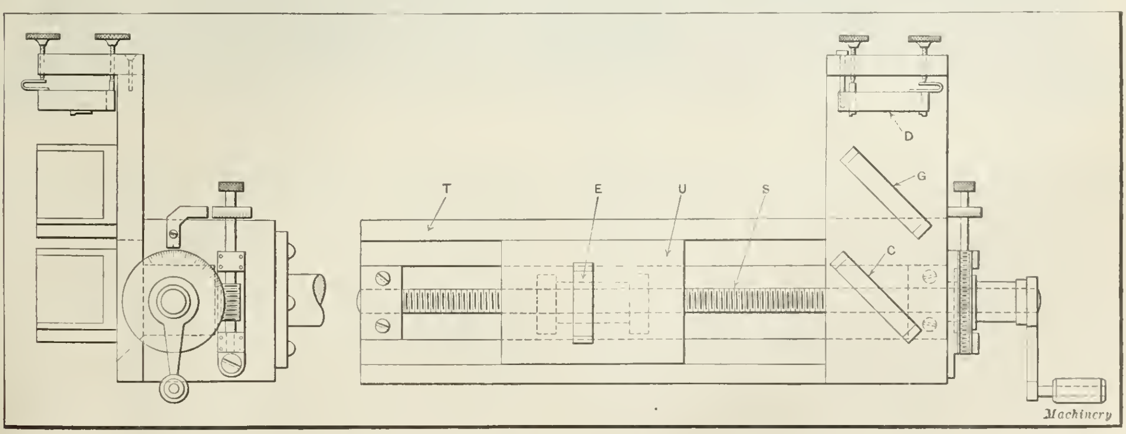


Fig. 22. Modification of Interferometer for testing Accuracy of Screw Threads

of all the primary colors from violet to red. Two pieces of plate glass held in contact may be used to demonstrate the interference of light. If held at an angle to the light, color bands will be noticed in circles and odd shapes throughout the plane of the two surfaces in contact. These colors indicate measurable variations in the surfaces from a true plane.

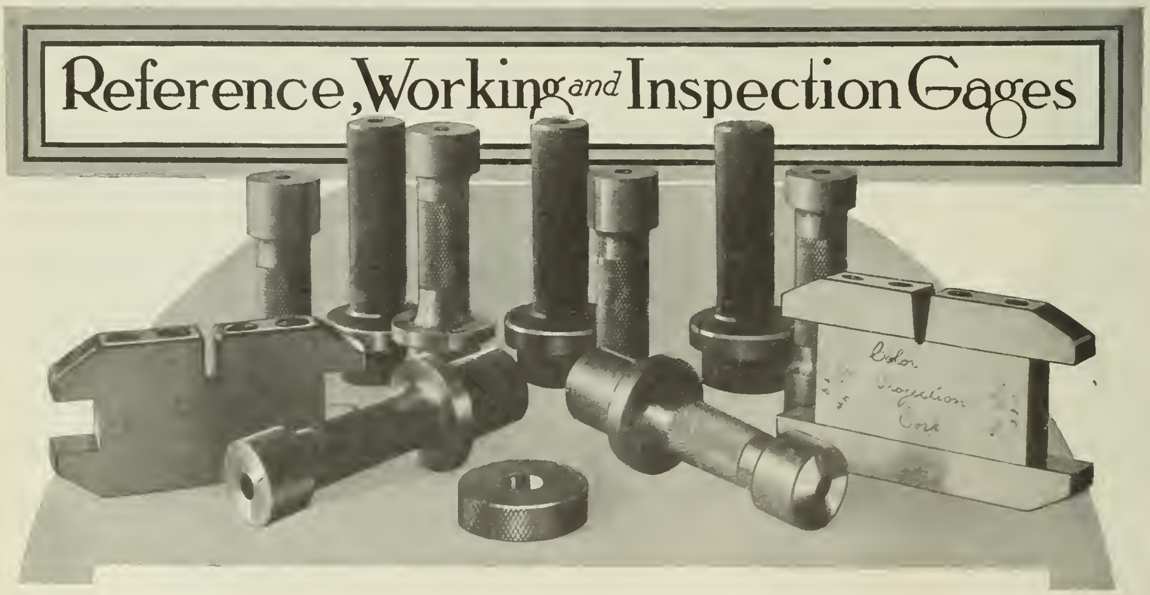
Principle of the Interferometer

The Michelson interferometer which is employed for precise laboratory measurements in the Bureau of Standards is shown diagrammatically in Fig. 19. Artificial light is used with this instrument to produce the different light waves, which indicate the variations from truth of the planes or other parts being measured. Sodium light, whose wave lengths are about 0.00002 inch, is generally employed. Referring to Fig. 19, *A* is a source of light rays, rendered approximately parallel by the lens *B*, that strike the glass plate *C* at an angle of about 45 degrees. Glass *C* is covered with a semi-transparent coat of silver which transmits some of the light rays to *D* and reflects some to *E*. These beams fall perpendicularly on the highly polished mirrors *D* and *E* and are reflected back to *C*. Some of the rays are reflected from *C*, and others are transmitted through *C* to the observing telescope or to the eye at *F*. The rays which are reflected by mirror *E* have to pass three times through plate *C* before reaching telescope *F*. A compensator plate *G*, is therefore put in the path of the other rays, so that the light reflected by *D* has to pass twice through *G* and once through *C* before it reaches the telescope. Plates *C* and *G* are cut from the same piece of glass in order that they may be of exactly the same thickness, the original piece of glass having been ground and polished until its surface was plane and parallel to within 0.000002 to 0.000005 inch, according to the accuracy of the measurements to be made.

When the paths of light from *C* to *D* and from *C* to *E* have been fixed nearly equal, the mirrors are so adjusted that the color fringes will appear as either horizontal or vertical lines. Then as one of the mirrors is displaced, the color bands will pass in succession before the eye of the observer, who can count them as they pass some point of reference, usually the cross-hairs in the eye piece of a telescope.

Construction of the Interferometer

The interferometer is constructed in different forms, depending upon the class of work for which it is to be used. For instance, an interferometer which would be used for checking the accuracy of angles would be constructed on a different principle from that used for testing the accuracy of straightedges or screw threads. For testing the accuracy of a screw thread, the interferometer would have a form somewhat like that shown in Fig. 22. The screw *S* to be tested is mounted in the bed *T* and is used to move the carriage *U* carrying the mirror *E*. The mirrors are adjusted so that the fringes appear in circles. This will happen when the fixed and movable mirrors *D* and *E*, respectively, are equidistant from plate *C* which divides the light, and when the reflection from mirror *E* in plate *C* is exactly parallel to the face of movable mirror *E*. The variation in the pitch of the screw is determined by the number of fringes that pass through mirror *C*. If the number of fringes is the same for each turn or fractional part of a turn of the screw, the screw is accurate. But if the number varies, the screw is inaccurate, the amount of the inaccuracy depending on the difference in the number of fringes cast. The method of counting the fringes and testing the accuracy of the screw is beyond the scope of this article. It is sufficient to say that by this method inaccuracies are detected in a screw amounting to about 0.0000005 inch.



A SATISFACTORY gaging system should be built around the basic reference and limit snap and plug gages. Reference gages are divided into three classes, as follows: working gages for shop use; inspection gages for final checking; and gages used in testing and adjusting both working and inspection gages. Limit gages include two classes, namely, allowance and tolerance gages. Tolerance gages provide for reasonable error in workmanship, whereas allowance gages take care of the necessary difference in the sizes of two pieces which go together. It should be understood in this connection that the female and male gages are referred to collectively and not individually. Allowance gages are again divided into four distinct classes, depending upon the fit desired—whether running, push, drive or force.

Reference Gages

In addition to the reference blocks and rods shown in Figs. 5 and 6, reference gages are made in several other forms, the most common or conventional type being the standard plug and ring gage shown in Fig. 23. This type of gage is of little or no value in connection with interchangeable manufacture, as it is made to one standard size and can only be used for setting micrometers, calipers and other measuring instruments. Owing to the great accuracy of this gage, it should not be used as a working gage for reasons which will be explained later.

Plug gages are made to standard size within very close limits, and most manufacturers guarantee them to be within 0.0001 inch of standard size, although as a matter of fact

they are made considerably closer than this. The tolerance is over rather than under the standard, so as to provide for wear. The ring gage is then made to fit the plug and is not measured. Theoretically speaking, there is no difference between the diameter of the plug and the diameter of the hole in the ring, and they are put together only with great difficulty by an experienced gage-maker. It is done by coating the plug and the ring with a film of light oil, then getting them into perfect alignment and with a quick twist inserting the plug in the ring. The plug, however, must be kept in motion to prevent it from "freezing." If the ring or the plug is allowed to remain stationary, it will stick to the other

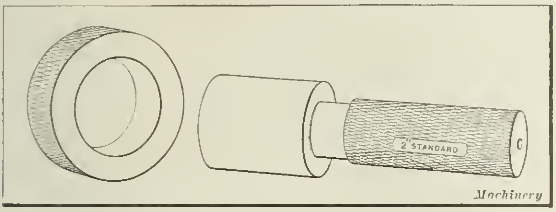


Fig. 23. Reference Plug and Ring Gage

piece in a short space of time, and they can only be separated by force. One way of separating them is to hit the ring quickly on the bench, and before the molecules have a chance to reset, immediately pull the plug out, using a twisting action. This, however, also requires considerable experience.

Reference Limit Gages

As has previously been mentioned, standard plug or ring gages made to one size are of little or no practical value in connection with interchangeable manufacture. Reference gages should be so made that both the inspection and working gages can be checked up by them from time to time, to prevent the limits changing due to the wear of the gages. A practical type of reference plug and snap gage for checking working and inspection snap and plug gages is shown in Fig. 24. Plug *A* has nuts on each end to facilitate lapping and prevent its use as a working gage. The limits are the same as on the working and inspection gages. As will be subsequently explained, it is the practice in some plants to tolerate wider limits on inspection than on working gages. The reason for doing this is to reduce the amount of spoiled work, and also provide for the greater amount of wear on the working gages. When this system is used, it is necessary to provide two sets of limits, one for working and the other for inspection purposes. Reference gages to check the working and inspection gages should, therefore, be made to take care of this. The Johansson blocks can be satisfactorily used for this instead of reference gages.

As an illustration to show how these are used, we will assume that the difference between the "Go" end of the working and inspection gages is 0.0005 inch; that is, the working gage is that amount larger than the inspection gage. The reference snap gage *B*, Fig. 24, can be used to determine when the working gage has worn down this amount; as soon as it has, it is turned over to the inspector, and the workman is supplied with a new gage. In this way the workman is never working to the extreme limits, and the amount of rejected work is thereby greatly reduced.

Manufacturing Tolerances on Reference Gages

Gages which are to be used as standards of reference should be made both carefully and accurately. The permissible manufacturing tolerances are dependent largely upon the class of work for which the gages are to be used, as well as the permanency of the gages. Some manufacturers make their reference standards from a good grade of machinery or tool steel and leave them soft. The reason for this is that soft steel has a lower coefficient of expansion than hardened steel that is not carefully seasoned. Soft reference gages have the one objection that they are subject to wear and are easily dented, and must be handled with care. Owing to the comparatively high coefficient of expansion of carbon steel gages, very close manufacturing tolerances are not feasible. Hence for the finest reference gages invar steel should be used. When this material is hardened and carefully seasoned, the expansion is comparatively low. The well-known Johansson gages are made from this material and are guaranteed to be within a tolerance of 0.00001 inch. As a matter of fact, each individual block is held much closer than this, as a combination of blocks making 8 inches is guaranteed to be accurate to within 0.00004 inch. This extreme accuracy, however, is greater than can be ordinarily expected in regular reference gages, and as a rule the manufacturing tolerances vary from 0.00005 to 0.0001 for sizes up to 1 inch and from 0.0001 to 0.0002 inch for sizes up to 2 inches.

This manufacturing tolerance on the reference gage is distributed so as to take care of the wear on the working and inspection gages which are checked up by the reference gage. For instance, the "Go" ends of a reference plug gage (*A*, Fig. 24) which would be used for checking the "Go" ends of the working and inspection gages would be made to the required size minus the manufacturing tolerance. On the reference snap gage which would be used for testing working and inspection plug gages the manufacturing tolerance would be added to the actual dimension required.

Abuse of Standard Gages

In some manufacturing plants—fortunately not many—it has been the practice to use standard plug and ring gages as working gages. In fact, this has been done to such an extent that a gage on which there is no limit of tolerance is known as a "fixed" gage and is used similar to a caliper. There are two good reasons why a standard plug or ring gage should not be used as a working gage. In the first place, these gages are made very carefully and to extremely close limits, and if used as a working gage, their accuracy would soon be impaired. In the second place, as they are not provided with a working tolerance, a greater amount of time is consumed in getting the work so that the plug will enter or so that the ring will go over it than would be necessary if a regular limit snap or plug gage were used. If both the plug and ring gages were used, they could no longer be considered as standard, as both would become larger from wear. Furthermore, work which is finished so that these gages would fit it would be

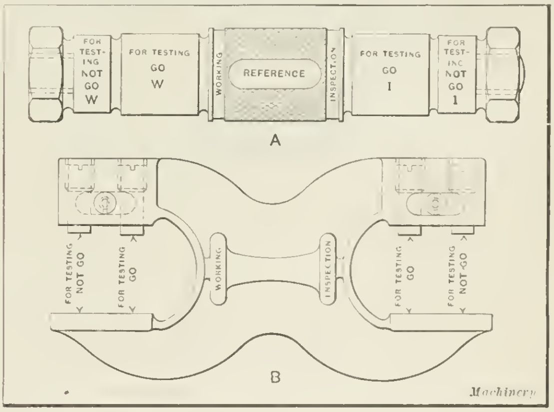


Fig. 24. Reference Limit Gages used in testing Limit Working and Inspection Gages

much more accurate than would ordinarily be necessary, and the time spent in bringing it to this degree of accuracy would be wasted. Therefore, standard snap or plug gages should not be used for other work than setting micrometers, calipers, etc.

Limit Working and Inspection Plug and Snap Gages

The most common forms of limit working gages are illustrated by the plug and snap gages shown in Fig. 25. Of course, the form in which these gages are made depends to a considerable extent on the character of the work and, in some cases, on the peculiar fancies of the designer. The two types shown at *A* and *B*, however, illustrate common forms of non-adjustable gages; other varieties will be illustrated and de-

scribed later. The difference between the "Not Go" and "Go" ends on the plug is the maximum error tolerated on the hole, and the difference between the sizes on the two ends of the snap gage, the maximum tolerance that can be permitted on the shaft. The difference between the small end of the plug and the large or "Go" end of the snap gage is the maximum allowance between the two parts—shaft and hole—and the difference between the large end of the plug and the small end of the snap gage is the minimum allowance between the two parts.

Manufacturing Tolerances on Working and Inspection Gages

There seems to be some disagreement between gage manufacturers as regards the manufacturing limits on plug and snap gages. Some manufacturers make all gages within a manufacturing limit of ±0.0001 inch. This degree of accuracy is not always necessary, and where the work can have considerable tolerance, it is desirable not to make the gages to very close dimensions; it would be preferable to make the plug gage, for instance, slightly large, so as to insure long life. The snap gage would be made correspondingly smaller for the same reason. This practice is being followed by one prominent concern which has adopted a unique system of plug and snap gages. The manufacturing limits on the gages are governed entirely by the limits on the work. For instance, where the work must be held to a limit of within ± 0.0005 inch, the limit on the plug or snap gage would be ± 0.0001 inch. Where the manufacturing limit on the work is 0.002 inch, the limit on the gage would be ± 0.0005 inch. On extremely accurate work, where a limit of only 0.00025 inch is allowed, the gage must be made to a limit of ± 0.00005 inch. This means, of course, that the life of the gage is considerably shortened, and in one instance, where the gage was used for work that was ground, it was found that the gage lasted only one day.

Setting Manufacturing Tolerances on Working and Inspection Gages

As an illustration of the point previously mentioned, Fig. 26 shows a plug and snap gage used in producing a shaft and hole that were required to have a good running fit. In this case, the maximum allowance between the largest shaft and smallest hole is 0.003 inch and the minimum allowance is

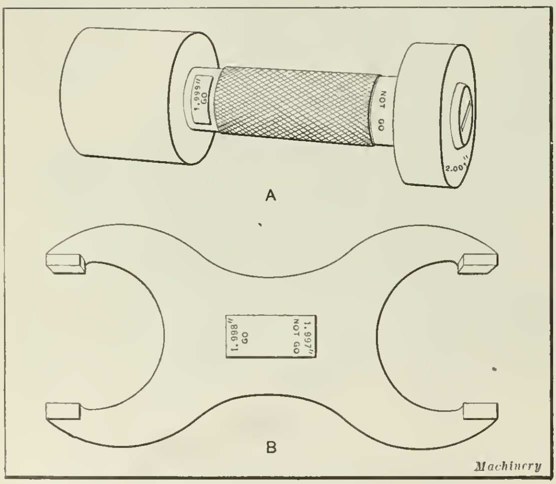


Fig. 25. Limit Working and Inspection Plug and Snap Gages

0.001 inch. The maximum tolerance on the shaft is 0.001 inch and the same tolerance is allowed on the hole. The difference, therefore, between the "Go" and "Not Go" sizes on the snap gage is 0.001 inch. In manufacturing the snap gage, the "Go" portion is made to a manufacturing limit of 0.9985 — 0.0001 inch + 0.0000. This provides 0.0001 inch for wear before the gage would be worn down to the size indicated. On the "Not Go" end, it is not so important whether the limit is set plus or minus, although it is preferable to have it minus, which would prevent work almost up to the "Not Go" size from going in. On the plug the "Go" end is made 0.0001 inch large to provide for wear, and the "Not Go" end is made this amount small. In this way the manufacturing limits are set so that the life of the gage will be increased without affecting the interchangeability of the work.

Advantages of Tool-setting Gages

In working to limit gages, the tendency is for the operator to work as close as possible to the "Go" end of the gage for fear of spoiling the work. This results in the parts going together with the minimum of freedom. The object, of course, is to make the parts to the mean dimensions. Tool-setting

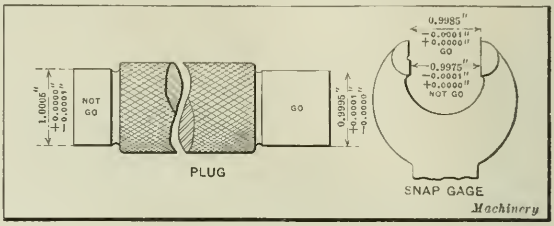


Fig. 26. Diagram illustrating Method of setting Manufacturing Tolerances on Working and Inspection Gages

gages which generally consist of hardened, ground and lapped blocks are used to set the cutting tools, and are made to the "mean dimension." These are used in connection with a hardened and ground locating block on the jig or fixture, and are employed principally on profiling and milling fixtures.

Life of Plug, Ring and Snap Gages

The life of a gage is governed by many conditions, among which might be mentioned: limit of tolerance allowed for wear; condition under which gage is used, whether for manufacturing or inspecting purposes; character of material on which gage is used, whether brass, cast iron, steel, etc.; condition of work on which gage is used, that is, whether rough-turned, finish-ground, lapped, etc.; material from which gage is made, whether cast iron, carbonized machinery steel, tool steel, malleable iron, etc.; condition of measuring surface on gage, whether ground or highly finished and lapped; care used in applying gage.

Limits of Tolerance Provided for Wear

As has been previously mentioned, limit gages are usually made with manufacturing limits that increase the life of the gage. In other words, on a plug gage, the "Go" end is made with a manufacturing limit larger than the size specified on the gage. The amount of this limit, in a general way, determines the life of the gage. As a case in point, on one extremely accurate piece of work a limit of 0.00025 inch was the greatest tolerance. The plug gage was therefore made with a plus wear limit of 0.00005 inch, and as this gage was used in testing a hole finished by grinding, where considerable grit and dirt accumulated, its life was only one day of ten hours. In other words, a new gage had to be furnished every day. This, however, is an exceptional case, but it serves to illustrate the necessity of setting manufacturing limits on the gage to provide for wear. The greater the limits on the work, the larger can be the permissible tolerance for wear on the gage, so as to increase its life as much as possible. Furthermore, when the "Go" end of a plug gage, for instance, is made larger than the lowest limit of tolerance, the machine operator is working closer to the mean or nominal dimension. In purchasing gages most manufacturers do not give the subject of wear the attention it deserves, and generally hold the gage-maker right down to the sizes given, which of course do not provide for wear. This results in greatly increasing the gaging and inspection expense.

Conditions Under Which Gages Are Used

The conditions under which a gage is used, that is, whether it is used for manufacturing or inspection purposes, governs to a large extent the number of pieces that can be gaged. It is, therefore, the practice of some firms to permit a larger

manufacturing limit on the working than on the inspection gages, and then interchange these gages as they begin to wear. For example, in one plant the machine operator is given the newest gage when it is of the plug variety, and the oldest when of the snap variety (solid type), and to keep close watch on the condition of the gages, this firm employs several men, known as "field" inspectors. The duties of these men are to cover the entire plant, inspecting the gages and replacing those that are worn out by new gages adapted to the work. When a job is turned in and the gages and tools sent with it, these gages are not allowed to be put in the tool storage or supply room, but are handed over to the field inspectors, who carefully go over the gages before they are stored. These field inspectors also see that the production and inspection departments are supplied with the proper gages. In this way, the machine operator is always provided with a gage with the closest limits, and consequently the greatest amount of wear is obtained from the gages. Gages wear much more rapidly, of course, when used for manufacturing than when used for inspection purposes, so that the interchange of gages greatly reduces the amount of rejected work.

Influence of Material Being Gaged on Life of Gages

The kind of material being gaged also has considerable bearing on the number of pieces that can be gaged before the gage is worn beyond the required limits. Some materials, such as cast iron and particularly aluminum, have a lapping effect and wear the gage down much more rapidly than either brass or steel. In one plant where a large number of aluminum fuse parts are being manufactured, a careful inspection of the gages proved that in gaging 10,000 aluminum parts the wear on the gage was 0.0005 inch. It was also found that five times as many brass parts could be turned out with the same amount of gage wear as aluminum parts; in other words, the same gage used on brass would inspect 50,000 parts before it was worn 0.0005 inch. Cast iron has a lapping effect somewhat similar to that of aluminum, but not so pronounced. In gaging cast iron, about 20,000 parts can be turned out with a wear of 0.0005 inch on the gage. The wear, of course, depends to a considerable extent on the diameter of the work and the condition in which it is received when being gaged.

Influence of Condition of Work on Wear of Gages

The condition of the work—whether rough or smooth—also has a governing effect on the life of the gage. Rough-turned work will wear a gage down much more rapidly than a ground surface, free from grit. As an indication of the life of an ordinary snap gage on work that is ground fairly smooth, it was found in one plant where a careful record was kept that 35,000 Russian shrapnel shells having a ground surface could be inspected with one gage before it was worn beyond the required limit. In this particular gage, 0.002 inch was allowed for wear, so that the gaging of 35,000 shells removed this amount of material from the surface of the measuring point on the gage. In this plant it was also found that solid snap gages did not give nearly as satisfactory service as those that were made with adjustable points. The latter could be readjusted every day to a standard plug, and the life, of course, could thereby be greatly increased. In another plant where a similar limit was allowed on the gage and where the work was turned instead of ground, the number of parts inspected varied between 8000 and 10,000 before the 0.002 inch limit was removed from the surface of the gage. From this it will be seen that ground work has not nearly as abrasive an effect on the gage surface as rough-turned work. In other words, a gage can be used for only about one-third as many rough-turned pieces as ground pieces.

Material Used for Gages

Gage-makers differ to a considerable extent in regard to the material from which gages should be made and its bearing upon the life of the gage. There are so many points to take into consideration in this connection that it is difficult to reach any definite conclusion. For instance, one point that must be considered is the total number of parts to be gaged; another, the limits on the gage which would make it unnecessary to inspect every part; still another, whether the gage is to be used for reference, working or inspection purposes. It is generally conceded, however, that for plug gages used for manufacturing purposes, it is preferable either to make the gage from a good grade of machinery steel and carbonize it or to make it from tool steel hardened, seasoned, ground and lapped. Gages are seldom left soft unless they are used for reference purposes or unless only a few parts are to be inspected. It is also the practice to leave thread gages soft; this point will be taken up under a separate heading.

The type of gage also has an important influence on the selection of material from which it should be made. For instance, a solid snap gage is seldom made from cast iron, either a malleable casting or a steel forging being used. Most manufacturers of solid snap gages make them from drop-forgings, when they are used for measuring up to 3 inches in diameter. Above this size, the gages are made from steel castings which are heat-treated, seasoned, ground and lapped to size. When snap gages are provided with adjustable points, it is the general practice to make the frame either from malleable castings or from cast iron. One prominent manufacturer of snap gages follows the practice of making the frame from cast iron of frail dimensions. This is done so that in case the gage is dropped on the floor, the frame will break rather than distort. In this way any chance of the operator distorting his gage without knowing it is eliminated. The frame is also made of such a shape that it is impossible for the operator to "peen" the gage to fit the work. The difference between the lives of a solid snap gage made from fine-grained cast iron and one made from hardened steel is considered by many gage-makers to be extremely slight.

Relation of Measuring Surface and Life of Gages

The condition of the measuring surface on the gage is not always considered a vital factor affecting the life of the gage. When it is understood, however, that it is practically impossible to secure a perfectly plane surface, the question of securing a smooth surface on the gage appears to be of greater importance. Some gages, especially the Johansson gages, have the property of sticking when wrung together with a force considerably greater than that due to atmospheric pressure on the areas in contact.

This phenomenon has been attributed to molecular attraction, but investigation has shown that the adhesion is due to the presence of a very thin liquid film. Blocks made from hardened steel were prepared, each weighing an ounce and a half and having surfaces 0.7 square inch, polished flat to within 1/100,000 inch of being a true plane. These blocks were then used to test the adhesive properties of different liquids. The contact faces were carefully freed from moisture and cleaned with alcohol. When the blocks were wrung together, they fell apart under their own weight, but as soon as a film of oil or other liquid was put between them, a force of 17 pounds for Rangoon oil, 20 pounds for lubricating oil, 29 for turpentine, and 35 for condensed water vapor was required to separate the blocks. From this test it was proved that it is impossible to get perfect union between two parts, and the only reason that they held together was because of the adhesive qualities of the lubricant or other liquid. Any machined surface, no matter how smooth, consists of humps and hollows so that a surface which is brought down to the closest approximation of a true plane is one in which there would be the greatest number of points in a common plane. It is therefore reasonable to assume that a gage made with a smooth measuring surface will wear much longer than one made with a rough surface.

Care Used in Applying Gages

It has been previously stated that gages used for inspection purposes wear much longer than those used as working gages. One reason for this is that the inspectors handle the gages much more carefully than the workmen do. In the first place, an inspector is seldom put on a piece-work basis, whereas a machine operator usually is. The chief point with the workman is to turn out as many parts as he can in the shortest possible time. To show that this is the case, a prominent

concern made a careful test of the gages used by an experienced inspector and found that in inspecting 130,000 pieces, the different gages were worn from 0.0015 to 0.003 inch. Similar gages used for manufacturing purposes were found to wear only one-half as long as those used in the inspection department.

Life of Gages Used on Ammunition Work

The production of munitions in this country has caused considerable attention to be paid to interchangeable manufacture and the use of limit gages. Parts for shells, fuses, etc., have been made by several different firms and then assembled in a separate plant, so that each part had to be made a duplicate of the other in order to have them go together without fitting. This necessitated each plant being equipped with a complete set of limit working and inspection gages.

Several interesting points have come up in connection with the design and use of gages, one of which is the length of time that a gage can be used before it is worn beyond the set limits of tolerance. Some manufacturers did not equip their plants with the necessary number of reserve gages, with the result that they had to wait for a considerable length of time to get deliveries from gage manufacturers. On account of this trouble a close record was kept of the life of various gages, so that considerable data were soon available. Wells Bros. Co. of Greenfield collected a large amount of information on this subject, some of which is presented in Table IV. The number of pieces tested by the various gages is based on data obtained from various munition manufacturers and represents a safe estimate of the approximate life. It should be noted in this connection that in very few cases were the gages provided with any tolerance for wear, so that their life was considerably shorter than would have been the case if a percentage of the manufacturing tolerance on the work had been placed on the gage.

Types of Plug Gages

Plug gages are made in a variety of forms and sizes, depending largely on the shape and size of the work to be measured. For gaging small holes, they are generally made from a solid piece of steel, whereas for gaging larger holes they are built up and so constructed as to make them easy to handle. A reference standard plug gage of the type shown at *A* in Fig. 27 is used chiefly for sizes up to 1 inch in diameter. For larger sizes, the gage generally has the form shown at *B*, and is made of flat section from either a drop-forging or a steel casting, ground and lapped on the circular contour. The gages shown at *A* and *B*, respectively, should not be used for working or inspection gages, but merely for reference purposes. Gages used for working or inspection purposes should be provided with certain tolerances, depending on the character of the work.

C is a simple form of limit plug gage for comparatively small work. This consists of a hexagon handle provided with tapered holes in each end, into which hardened, ground and lapped plugs are fitted. The "Go" plug is made considerably longer than the "Not Go" plug, to distinguish between them. Another type of plug gage shown at *D* is used for work of larger diameter, generally up to about 1 inch. This gage also has one end longer than the other, the longer being the "Go" end of the gage. When a gage of this type is being used on a grinding machine, the operator does not know how much material is to be removed until the "Go" end enters the work. For this reason, it is the practice in some plants to taper the "Go" end of the gage as indicated by the dotted lines *a*, making the end from 0.005 to 0.010 inch smaller than the regular "Go" size or straight portion. This enables the operator to enter the gage into the work practically after he has taken his first roughing cut, and he can thus work much more rapidly; the chances of grinding the hole too large are also reduced, and at the same time the gage does not have to be used so frequently. When a plug gage of this kind is used, it is advisable to have the limit on the "Go" end as close as possible to the mean dimension and have the greater amount of tolerance on the "Not Go" end. The reason for this is that it is easier for the operator to work to the "Go" end with this type of gage, and as it is the mean dimension that is always

TABLE IV. ESTIMATED LIFE OF GAGES USED FOR 4.7-INCH HIGH-EXPLOSIVE SHELLS

Operation	Type of Gage	Estimated Life—Pieces Gaged
Rough Blank		
Length of billet	Crescent	100,000
Diameter of billet	Crescent	100,000
Forged Blank		
Diameter and length	Templet, snap	10,000
Cavity	Plug, flat	10,000
Diameter	Crescent	100,000
Wall thickness	Caliper	50,000
Length, total	Flat hook	100,000
Shell Body		
Trim base	Plunger, depth	30,000
Trim length	Fixture	30,000
Form nose	Flat, profile	11,000
Nose diameter	Crescent	100,000
Nose diameter	Ring	25,000
Body diameter	Crescent	100,000
Base diameter	Crescent	100,000
Band groove	Crescent	100,000
Base groove	Crescent, special point	100,000
Base groove	Flat, snap	5,000
Base groove	Flat, profile	11,000
Crimping groove	Flat, profile	11,000
Band groove	Flat, profile	11,000
Width band groove	Flat, limit	25,000
Base to bourrelet	Flat, profile	100,000
Bore for thread	Limit, plug	25,000
Thread recess	Flat, location	11,000
Thread plug	Limit	4,000
Counterbore	Limit, plug	25,000
Wall thickness	Concentric special	50,000
Band profile	Flat, limit	11,000
Base diameter	Ring gage	25,000
Diameter over band	Ring gage	25,000
Band		
Cut length	Fork, limit	100,000
Wall thickness	Fork, limit	100,000
Chamfer	Flat, profile	11,000
Hole	Plug, limit	25,000
Base Plug		
Large diameter	Crescent	100,000
Thread diameter	Crescent	100,000
Concentricity diameter	Thread ring	20,000
Thread and groove	Crescent	100,000
Length thread and head	Flat, profile	11,000
Counterbore	Limit, cylinder plug	25,000
Thread bore	Limit, cylinder plug	25,000
Thread	Limit thread plug	4,000
Thread and groove	Flat, location	11,000
Depth and width, slot	Special plug	25,000
Outer thread diameter	Crescent, thread	100,000
Iron or Bronze Fuse Hole Plug		
Head diameter	Fork, limit	100,000
Flat for wrench	New Corey, limit	100,000
Thread and groove	Fork, special point	100,000
Thread O. D.	Fork, limit	100,000
Concentricity	Ring, thread templet	20,000
Length and shoulder	Flat, limit	11,000
Internal thread groove	Flat, limit	11,000
Thread size	Fork, thread	100,000
(Alternative) Die-cast Fuse Hole Plug		
Head diameter	Fork, limit	100,000
Socket	Plug, limit	25,000
Thread diameter	Fork, limit	100,000
Concentricity	Ring thread templet	20,000
Thread I. groove	Fork, special point	100,000
Length and shoulder	Flat, limit	11,000
Thread size	Fork, thread	100,000

Machinery

desired, it is advisable to have the limit here as close as practicable. Say, for instance, that the total tolerance between the "Go" and "Not Go" ends is 0.002 inch; then the limit on the "Go" end should be 0.00025 inch below the mean dimension and the remainder of the tolerance should be on the "Not Go" end.

It is the practice of some manufacturers to make a gage of this sort single-ended and use the taper as a limit. This practice is not recommended for the reason that if the cylindrical part of the gage enters the hole, it would be too large. Consequently, it is necessary to have the plug enter about half way up on the taper. This does not give the operator a chance to tell whether he has a bell-mouthed hole or not. Neither does it give him a chance to tell whether the hole is truly cylindrical or tapered unless he removes it from the chuck and tests both ends. It is preferable when using a gage with a tapered end to have the taper on the "Go" end and the cylindrical part as close as possible to the mean dimension, as previously stated.

When the work has a hole passing through it, the plug gage is sometimes made of the type shown at *E*. This gage has an advantage over that shown at *D* in that the "Go" and "Not Go" sizes are on the same end of the gage, so the operator is not likely to use one for the other. In order to facilitate grinding a hole to the correct size, the end of this plug gage can be tapered similarly to that shown by the dotted lines *a*.

An improvement over the gage shown at *E* is shown at *F*; this gage, of course, can only be used where the hole passes completely through the work. Here the gage is provided with three dimensions, one the "Go," one the "mean" or exact dimension desired and the other the "Not Go." In all manufacturing, especially on close work, the mean dimension is the one desired, and having a gage made with the three sizes, low, mean and high on one end, it is easy for the operator to work to extremely close limits with comparatively little trouble.

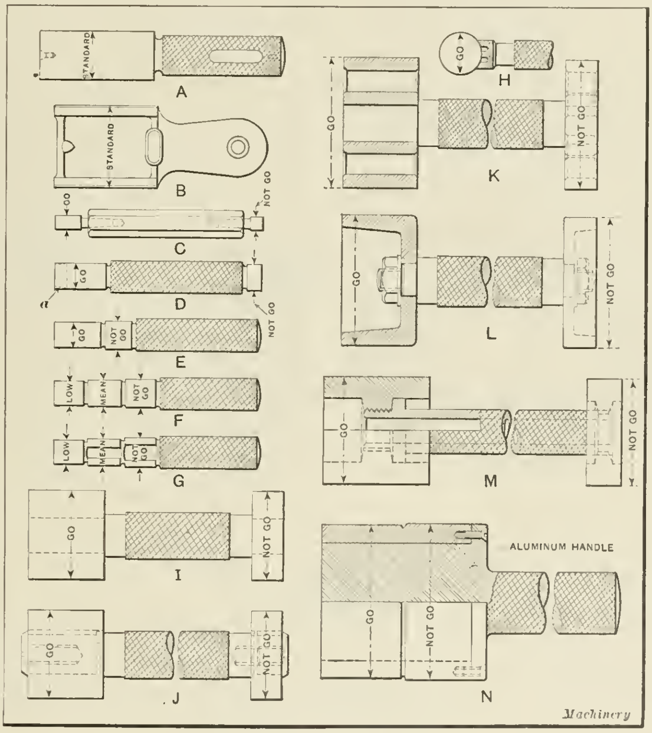


Fig. 27. Types of Plug Gages

As a matter of fact, however, the plug gage is not a true detector of all the errors in the hole; for instance, a plug gage will not indicate whether the hole is truly cylindrical or not. It merely tests whether the hole is of the required size at a certain point, and for the majority of work this is sufficient. With a plug gage made as shown at *G* it is possible to tell whether the hole is round or not within the required limit. The "mean" and "Not Go" shoulders are ground flat as shown, so that only two points of the circumference are up to the required size. By turning the gage around, it is possible to determine the truth of the hole. This gage has been found satisfactory where an extra degree of refinement is necessary and where the hole is not three-cornered.

The gages shown from *C* to *G* are for inspecting small sized holes up to 1 inch in diameter. When the holes are greater in diameter, a built-up gage is preferable in order to economize in stock. One type of built-up gage is shown at *I*. This, as will be seen, consists of "Go" and "Not Go" cylindrical plugs fitted onto a soft steel shank by simply having the turned down end of the shank slightly tapered and driving the rings on. This is a comparatively cheap gage to manufacture and is satisfactory for the majority of work. Another type of built-up plug gage for large work is shown at *J*. In this case, the handle is made an easy fit in the holes of the "Go" and "Not Go" plugs; the latter are fastened to the handle by means of screws, as shown, and are prevented from turning by pins which fit in a slot in the hole in the plug. This type of gage is a little more expensive to manufacture than the type shown at *I*, but there is little danger of the plugs turning around or coming off while in the work.

K shows a type of plug gage for gaging very large holes. The "Go" and "Not Go" plugs are lightened by drilling six holes around the plugs midway between the outer circumference and the hole. A gage of this type must be carefully hardened to prevent cracking, and also seasoned to eliminate any internal strains that might develop after the gage had been in use.

An unsuccessful attempt to lighten a plug gage is shown at *L*. This type of gage has many disadvantages, one of which is the difficulty of hardening without springing it out of shape. Also, owing to the unequal strains set up in hardening, which are only partially removed by annealing, it will not retain its shape when in use, and soon becomes out of round and inaccurate. It is also affected considerably by temperature changes. A plug gage of this shape which is held in the hand for a few minutes will be found to be out of round about a half-thousandth inch, simply because of the strains set up and the lack of sufficient support, on the extreme outer end. This gage is much lighter than the solid gage, but the objections are so great that it is not recommended, although it has been used to some extent.

A gage which is made in a somewhat similar manner, but is so constructed that the strains are equally divided, is shown at *M*. Here it will be noticed that the "Go" and "Not Go" plugs are counterbored, and the mass of material is in the center. In hardening, the strains are more equally distributed throughout the mass, and by careful annealing and seasoning, can be practically eliminated. The gage is also lightened by making the handle hollow, as shown. This type of construction is used by C. E. Johansson, maker of the well-known Johansson block gages. The hollow handles allow the air to pass through the gage when gaging blind holes, and the plugs are reversible, insuring double life. The measuring plugs are made of high-carbon Swedish crucible steel, hardened clear through and tempered and seasoned. The operations on these plugs consist in hand-forging, roughing to shape, hardening, rough-grinding, seasoning for a long period, and finally grinding and lapping. It is also claimed by this concern that making gages from low-carbon steel, casehardened, is unsatisfactory, due to two causes. One is the rapid method of seasoning generally followed, and the other the constant pulling of the hard case on the soft core. Gages that are hardened all through and carefully seasoned are not so likely to change as those are are casehardened and improperly seasoned.

Very large plug gages are made of a type somewhat similar to that shown at *B*, except that they are provided with two diameters giving the plus and minus limits; or they are made of the bushing type shown at *N*, having an aluminum core and handle. A gage made of this type must be carefully hardened, and seasoned for a considerable period. It is also inadvisable to drive the sleeve onto the aluminum core. A preferable method is to hold the sleeve on the aluminum core by means of screws, as shown. This prevents distortion of the ring. The ring, of course, should be finish-ground and lapped while it is attached to the aluminum core, so as to prevent any liability of distorting it by assembling after lapping.

Another plug gage which is comparatively cheap to manufacture, and also very accurate, is shown at *H*. This consists of two balls which are electrically welded to a handle, as shown. This gage has one serious disadvantage, in that its life is comparatively short, owing to the line contact which it presents to the work. There are many other types of plug gages used in various plants, but those shown in the foregoing illustrate the general principles of construction.

shown at *D*. This gage is made in two principal forms, one being shown by the full outline and the other by the dotted outline *a*. The dotted outline type of gage is used when the diameter to be measured is greater than 1 inch. Making a gage to this shape lightens it considerably. A single-ended type of limit gage is illustrated at *E*. This is provided with one flat jaw and one having the permissible tolerance on it. Gages of this kind are usually made from drop-forgings and hardened. *F* shows a limit snap gage in which the body is made from cast iron with solid measuring points inserted. This gage is not provided with any adjustment, and it is necessary to renew the points when they become worn. This type is used only on very large work.

Another type of limit gage having only one jaw, but being provided with adjustable points, is shown at *G*. The adjustable points are prevented from turning in the holder by means of screws, as shown, the points having a flat side against which the heads of the screws rest. The anvils are adjusted in and out by means of the headless screws and are clamped by the screws passing through at right angles to the axis of the anvils. The forward faces of these anvils are beveled to

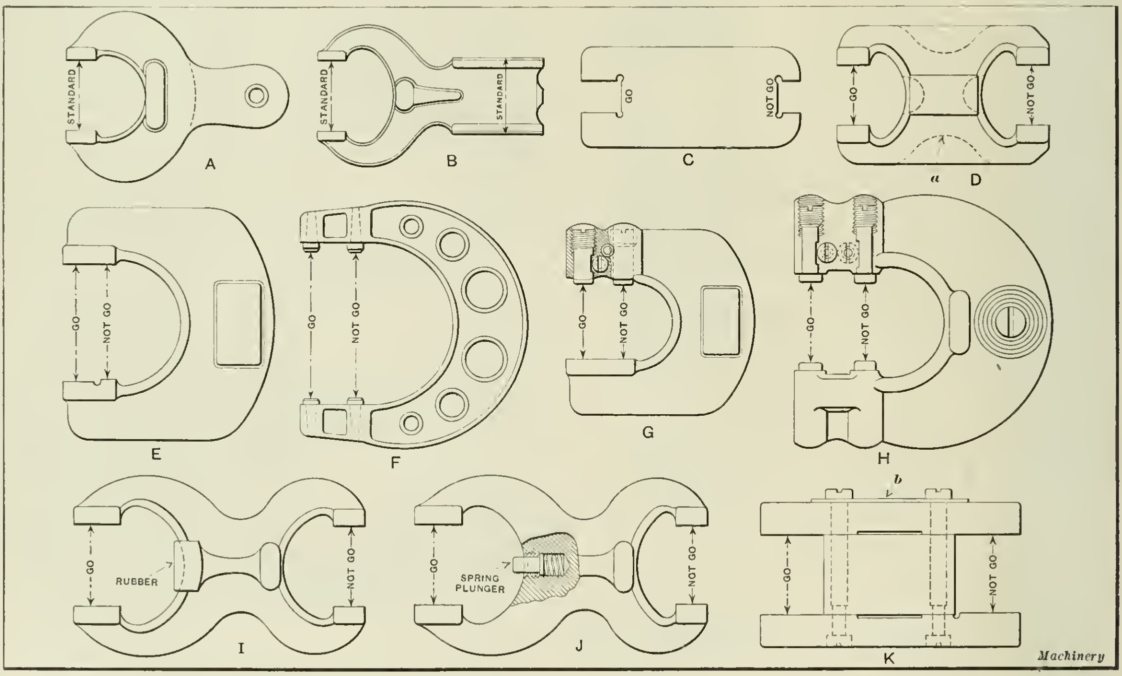


Fig. 28. Types of Snap Gages

Types of Snap Gages

Snap gages used in general manufacturing are made in three types, namely, solid, adjustable and built-up gages. The adjustable type consists of a frame having adjustable anvils, and the built-up type is made from separate blocks. One type of snap gage, which is shown at *A* in Fig. 28, is known as a standard or reference gage. This gage is not provided with any working limit and is made to standard size, being used for reference purposes only. It is usually made from a high-carbon steel forging, carefully hardened, seasoned, ground on the measuring faces and lapped. As has been previously stated, the use of this gage for other than reference purposes should be discouraged.

A type of gage which is a combination of snap and plug gages is shown at *B*. This is made and used in the same way as gage *A*. *C* shows a common type of limit snap gage which is made from sheet steel, varying in thickness from 1/4 to 1/2 inch, depending on the diameter and character of the work being gaged. Snap gages of this type should have as wide a bearing surface as possible, as this greatly increases their life.

Another type of limit snap gage which is usually made from a forging, although sometimes from a malleable casting, is

prevent marking the work. Usually on an adjustable snap gage of this kind the points are not made absolutely flat, but are slightly convex. This insures that the measurement is always taken directly on the axis of the plug.

Still another type of adjustable point measuring gage in which all four measuring points are adjustable is shown at *H*. This type of gage is the Johansson patented limit adjustable snap gage. The measuring plugs are not threaded and do not turn in the body, having an end movement only which prevents any possibility of their becoming cocked, as is the case with threaded plugs. They consist of plain cylinders of hardened steel, with flats on one side, and are lapped a snug, sliding fit in the lapped holes in the body. The ends which come in contact with the work and the faces of the adjusting screws are lapped square with the axis. The flat surface on the plugs and clamping screws prevent the plugs from turning in the body when adjustments are being made. The rear end of each adjusting screw is provided with a screwdriver slot, and the forward ends which come in contact with the plugs are lapped square with the axis. These screws should be sealed by the inspector after the gage has been set to prevent the workmen tampering with it. The clamping screws

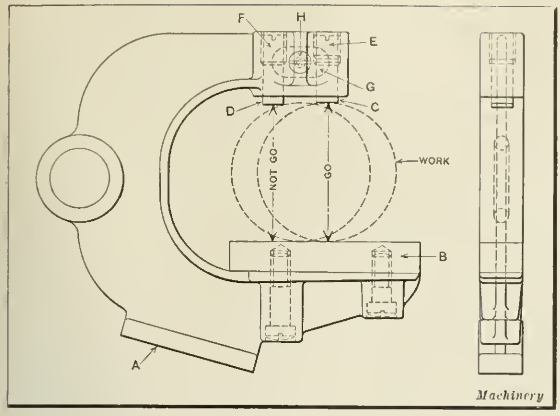


Fig. 29. Wells Bros. Co.'s Rapid Inspection Limit Snap Gage

are so arranged that they not only clamp the plugs, but also tend to force them to a seat on the adjusting screws. The body of the gage is made from an iron casting of comparatively frail dimensions, so that if it should be dropped, it is more likely to break than to be distorted. The frame is also provided with an insulated rubber grip to prevent the heat of the hand from affecting the accuracy of the gage. By holding the gage with two fingers on the insulated grip, a sensitive touch can be attained, and at the same time the gage will not be distorted by the heat from the hand.

In using double-ended limit gages of the type shown at *D*, where the "Go" end passes over the work, the gage will soon become inaccurate unless handled carefully, owing to the hammer effect on the throat of the gage when it hits the work. This causes a peening action which gradually opens the jaws. Different devices have been used for overcoming this. One, which is shown at *I*, consists in using a rubber pad fastened to the throat of the gage, as indicated. This takes the shock of impact of the gage on the work and prevents the peening action. Another method is shown at *J*, which consists of inserting a spring plunger in the throat of the "Go" end of the gage. The "Not Go" end, of course, need not be made in this manner, as it is not supposed to pass over the work.

Rapid Inspection Limit Snap Gage

A type of limit snap gage provided with an extension jaw, and which can be used either as a working or inspection gage, is shown in Fig. 29. This gage, which is patented by Wells Bros. Co., Greenfield, Mass., consists of a frame carrying a hardened, ground and lapped anvil plate and two adjustable measuring points. For snap gages having a capacity up to 1¼ inch, the frame is made from a drop-forging, while for larger sizes malleable castings are used. Cast-iron frames were tried, but it was found that they did not always break when dropped on the floor, but sometimes became distorted slightly. Consequently it was decided to make the frame from either a drop-forging or a malleable casting.

Referring to Fig. 29, it will be noticed that in the rear end of the frame is a hole which is elongated on the larger sizes to facilitate holding; there is also an extension base *A*, which can be used for holding the gage in a stand when it is desired to use it for inspection purposes. The lower jaw carries a hardened, ground and lapped anvil *B*, which is held in place by two screws as shown. This anvil greatly facilitates the location of the gage on the work, and makes rapid inspection possible. The measuring points *C* and *D* for the "Go" and "Not Go" sizes, respectively, are hardened, ground and lapped on the circumference and ends. The plugs are adjusted by screws *E* and *F*, and are clamped by a bar *G* and screw *H*.

Built-up Limit Snap Gages

In many plants, and especially in those industries where a limit gage system is used extensively, considerable use is made of the built-up type of snap gage, one form of which is shown at *K* in Fig. 28. This gage consists of three members—one center spacing block and two measuring blocks. The form in which these measuring blocks are made differs in various plants. In some cases, one of the measuring blocks is split in half and the limit provided by grinding down half the center block the required amount for the "Not Go" end. The other system which is shown at *K* consists in having the limits on one of the measuring blocks. This type of gage is comparatively cheap to manufacture, as it can be finished complete on the surface grinder and is easily built up and torn down for different sizes; it is only necessary to change the center block and the tolerance on one of the side blocks to adapt it for different sizes. A brass plate *b* is fastened under the head of the screws to carry the job number and any other necessary data. It is the practice in some plants to put the "Go" and "Not Go" dimensions on this piece, so that the operator knows what dimensions he is working to. Usually, however, this piece simply carries the job number, and is substituted by another when the gage is built up for a different size.

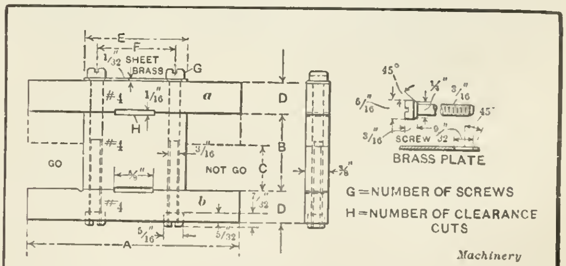
Proportions for Built-up Limit Snap Gages

Table V gives proportions for standard parts of built-up snap gages of the type shown at *K* in Fig. 28. This gage, as the table shows, is made in five sizes. The spacing blocks are made from machinery steel and vary in thickness by 1/32 inch; that is, the space between the maximum and minimum sizes *B* and *C* for each number of gage is divided into thirty-seconds of an inch. Hence, eight spacing blocks would be needed for gage No. 2. These spacing blocks are casehardened and ground and have the size stamped in the clearance cut. The top block *a* is ground perfectly parallel, while the bottom block *b* is made to provide for the manufacturing tolerance on the work and is stamped accordingly. Both these blocks are made from tool steel and hardened. When a snap gage of a certain size is desired, two blocks *a* and *b* and a spacer of the required thickness are obtained from the store-room and fastened together by screws which are standardized. A brass nameplate carrying the piece and operation numbers is put on, thus obviating the stamping of the gage proper; when worn, the gage can be taken apart, ground, lapped and put together again, and used indefinitely. The advantages of this type of snap gage for interchangeable manufacturing are obvious.

Taper Plug and Ring Gages

The measuring of taper holes is practically always a fitting proposition. In fitting taper parts, the points that receive attention are the degree of taper per foot or inch, and the relative longitudinal positions of the two parts which go together. In making a taper fit, the largest diameter of the hole and the largest diameter of the shaft must correspond within certain limits, these limits being taken lengthwise with

TABLE V. PROPORTIONS FOR BUILT-UP LIMIT SNAP GAGES



No. of Gage	Dimensions in Inches							
	A	B	C	D	E	F	G	H
1	2 1/16	1/4	0.00	1/4	1 5/8	1 1/4	2	1
2	2 3/8	1/2	1/4	5/16	1 5/8	1 1/4	2	1
3	2 5/8	3/4	1/2	3/8	1 5/8	1 1/4	2	1
4	3 3/8	1 1/4	3/4	1/2	1 5/8	1 1/4	2	1
5	5	2	1 1/4	5/8	2 1/2	1 1/16	3	2

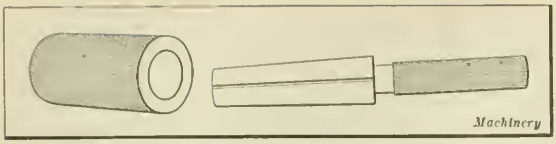


Fig. 30. Reference Taper Plug and Ring Gage

the taper. The limits of tolerance allowed on a taper fit are dependent on the degree of taper on the members, the methods used in holding the parts, and their relative positions. The limits for a taper fit are seldom less than 0.010 inch, longitudinal dimension, and vary as much as ⅛ inch on slight tapers.

Reference Taper Plug and Ring Gages

The gages used for inspecting taper shafts or holes are usually of a simple type, the test being made largely by applying Prussian blue to either the plug or the ring; especially is this necessary when testing the degree of taper. Fig. 30 shows what is known as a standard or reference taper plug and ring gage. The standard plug, as a rule, is provided with two or more shallow grooves to catch dust and dirt. The ring is also made with grooves, in some cases. When a taper plug is to be made for a standard taper, such as the Brown & Sharpe, Morse, Jarno, etc., the plug is made to the exact length specified, and the largest and smallest diameters on the plug are checked up within limits very close to those given for the different numbers of tapers. The same remarks, of course, apply to the ring. When a plug is to be made for other than what is known as the standard taper, the size of the large end and the amount of taper are the only two governing points.

Setting Limits on Taper Gages

As has been previously mentioned, the two chief points to consider in securing a taper fit between two parts is the fit of the taper and the relative longitudinal positions of the parts. In most cases the largest diameter is taken as the standard size, but there are, of course, exceptions to this rule, the locomotive standard taper of 1/16 inch to the foot being a case in point. For average machine work, however, the large end of the taper is the point worked from, and consequently is the end of the gage on which the tolerance is given.

As it is seldom necessary to have a taper finish at a shoulder on average machine work, the tolerance permitted between two parts is, as a rule, not held to very close limits. There are cases, however, when the longitudinal position of one part on another must be held to close limits, and when this is so great care should be taken in setting the limits of tolerance. Knowing that it is possible to work to limits of ± 0.001 inch on cylindrical work, we will assume that this is also possible on taper work. Knowing also the tolerance on the longitudinal distance, we can obtain the distance which governs the positions of the "Go" and "Not Go" points for the various tapers per foot from Table VI. This table forms a basis for the location of the limit points. For example, assume that the taper on a shaft and hole which must go together is ¾ inch to the foot, and that these two parts must be made on a strictly interchangeable basis in large quantities. Assume also that the relative longitudinal position of the two parts is not highly important. The question to be settled is the distance between the "Go" and "Not Go" points on the male and female gages, respectively.

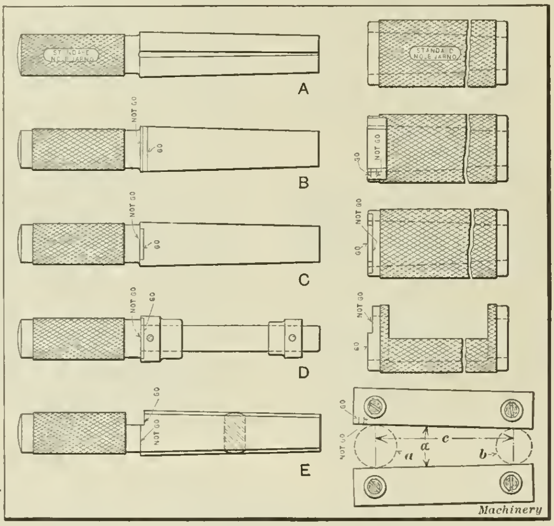


Fig. 31. Different Types of Taper Plug and Ring Gages

In order to provide as wide a limit as practicable, we will assume that the maximum tolerance on the hole and shaft, respectively, is 0.001 inch. In other words, assuming that the nominal size is 1.500, the largest hole would be 1.501 inch, and the largest diameter on the smallest shaft 1.499 inch. This gives an allowance between the diameters of the largest hole and smallest shaft of 0.002 inch. Hence it is necessary to know what longitudinal tolerance this represents in order to fix the limits on the male and female gages. Referring to Table VI, it will be noted that for a difference of 0.001 inch in diameter the length of the taper is 0.016 inch; hence for a difference of 0.002 inch in diameter the length of the taper is 0.032 inch. This amount is, therefore, the distance between the limit points on the male and female gages. When the taper is slight, say 0.250 inch to the foot, the length of the taper for a difference of 0.001 inch in diameter holds good only when the parts are put together without pressure.

Reference to Fig. 31, which shows various types of limit taper plug and ring gages, will show how the limit for longitudinal position is set. In the case shown at *B* the plug has two lines on it, the lower one of which is the "Go" and the other the "Not Go" position. The ring is cut away, as illustrated, and also has two lines on it, the lower one being the "Not Go" and the other the "Go" position. In setting the limits on the plug and ring gages, respectively, the "Go" position on the plug should correspond exactly with the "Not Go" position on the ring. In other words, when the ring is placed over the taper plug, the "Not Go" line on the ring should coincide with the "Go" line on the plug, and the "Go" line on the ring should coincide with the "Not Go" line on the plug. The distance between these two lines is the longitudinal tolerance. Of course, it is evident that the mean dimension on both the ring and the plug would be exactly the same size.

The kind of fit is governed by the amount of taper given to the part. For instance, on taper pins which will not work loose, the amount of taper varies from 1/16 to 1/4 inch to the foot. For sockets which are required to drive cutting tools, the tapers vary from 0.500 to 0.630 inch to the foot. For locomotive frame bolts, the taper is generally 1/16 inch to the foot. For arbors which carry shell reamers, etc., the taper is ⅛ inch to the foot. For general automobile work, the accepted taper is 1½ inch to

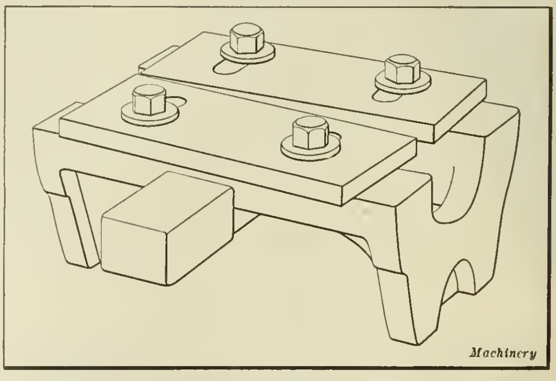
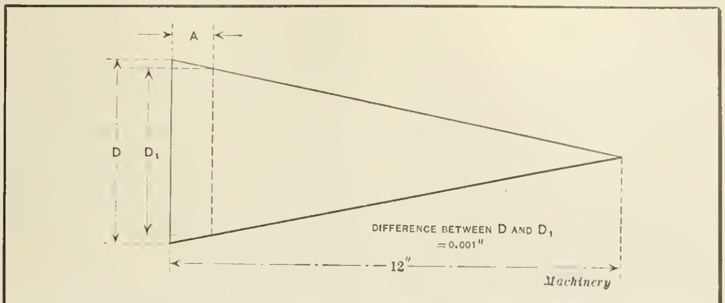


Fig. 32. Adjustable Taper Gage manufactured by Taft-Peirce Mfg. Co. incorporating Principle illustrated at E in Fig. 31

the foot. When the longitudinal movement of two parts that go together is not to be greater than 0.010 inch, a taper not less than 1½ inch to the foot is necessary, whereas if a longitudinal distance has a tolerance of 1/16 inch, a taper as small as ½ inch to the foot would be satisfactory, when the longitudinal position is the only factor that need be considered.

TABLE VI. LENGTHS OF STANDARD TAPERS CORRESPONDING TO DIFFERENCE OF 0.001 INCH IN DIAMETER



Taper per Foot	A in Inches	Taper per Foot	A in Inches
0.0625 (locomotive work)	0.1920	0.6020 (Morse s't'd.)	0.0199
0.1250 (shell reamer arbors)	0.0960	0.6210 (American s't'd.)	0.0193
0.1875	0.0640	0.6230 (Morse s't'd.)	0.0192
0.2500 (standard taper pins)	0.0480	0.6250 (Morse s't'd.)	0.0192
0.3750	0.0320	0.6260 (Morse s't'd.)	0.0191
0.5000 (Brown & Sharpe s't'd.)	0.0240	0.6300 (Morse s't'd.)	0.0190
0.5161 (Brown & Sharpe s't'd.)	0.0232	0.7500	0.0160
0.5430 (American s't'd.)	0.0229	1.0000	0.0120
0.5910 (American s't'd.)	0.0203	1.1250	0.0106
0.5920 (American s't'd.)	0.0200	1.2500	0.0096
0.6000 (Morse & Jarno s't'd.)	0.0200	1.5000 S. A. E. s't'd.	0.0080

Machinery

Types of Taper Plug and Ring Gages

The taper plug and ring gage shown at *A* in Fig. 31, as previously mentioned, is used only for reference purposes. *B* shows a type of taper plug and ring gage in which the limit is indicated by two lines. Another type of taper plug and ring gage is shown at *C*. Here instead of having the limit lines on the plug and ring, the two members are milled down as shown, the distance between the two milled cuts being the amount of tolerance on the work.

Another type of limit plug and ring gage is shown at *D*. In this case the plug consists of a handle to which two bushings are attached, which are ground to the correct taper. With this type of plug, it is a comparatively simple matter to get a correctly machined taper hole without the use of Prussian blue or other fitting pastes. The taper in the hole can be easily tested by the wabble of the plug, as it rests in the hole at two points only, instead of its entire length. A similar idea is carried out on the ring, which is cut away and relieved in the center as illustrated.

In using plug gages of the type illustrated at *B* and *C*, difficulty is sometimes experienced, especially when the taper is slight, in getting the plug stuck in the hole. One way of eliminating this is to make the plug as shown at *D*, but probably a more satisfactory way is to make it as shown at *E*. Here the plug is slabbed down on both sides, which allows free passage of the air; this will be found especially advantageous in gaging blind holes. The only disadvantage of this plug is the difficulty of lapping it accurately. At the right-hand side of the illustration at *E* is shown a method of using two straightedges for testing a taper. This type of gage is generally used on the bench, being mounted on a stand, and is especially useful for originating tapers. In connection with two hardened and ground rolls, as shown by the dotted line, these tapered straightedges can be set very accurately to any degree of taper desired and used as a standard, if a standard plug gage does not happen to be available.

Measuring Tapers Accurately

When great accuracy is required in the measurement of tapers, the type of gage shown to the right of the illustration at *E* in Fig. 31 can be employed. This gage is made on the disk principle of measurement. It will be seen that if two disks of unequal diameters are held in contact or a certain distance apart, lines drawn tangent to their peripheries will represent an angle or taper, the degree of which depends on the relative diameters of the disks and the distance they are placed apart. Referring to *E* in Fig. 31, we will assume that it is necessary to set the gage to a taper of ¾ inch to the foot, and that the disk a is 1.5 inch and b 1.25 inch. It is desired to find the distance c, or the center distance between the two disks.

Rule:—Divide the taper per foot by 24 and find the angle corresponding to the quotient in a table of tangents; then find the sine corresponding to this angle, and divide the difference between the disk diameters by twice the sine. For example, let a = taper per foot; a = diameter of large disk; b = diameter of small disk; and c = the required center distance. Then $\frac{0.75}{24} = 0.03125$, which is the tangent of 1 degree, 47.4 minutes. Sin 1 degree, 47.4 minutes = 0.03123; 1.50 — 1.25 = 0.25 inch, $\frac{0.25}{2 \times 0.03123} = 4.002$ inch = center distance c.

A practical type of taper gage which incorporates the principle illustrated at *E* in Fig. 31, is shown in Fig. 32. This gage is made up of two adjustable straightedges mounted on a cast-iron body having a convenient handle on one side by which the gage may be held or clamped when in use. The

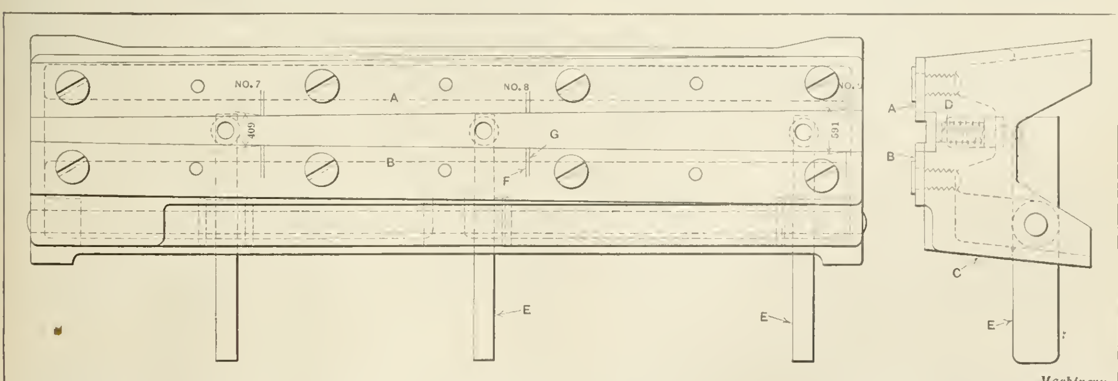


Fig. 33. Gage for testing Standard Taper Pins

straightedges are made of tool steel, hardened, ground and lapped, and are adjusted either to a standard taper gage or by means of disks, as previously mentioned.

Taper Pin Gage

A standard gage for testing taper pins is shown in Fig. 33. This gage is made so that it tests Nos. 7, 8 and 9 taper pins. It consists of two straightedges *A* and *B* fastened to a cast-iron base *C*. Located close to the largest diameter of each size of pin is a spring plunger *D* which is operated by the individual handles *E*. Lines *F* and *G* for each number indicate the minimum and maximum sizes at the large end of the pins. In being tested, the pins are slid along the slot until they bear against the sides of the straightedge. If the large end passes the limit lines, they are rejected.

This subject will be continued in the November number of MACHINERY, taking up templet gages, flush pin gages, height gages, and indicating gages of the multiple lever and dial types.

* * *

WORKING HOURS OF BULLARD MACHINE TOOL CO.

An article appeared in the June number on the Bullard "Maxi-pay" plan and twenty-four-hour, three-shift working day, which called forth an inquiry from H. Bollinckx, formerly of Brussels, Belgium, but now in Switzerland, waiting for the eviction of the German invaders to resume his engineering activities in Brussels. Mr. Bollinckx asked the following questions, which have been arranged in order with the answers kindly furnished by the Bullard Machine Tool Co.

1. At what time does each group of workmen begin work?

A.—The three shifts report at 7 A. M., 3 P. M., and 11 P. M.

2. What are the hours of rest during the eight hours of employment?

A.—Assemblers, erectors, bench hands and others are allowed fifteen minutes for lunch on two shifts only—from 10:45 to 11 on shift No. 1, reporting at 7 A. M., and from 7 to 7:15 on shift No. 2, reporting at 3 P. M. The men working under this arrangement make up eight hours by reporting fifteen minutes earlier than the machine operators, who eat their lunch between cuts. We employ machine operators only on the 11 P. M. shift. Therefore, no time out for lunch is necessary for No. 3 shift.

3. Does each group enter some time before the other quits work?

A.—Each shift reports in time to start when the other leaves.

4. Does each group or shift of workmen have its own foremen and sub-foremen?

A.—Yes; there are foremen and sub-foremen for each shift.

5. Is the pay for the night workers higher than for the day workers?

A.—No; we do not necessarily pay the night workers more than those working days.

6. Is it always the same group that works during the night?

A.—We have been working the same men at night, but the shifts should alternate.

7. How is the work handled which must be continued by a worker in the following shift?

A.—The foremen of each group report early and work overtime if necessary to explain work that must be finished by men in the following shifts.

* * *

Much attention has been given to the perfection of platinum substitutes for use in chemical work. Although several alloys are employed for certain purposes in which platinum was formerly used, it does not appear that any successful substitute has been found for platinum for the dishes and crucibles used in analytical work. These dishes must of necessity be such that they are not affected by the reagent used. Recent experiments conducted by Prof. Parr have resulted in the development of an alloy which is resistant to nitric acid. The alloy was conceived with the idea of combining elements of positive and negative electric properties in such a manner that the alloy would have a zero electric potential. The analysis of one of the alloys made during these experiments which satisfied the conditions required is as follows: Copper, 6.42; manganese, 0.98; silicon, 1.04; tungsten, 2.13; nickel, 60.65; aluminum, 1.09; iron, 0.76; chromium, 21.07; molybdenum, 4.67. Total, 98.81.—*Mineral Resources of the United States, 1915—Part I.*

CHOOSING A TRADE

BY F. B. JACOBS*

The young man whose parents can afford to send him to college with the object of fitting him for a profession is indeed fortunate. Not everyone, however, can afford to spend from \$2000 to \$10,000 in fitting their sons for life's struggle in the business world, and, on the other hand, many young men would rather not spend four years of valuable time in acquiring theory. Thus when the average boy leaves high school, he begins to think seriously of the problem of making a success of life. He joins the vast army of those who, because they do not possess capital, are required to exchange their labor, either mental or manual, for the dollars of their more fortunate brethren. Honest toil, no matter how menial, should not be disparaged, but when the boy chooses for himself, does he always choose wisely? Does he select a trade or calling that offers him chances for something better than unremitting toil year in and year out until he is thrown in the discard in old age?

Boys have their hobbies between the ages of twelve and sixteen, and these innocent pastimes often exert a powerful influence as regards their life work. As in illustration, how common it is to see a boy enthused over electricity. What a vast amount of time he spends in conducting experiments and poring over technical literature on the subject! This is all very well, as it keeps him out of mischief, but when he seriously considers becoming an electrician, why not point out to him that it is an utter impossibility to climb to the top of the ladder in this particular field without a college degree as an electrical engineer? The best he can attain is a job as a lineman at \$3.50 a day, and mighty hard work at that.

As another illustration of energy that is often misplaced, look at the number of boys infected with the wireless telegraphy bacillus. They will barter almost anything for the materials with which to equip a receiving and sending apparatus, and it can be said with due credit to many of them that they actually succeed in sending and sometimes in receiving messages with a degree of proficiency that has more than once caused the federal authorities not a little concern. While wireless telegraphy is no doubt interesting, with a fair chance for a little melodrama thrown in once in awhile, it cannot truthfully be classed among the well paid trades. The boy becomes a competent operator in time, and there he stops. To be sure, the wireless operator has a comparatively easy time, as the amount of actual labor he does is almost nil. I remember one wireless operator, a young man of twenty-one or thereabout, with whom I became acquainted on one of the boats plying between Savannah and northern points. He confided to me that his salary was low, somewhat less than \$100 a month, but he pointed with pride to the fact that he did not have to work hard. Anyone could see that, as his chief occupation seemed to be playing solitaire while he smoked an exceedingly strong cob pipe with a nonchalant air. No one can be blamed for choosing a calling whereby he earns a living with little physical exertion, but why settle on something that will never net more than \$100 a month?

Many boys who are inclined to be fastidious choose callings that enable them to wear nice clothes and keep their hands clean. Drawing soda water and measuring ribbon are all very well in themselves, but the young man who spends the best years of his life at some simple work that will never net over \$60 per month at best will bitterly regret his choice in after years. The desire to wear good clothes, which in truth is the outward appearance of prosperity, has led many a youth to accept a comparatively poorly paid position in preference to choosing a well paid trade, and only in later years, when precious opportunities are factors of the past, does he realize his mistake.

As a practical illustration of this, the following incident, which happened in a busy New England city of 20,000 inhabitants, may be of interest. The person in question, a young man of twenty-one, had just finished his apprenticeship as a stone mason. He learned the trade of his father, who had a well established business, and as the son was a skilled workman, his father had decided to take him into partnership.

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One day the young man, clad in overalls, happened to be walking down the main street of the city, where he passed a young lady with whom he was in love. They had already decided to marry, but preferred to wait until he was in a fair way to succeed in business. The next time he called on the object of his affections she told him that she could never marry a man who wore overalls, and further informed him by way of an ultimatum that he must do one of two things: seek more genteel employment or relinquish his claim on her. To make a long story short, he secured a clerkship at a moderate salary, married, raised a family in a state of what is often termed "genteel" poverty, and now in the afternoon of life his nose is still to the grindstone, so to speak; he must toil along until he dies in harness. It is needless to state that he would have shown better judgment in sticking to his trade and marrying a woman who did not object to overalls. As a contracting mason, he could easily have laid by a sufficient sum, say $15,000 to $25,000, upon which to retire. As it is, he is still sticking to his "genteel" position.

It is to be regretted that the average young man shuns well paid trades because of the actual labor involved. What is the matter with the younger generation; are they afraid to bend their backs or soil their hands? Ask the average high school boy of today how he would like to learn the molder's trade and he will look at you aghast. "Work in a dirty foundry?" he would probably reply. "I should say not." It is a common belief that the art of molding calls for a strong back and a weak head. What a fallacy! In this day of alloy steels and perfected foundry practice, there is hardly a trade that calls for more skill or actual technical knowledge, and the young man who fits himself to take charge of a modern steel foundry will eventually fill a well paid position, while his schoolmates who chose nice, clean, ordinary work will find themselves in the same class with the ex-stone mason referred to previously. I have in mind two young molders who some time ago decided to go into business for themselves. They leased a vacant building in one of the Middle Western cities and started a steel foundry. One looks after the foundry, while the other attends to the correspondence and sales end of the business. Today they are on the road to prosperity. I wonder if they would have been as successful if they had chosen to clerk in a dry goods store. Ten or fifteen years hence, when the average store clerk is complaining about the high cost of living, these men will be riding in their high-powered touring cars, and they will not have to mortgage their homes for the sake of this luxury either.

In considering trades in general it is doubtful if any offers more opportunities than the machinist's trade. This may sound like a sweeping statement, but a little thought will convince the most skeptical that my theory is well grounded. In speaking of a machinist, I do not refer to a screw machine, milling machine, grinder or lathe hand, as these men, at best, are only operators. I refer to the all-around machinist, who can prosecute machine work of all kinds from blueprints. It is to be regretted that workmen of this kind are getting scarcer as the years go by, owing chiefly to the fact that machine work is rapidly becoming specialized. Indeed, this specialization has even invaded the tool-room. In place of the all-around toolmaker of a decade ago, we have the tool planer hand, the tool milling machine hand, the tool lathe hand, the tool grinder hand, and so on. It is getting to a point where the actual toolmaker does little else than lay out and bore jigs. In that case some one is sure to inquire: "What is the use of becoming an all-around man?" It is a fact that modern shop practice has reached a point where all-around men are not needed on actual production work, but at the same time we must not overlook the fact that there will always be good opportunities for the man who understands all sides of the machinist's trade. Such a man can always find employment at experimental or repair work—two of the most interesting as well as the best paid branches of modern shop practice. Work of this kind develops initiative, because the individual is compelled to do his own thinking, and when a man has once learned the secret of thinking carefully and planning for the future, even if it is only for a few minutes or hours ahead, he has discovered the true secret of success.

As an all-around machinist, the individual finds steady employment at good wages, because the management realizes that his services are too valuable to dispense with, even in moderately dull times. In summing up evidence to substantiate the claim that the machinist's trade offers exceptional inducements to the average young man, we must not overlook the fact that it often serves as a stepping stone to better paying positions, among which might be mentioned mechanical drafting and salesmanship. Of course there is absolutely no comparison between these two callings, but I mention them because it is an undisputed fact that any number of machinists have succeeded in these two lines owing to their previous shop training. The machinist makes an excellent draftsman, provided he has a talent for drawing (and most machinists have), because he understands how various pieces can be designed so as to be produced economically. Machinist draftsmen do not design pieces that are impossible to mold, neither do they create monstrosities that are impossible to machine, because their practical experience has taught them to avoid these blunders. They succeed at drafting because they understand the practical side of the work from the ground up, whereas the purely theoretical man gropes along in the dark, to a certain extent at least. In considering the machinist as a salesman, it is understood, of course, that he should exercise his abilities in mechanical lines. One might be an excellent machinist, but this fact would not prove of any value should he try to sell shoes or clothing. Machine tools, shop accessories, small tools, or mill supplies are the lines wherein the machinist succeeds, because his practical knowledge, gained from actual experience, proves of untold value in setting forth the merits of his goods. Shop superintendents admire practical knowledge in salesmen who interview them, even if they do not always admit this to be a fact, and the man who can answer mechanical questions in an intelligent manner stands a far better show in obtaining a satisfactory hearing than the man who has acquired his knowledge, parrot like, from the sales manager, or from reading books. Actual salesmanship, or the art of influencing the purchasing agent to "come across" with an order, to use a common expression, can be developed to a high degree, but we must also consider the fact that selling methods have changed in the last fifteen years, owing to the fact that the purchasing of goods is also becoming a science in itself. The purchasing agent of today is as keen to ward off undue influence as the salesman is to exercise it; thus the time is rapidly approaching when goods will be sold strictly on their merits. Therefore it will be seen that the man who understands the practical application of mechanical principles should succeed at salesmanship, provided he has latent ability at selling and understands the goods he handles.

Thus the machinist's trade offers excellent opportunities for any young man who is compelled to work for a living. The art of working metals is one of the oldest and most interesting handicrafts known to man, and in a large manufacturing country like ours the opportunities for master workmen are practically unlimited. We are inclined to point with pride to the remarkable mechanical achievements of the last half century, yet in spite of all we have accomplished, the machine industry is yet in its infancy, and the young man who connects himself with the trade at the present time is sure to reap the harvest in later years, his success, of course, being governed by his individual application to the various problems that confront him.

* * *

The electric welding of iron and steel will be a feature exhibit of the New York Electrical Exposition that will be held in the Grand Central Palace, October 11 to 21. The exhibit is being arranged by the Arc Welding Machine Co. of New York City. All grades of welding will be done in iron and steel, including structural pieces, plates and castings. Two arcs will be in operation equipped with automatic control which prevents the metal from burning through drawing too long an arc. The length of the arc is automatically controlled so that even a comparatively unskilled worker cannot draw it beyond the point set.

SINE BAR APPLICATIONS*

DETAILS OF CONSTRUCTION AND METHODS OF OBTAINING ACCURATE ANGULAR WORK

BY DONALD BAKER†

THE method of setting up or laying out angular work of various kinds most familiar to the average mechanic is by means of some form of protractor; the accuracy of this method depends first upon the accuracy of the instrument used, and second upon the workman's ability to set it to the marked graduations. When the limits allowed upon the work are not greater than five to ten minutes, a good protractor will usually answer all purposes, but for finer work, such as the laying out or testing of accurate jigs, fixtures and gages, or the making of sheet metal templets for typewriter, adding machine parts, etc., for experimental purposes, or as masters from which to make tools and dies, an instrument known as the sine bar has come into limited use. Its use is limited, however, only because of a lack of familiarity with it by men who would find a ready application for it were they better acquainted with its convenience and adaptability. The fact that few workmen are able to use simple shop trigonometry also tends to prevent the common use of the sine bar.

This article will not deal with the principles of trigonometry, as a knowledge of it is unnecessary in using a sine bar for setting up a piece of work to a given angle. However, as a knowledge of the use of trigonometrical functions is of the utmost use to the toolmaker who wishes to advance himself, and as the process is, after all, very simple and easy to use, I cannot but recommend that all who read this article will take the few hours needed to obtain a working knowledge of the process. Tables of sines, tangents, etc., with directions for their use, may be found in any engineering handbook, and one of the best for the toolmakers' use is contained in MACHINERY'S HANDBOOK.

The sine bar in its simplest form is a plain bar of metal, having a disk of steel at each end. These disks are of equal diameter and their centers lie in a line that is parallel with the edges of the bar on which they are mounted. It is customary to clamp this bar to the face of an angle-plate as shown in Fig. 1,

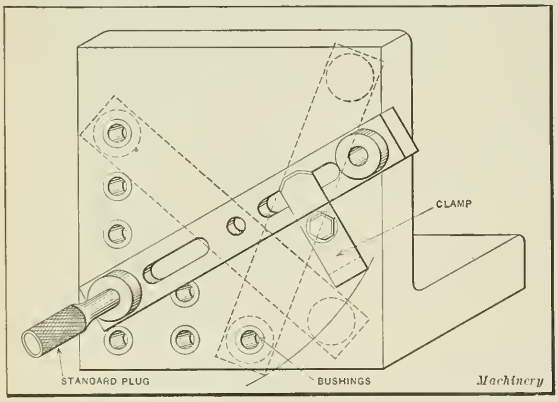

Fig. 1. Special Angle-plate with Sine Bar in Position

setting one of the steel disks above the other an amount corresponding to the sine of the angle desired, multiplied by the center distance between the disks. Let us assume that the bar shown in the illustration has the disks spaced five inches from center to center and that it is desired to set it up to an angle of 30 degrees from the horizontal. Referring to a table of sines, we find under the column 30 degrees, 0 minutes the figure 0.5000; multiplying this by 5 gives us 2.500, or 2½ inches, which is the height one disk must be set above the other. The setting is accomplished by the use of a height gage, size blocks, or other means which will give the required accuracy. When properly set, the sine bar is clamped fast to the angle-plate so that the work can be placed on top of it and likewise clamped in position. The work of laying out, drilling, grinding, or any other operation may now be carried on with the assurance that the angular setting is correct.

Construction of a Sine Bar

Fig. 2 shows a detail of a sine bar somewhat as described, but having a few improvements which have suggested themselves to the writer in his experience with this type of instrument. The body of the sine bar A can be made of tool steel, hardened, or of machine steel, pack-hardened. I prefer the latter, as there is less likelihood of changes occurring due to hardening strains which sometimes affect the accuracy of a tool steel bar after it has been made. The two steel disks B (one at each end) have their centers exactly 5 inches apart, or 10 inches apart for a larger sine bar. Other lengths may be used, but the 5-inch bar has been found the most convenient for average small tool work. The figures 5 and 10, which represent the center distances of the disks, are most convenient to use in multiplying the figures taken from a table of sines. In the case of the 10-inch bar, no multiplying is required when using the regular table of sines, as it is only necessary to point off one decimal place to the right to obtain the required figure.

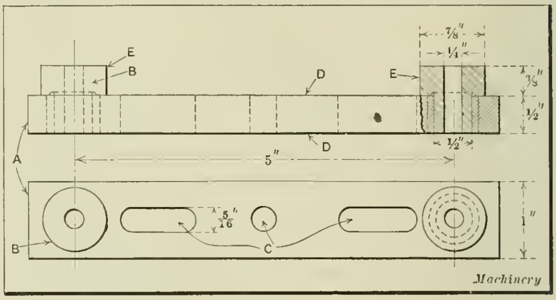

Fig. 2. Detail of Simple Sine Bar

In making a bar of this kind, a piece of steel is first planed or milled for the body A, and two 11/16-inch holes are bored through it, one at each end approximately 5 inches between centers; then the holes C are drilled, no particular pains being taken with these, as they are only clearance holes, as will be explained later. The bar is now ready to harden, after which the two end holes must be lapped out just enough to remove the hardening scale and two soft steel plugs pressed into them. The surfaces D are next ground parallel with each other on a surface grinder. After grinding, the bar is strapped to the faceplate of an engine lathe while one of the soft steel plugs is bored out to ½ inch diameter, after which a half-inch standard plug is placed in the hole and a half-inch standard jig button is fastened to the soft plug at the other end. The button is then adjusted until its center comes central with the edges of the bar and is exactly 5 inches from the standard plug, this dimension being easily determined by measuring across the outside diameters or by means of a 4½-inch space bar placed between the plug and the button. The standard plug is now removed, and the bar carrying the jig button is again taken to the engine lathe and clamped to the faceplate while the button is indicated until it runs perfectly true. It is then removed and a hole drilled and bored to half-inch diameter in the usual manner. After the bar is removed from the lathe, two half-inch standard plugs or their equivalent are placed in the two holes and the bar tested for accuracy. If there has been an error by any chance, it is an easy matter to remove one of the soft plugs and replace it with another,

* For other articles on angle measurement, see "Precision Method of Measuring Angles," October, 1914; "Disk and Square Method of Determining Angular Settings," October, 1913; and "Use of the Sine Bar for Measuring Angles," January, 1912.

† Address: 252 Eighth Ave., Long Island City, N. Y.

CONSTANTS FOR 5-INCH SINE BAR

M	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°
0	0.00000	0.08725	0.17450	0.26170	0.34880	0.43580	0.52265	0.60935	0.69585	0.78215	0.86825	0.95405	1.0395	1.1247	1.2096
1	.00145	.08870	.17595	.26315	.35025	.43725	.52410	.61080	.69730	.78360	.86965	.95545	.0410	.1261	.2110
2	.00290	.09015	.17740	.26460	.35170	.43870	.52555	.61225	.69875	.78505	.87110	.95690	.0424	.1276	.2124
3	.00435	.09160	.17885	.26605	.35315	.44015	.52700	.61370	.70020	.78650	.87255	.95835	.0438	.1290	.2138
4	.00580	.09310	.18030	.26750	.35460	.44155	.52845	.61510	.70165	.78790	.87395	.95975	.0452	.1304	.2152
5	0.00725	0.09455	0.18175	0.26895	0.35605	0.44300	0.52985	0.61655	0.70305	0.78935	0.87540	0.96120	1.0466	1.1318	1.2166
6	.00875	.09600	.18320	.27040	.35750	.44445	.53130	.61800	.70450	.79080	.87685	.96260	.0481	.1332	.2181
7	.01020	.09745	.18465	.27185	.35895	.44590	.53275	.61945	.70595	.79225	.87825	.96405	.0495	.1346	.2195
8	.01165	.09890	.18615	.27330	.36040	.44735	.53420	.62090	.70740	.79365	.87970	.96545	.0509	.1361	.2209
9	.01310	.10035	.18760	.27475	.36185	.44880	.53565	.62235	.70885	.79510	.88115	.96690	.0523	.1375	.2223
10	0.01455	0.10180	0.18905	0.27620	0.36330	0.45025	0.53710	0.62380	0.71025	0.79655	0.88255	0.96830	1.0538	1.1389	1.2237
11	.01600	.10325	.19050	.27765	.36475	.45170	.53855	.62520	.71170	.79795	.88400	.96975	.0552	.1403	.2251
12	.01745	.10470	.19195	.27910	.36620	.45315	.54000	.62665	.71315	.79940	.88540	.97115	.0566	.1417	.2265
13	.01890	.10615	.19340	.28055	.36765	.45460	.54145	.62810	.71460	.80085	.88685	.97260	.0580	.1431	.2279
14	.02035	.10760	.19485	.28200	.36910	.45605	.54290	.62955	.71600	.80230	.88830	.97405	.0594	.1446	.2293
15	0.02180	0.10905	0.19630	0.28345	0.37055	0.45750	0.54435	0.63100	0.71745	0.80370	0.88970	0.97545	1.0609	1.1460	1.2307
16	.02325	.11055	.19775	.28490	.37200	.45895	.54580	.63245	.71890	.80515	.89115	.97690	.0623	.1474	.2322
17	.02475	.11200	.19920	.28635	.37345	.46040	.54725	.63390	.72035	.80660	.89260	.97830	.0637	.1488	.2336
18	.02620	.11345	.20065	.28780	.37490	.46185	.54865	.63530	.72180	.80800	.89400	.97975	.0651	.1502	.2350
19	.02765	.11490	.20210	.28925	.37635	.46330	.55010	.63675	.72320	.80945	.89545	.98115	.0665	.1516	.2364
20	0.02910	0.11635	0.20355	0.29070	0.37780	0.46475	0.55155	0.63820	0.72465	0.81090	0.89685	0.98260	1.0680	1.1531	1.2378
21	.03055	.11780	.20500	.29220	.37925	.46620	.55300	.63965	.72610	.81230	.89830	.98400	.0694	.1545	.2392
22	.03200	.11925	.20645	.29365	.38070	.46765	.55445	.64110	.72755	.81375	.89975	.98545	.0708	.1559	.2406
23	.03345	.12070	.20795	.29510	.38215	.46910	.55590	.64255	.72900	.81520	.90115	.98685	.0722	.1573	.2420
24	.03490	.12215	.20940	.29655	.38360	.47055	.55735	.64400	.73040	.81665	.90260	.98830	.0737	.1587	.2434
25	0.03635	0.12360	0.21085	0.29800	0.38505	0.47200	0.55880	0.64540	0.73185	0.81805	0.90405	0.98970	1.0751	1.1601	1.2448
26	.03780	.12505	.21230	.29945	.38650	.47345	.56025	.64685	.73330	.81950	.90545	.99115	.0765	.1615	.2462
27	.03925	.12650	.21375	.30090	.38795	.47490	.56170	.64830	.73475	.82095	.90690	.99255	.0779	.1630	.2477
28	.04070	.12800	.21520	.30235	.38940	.47635	.56315	.64975	.73615	.82235	.90830	.99400	.0793	.1644	.2491
29	.04220	.12945	.21665	.30380	.39085	.47780	.56455	.65120	.73760	.82380	.90975	.99540	.0808	.1658	.2505
30	0.04365	0.13090	0.21810	0.30525	0.39230	0.47925	0.56600	0.65265	0.73905	0.82525	0.91120	0.99685	1.0822	1.1672	1.2519
31	.04510	.13235	.21955	.30670	.39375	.48070	.56745	.65405	.74050	.82665	.91260	.99825	.0836	.1686	.2533
32	.04655	.13380	.22100	.30815	.39520	.48210	.56890	.65550	.74190	.82810	.91405	.99970	.0850	.1700	.2547
33	.04800	.13525	.22245	.30960	.39665	.48355	.57035	.65695	.74335	.82955	.91545	1.0011	.0864	.1714	.2561
34	.04945	.13670	.22390	.31105	.39810	.48500	.57180	.65840	.74480	.83100	.91690	.0016	.0879	.1729	.2575
35	0.05090	0.13815	0.22535	0.31250	0.39955	0.48645	0.57325	0.65985	0.74625	0.83240	0.91835	1.0039	1.0893	1.1743	1.2589
36	.05235	.13960	.22680	.31395	.40100	.48790	.57470	.66130	.74770	.83385	.91975	.0054	.0907	.1757	.2603
37	.05380	.14105	.22825	.31540	.40245	.48935	.57615	.66270	.74910	.83530	.92120	.0068	.0921	.1771	.2617
38	.05525	.14250	.22970	.31685	.40390	.49080	.57760	.66415	.75055	.83670	.92260	.0082	.0935	.1785	.2631
39	.05670	.14395	.23115	.31830	.40535	.49225	.57900	.66560	.75200	.83815	.92405	.0096	.0949	.1799	.2645
40	0.05820	0.14540	0.23265	0.31975	0.40680	0.49370	0.58045	0.66705	0.75345	0.83960	0.92545	1.0110	1.0964	1.1813	1.2660
41	.05965	.14690	.23410	.32120	.40825	.49515	.58190	.66850	.75485	.84100	.92690	.0125	.0978	.1828	.2674
42	.06110	.14835	.23555	.32265	.40970	.49660	.58335	.66995	.75630	.84245	.92835	.0139	.0992	.1842	.2688
43	.06255	.14980	.23700	.32410	.41115	.49805	.58480	.67135	.75775	.84390	.92975	.0153	.1006	.1856	.2702
44	.06400	.15125	.23845	.32555	.41260	.49950	.58625	.67280	.75920	.84530	.93120	.0168	.1020	.1870	.2716
45	0.06545	0.15270	0.23990	0.32700	0.41405	0.50095	0.58770	0.67425	0.76060	0.84675	0.93260	1.0182	1.1035	1.1884	1.2730
46	.06690	.15415	.24135	.32845	.41550	.50240	.58915	.67570	.76205	.84820	.93405	.0196	.1049	.1898	.2744
47	.06835	.15560	.24280	.32990	.41695	.50385	.59060	.67715	.76350	.84960	.93550	.0210	.1063	.1912	.2758
48	.06980	.15705	.24425	.33135	.41840	.50530	.59200	.67860	.76495	.85105	.93690	.0225	.1077	.1926	.2772
49	.07125	.15850	.24570	.33280	.41985	.50675	.59345	.68000	.76635	.85250	.93835	.0239	.1091	.1941	.2786
50	0.07270	0.15995	0.24715	0.33425	0.42130	0.50820	0.59490	0.68145	0.76780	0.85390	0.93975	1.0253	1.1106	1.1955	1.2800
51	.07415	.16140	.24860	.33570	.42275	.50960	.59635	.68290	.76925	.85535	.94120	.0267	.1120	.1969	.2814
52	.07565	.16285	.25005	.33715	.42420	.51105	.59780	.68435	.77070	.85680	.94260	.0281	.1134	.1983	.2828
53	.07710	.16430	.25150	.33865	.42565	.51250	.59925	.68580	.77210	.85820	.94405	.0296	.1148	.1997	.2842
54	.07855	.16580	.25295	.34010	.42710	.51395	.60070	.68720	.77355	.85965	.94550	.0310	.1162	.2011	.2856
55	0.08000	0.16725	0.25440	0.34155	0.42855	0.51540	0.60215	0.68865	0.77500	0.86110	0.94690	1.0324	1.1176	1.2025	1.2870
56	.08145	.16870	.25585	.34300	.43000	.51685	.60355	.69010	.77645	.86250	.94835	.0338	.1191	.2039	.2884
57	.08290	.17015	.25730	.34445	.43145	.51830	.60500	.69155	.77785	.86395	.94975	.0353	.1205	.2054	.2899
58	.08435	.17160	.25875	.34590	.43290	.51975	.60645	.69300	.77930	.86540	.95120	.0367	.1219	.2068	.2913
59	.08580	.17305	.26028	.34735	.43435	.52120	.60790	.69445	.78075	.86680	.95260	.0381	.1233	.2082	.2927
60	0.08725	0.17450	0.26170	0.34880	0.43580	0.52265	0.60935	0.69585	0.78215	0.86825	0.95405	1.0395	1.1247	1.2096	1.2941

M	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°
0	1.2941	1.3782	1.4618	1.5451	1.6278	1.7101	1.7918	1.8730	1.9536	2.0337	2.1131	2.1918	2.2699	2.3473	2.4240
1	.2955	.3796	.4632	.5464	.6292	.7114	.7932	.8744	.9550	.0350	.1144	.1931	.2712	.3486	.4253
2	.2969	.3810	.4646	.5478	.6306	.7128	.7945	.8757	.9563	.0363	.1157	.1944	.2725	.3499	.4266
3	.2983	.3824	.4660	.5492	.6319	.7142	.7959	.8771	.9576	.0376	.1170	.1958	.2738	.3512	.4278
4	.2997	.3838	.4674	.5506	.6333	.7155	.7972	.8784	.9590	.0390	.1183	.1971	.2751	.3525	.4291
5	1.3011	1.3852	1.4688	1.5520	1.6347	1.7169	1.7986	1.8797	1.9603	2.0403	2.1197	2.1984	2.2764	2.3538	2.4304
6	.3025	.3865	.4702	.5534	.6361	.7183	.8000	.8811	.9617	.0416	.1210	.1997	.2777	.3550	.4317
7	.3039	.3879	.4716	.5547	.6374	.7196	.8013	.8824	.9630	.0430	.1223	.2010	.2790	.3563	.4329
8	.3053	.3893	.4730	.5561	.6388	.7210	.8027	.8838	.9643	.0443	.1236	.2023	.2803	.3576	.4342
9	.3067	.3907	.4743	.5575	.6402	.7224	.8040	.8851	.9657	.0456	.1249	.2036	.2816	.3589	.4355
10	1.3081	1.3921	1.4757	1.5589	1.6416	1.7237	1.8054	1.8865	1.9670	2.0469	2.1262	2.2049	2.2829	2.3602	2.4367
11	.3095	.3935	.4771	.5603	.6429	.7251	.8067	.8878	.9683	.0483	.1276	.2062	.2842	.3614	.4380
12	.3109	.3949	.4785	.5616	.6443	.7265	.8081	.8892	.9697	.0496	.1289	.2075	.2855	.3627	.4393
13	.3123	.3963	.4799	.5630	.6457	.7292	.8108	.8919	.9724	.0522	.1302	.2088	.2868	.3640	.4405
14	.3137	.3977	.4813	.5644	.6471	.7242	.8108	.8919	.9724	.0522	.1315	.2101	.2881	.3653	.4418
15	1.3151	1.3991	1.4827	1.5658	1.6484	1.7306	1.8122	1.8932	1.9737	2.0536	2.1328	2.2114	2.2893	2.3666	2.4431
16	.3165	.4005	.4841	.5672	.6498	.7319	.8135	.8946	.9750	.0549	.1341	.2127	.2906	.3679	.4444
17	.3179	.4019	.4855	.5686	.6512	.7333	.8149	.8959	.9764	.0562	.1354	.2140	.2919	.3691	.4456
18	.3193	.4033	.4868	.5699	.6525	.7347	.8162	.8973	.9777	.0575	.1368	.2153	.2932	.3704	.4469
19	.3207	.4047	.4882	.5713	.6539	.7360	.8176	.8986	.9790	.0589	.1381	.2166	.2945	.3717	.4482
20	1.3221	1.4061	1.4896	1.5727	1.6553	1.7374	1.8189	1.8999	1.9804	2.0602	2.1394	2.2179	2.2958	2.3730	2.4494
21	.3235	.4075	.4910	.5741	.6567	.7387	.8203	.9013	.9817	.0615	.1407	.2192	.2971	.3743	.4507
22	.3250	.4089	.4924	.5755	.6580	.7401	.8217	.9026	.9830	.0628	.1420	.2205	.2984	.3755	.4520
23	.3264	.4103	.4938	.5768	.6594	.7415	.8230	.9040	.9844	.0642	.1433	.2218	.2997	.3768	.4532
24	.3278	.4117	.4952	.5782	.6608	.7428	.8244	.9053	.9857	.0655	.1447	.2232	.3010	.3781	.4545
25	1.3292	1.4131	1.4966	1.5796	1.6622	1.7442	1.8257	1.9067	1.9870	2.0668	2.1460	2.2245	2.3023	2.3794	2.4558
26	.3306	.4145	.4980	.5810	.6635	.7456	.8271	.9080	.9884	.0681	.1473	.2258	.3036	.3807	.4570
27	.3320	.4159	.4993	.5824	.6649	.7469	.8284	.9094	.9897	.0695	.1486	.2271	.3048	.3819	.4583
28	.3334	.4173	.5007	.5837	.6663	.7483	.8298	.9107	.9911	.0708	.1499	.2284	.3061	.3832	.4596
29	.3348	.4187	.5021	.5851	.6676	.7496	.8311	.9120	.9924	.0721	.1512	.2297	.3074	.3845	.4608
30	1.3362	1.4201	1.5035	1.5865	1.6690	1.7510	1.8325	1.9134	1.9937	2.0734	2.1525	2.2310	2.3087	2.3858	2.4621
31	.3376	.4214	.5049	.5879	.6704	.7524	.8338	.9147	.9951	.0748	.1538	.2323	.3100	.3870	.4634
32	.3390	.4228	.5063	.5893	.6718	.7537	.8352	.9161	.9964	.0761	.1552	.2336	.3113	.3883	.4646
33	.3404	.4242	.5077	.5906	.6731	.7551	.8365	.9174	.9977	.0774	.1565	.2349	.3126	.3896	.4659
34	.3418	.4256	.5091	.5920	.6745	.7565	.8379	.9188	.9991	.0787	.1578	.2362	.3139	.3909	.4672
35	1.3432	1.4270	1.5104	1.5934	1.6759	1.7578	1.8392	1.9201	2.0004	2.0801	2.1591	2.2375	2.3152	2.3922	2.4684
36	.3446	.4284	.5118	.5948	.6772	.7592	.8406	.9215	.0017	.0814	.1604	.2388	.3165	.3934	.4697
37	.3460	.4298	.5132	.5961	.6786	.7605	.8419	.9228	.0031	.0827	.1617	.2401	.3177	.3947	.4709
38	.3474	.4312	.5146	.5975	.6800	.7619	.8433	.9241	.0044	.0840	.1630	.2414	.3190	.3960	.4722
39	.3488	.4326	.5160	.5989	.6813	.7633	.8447	.9255	.0057	.0853	.1643	.2427	.3203	.3973	.4735
40	1.3502	1.4340	1.5174	1.6003	1.6827	1.7646	1.8460	1.9268	2.0070	2.0867	2.1656	2.2440	2.3216	2.3985	2.4747
41	.3516	.4354	.5188	.6017	.6841	.7660	.8474	.9282	.0084	.0880	.1670	.2453	.3229	.3998	.4760
42	.3530	.4368	.5201	.6030	.6855	.7673	.8487	.9295	.0097	.0893	.1683	.2466	.3242	.4011	.4773
43	.3544	.4382	.5215	.6044	.6868	.7687	.8501	.9308	.0110	.0906	.1696	.2479	.3255	.4024	.4785
44	.3558	.4396	.5229	.6058	.6882	.7701	.8514	.9322	.0124	.0920	.1709	.2492	.3268	.4036	.4798
45	1.3572	1.4410	1.5243	1.6072	1.6896	1.7714	1.8528	1.9335	2.0137	2.0933	2.1722	2.2505	2.3280	2.4049	2.4811
46	.3586	.4423	.5257	.6085	.6909	.7728	.8541	.9349	.0150	.0946	.1735	.2518	.3293	.4062	.4823
47	.3600	.4437	.5271	.6099	.6923	.7742	.8555	.9362	.0164	.0959	.1748	.2531	.3306	.4075	.4836
48	.3614	.4451	.5285	.6113	.6937	.7755	.8568	.9376	.0177	.0972	.1761	.2544	.3319	.4087	.4848
49	.3628	.4465	.5298	.6127	.6950	.7769	.8582	.9389	.0190	.0986	.1774	.2557	.3332	.4100	.4861
50	1.3642	1.4479	1.5312	1.6141	1.6964	1.7782	1.8595	1.9402	2.0204	2.0999	2.1787	2.2570	2.3345	2.4113	2.4874
51	.3656	.4493	.5326	.6154	.6978	.7796	.8609	.9416	.0217	.1012	.1801	.2583	.3358	.4126	.4886
52	.3670	.4507	.5340	.6168	.6991	.7809	.8622	.9429	.0230	.1025	.1814	.2596	.3371	.4138	.4899
53	.3684	.4521	.5354	.6182	.7005	.7823	.8636	.9443	.0244	.1038	.1827	.2609	.3383	.4151	.4912
54	.3698	.4535	.5368	.6196	.7019	.7837	.8649	.9456	.0257	.1052	.1840	.2621	.3396	.4164	.4924
55	1.3712	1.4549	1.5381	1.6209	1.7032	1.7850	1.8663	1.9469	2.0270	2.1065	2.1853	2.2634	2.3409	2.4177	2.4937
56	.3726	.4563	.5395	.6223	.7046	.7864	.8676	.9483	.0283	.1078	.1866	.2647	.3422	.4189	.4949
57	.3740	.4577	.5409	.6237	.7060	.7877	.8690	.9496	.0297	.1091	.1879	.2660	.3435	.4202	.4962
58	.3754	.4591	.5423	.6251	.7073	.7891	.8703	.9510	.0310	.1104	.1892	.2673	.3448	.4215	.4975
59	.3768	.4604	.5437	.6264	.7087	.7905	.8717	.9523	.0323	.1117	.1905	.2686	.3460	.4228	.4987
60	1.3782	1.4618	1.5451	1.6278	1.7101	1.7918	1.8730	1.9536	2.0337	2.1131	2.1918	2.2699	2.3473	2.4240	2.5000

Machinery

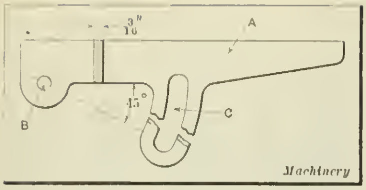

Fig. 3. Special Attachment for Use with Sine Bar shown in Fig. 2

after which the operations described can be repeated until the holes are absolutely correct.

Making the Disks

The disks used on the sine bar are made of tool steel, hardened and ground all over. These disks are made to the dimensions given in Fig. 2, roughing them out first on the lathe, allowing 0.010 inch on the outside for grinding and 0.002 inch on the inside for lapping. After the disks have been hardened, the center hole is lapped out to 0.250 inch and a short piece of drill rod is placed in the bench lathe chuck and ground until the button will just wring on by hand, in which position it can be ground on the outside with the assurance that all parts will run perfectly true with each other. In grinding the disks, about 0.0005 inch is left on the large diameter, this amount being afterward lapped off to make the button perfectly round and bring it to size. The buttons are next forced into the soft bushings at the ends of the sine bar, the bar fastened to an angle-plate with one edge up, and the buttons indicated until they are level; the bar is then ground on one edge in this position on a surface grinder. After this,

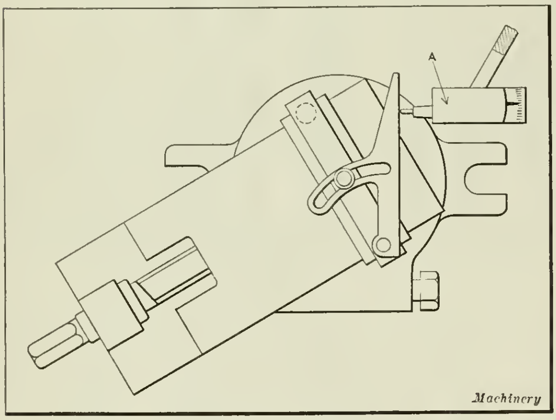

Fig. 4. Method of Setting a Milling Machine Vise by the Use of a Sine Bar

the bar is removed and the ground edge is placed down on a magnetic chuck or the bed of the grinder while the other edge is being finished. At this point it might be well to give a word of caution to the inexperienced toolmaker; it is necessary to rough out all parts that are to be hardened, then harden and rough-grind, and lay them away for a period of six months or so before the final finishing, if the most accurate work is required. Unless this is done there is always a chance that the parts may change their shape in a short time sufficiently to render them more or less inaccurate, especially if tool steel is used in the construction.

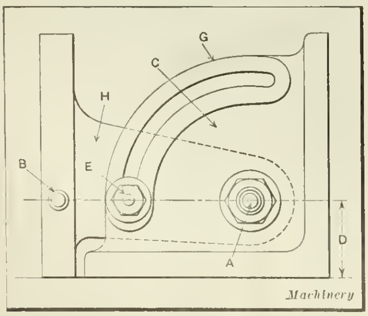

Fig. 5. Special Angular Fixture for Toolroom Use

Method of Using the Sine Bar

The attachment shown in Fig. 3 may be used in any place in which the regular bar can be used, but has the other features noted herewith. Screws may be placed through the slot and hole to clamp the attachment directly to a piece of work or to the angle-plate when it is desired to do so. In order to make settings more rapidly, I have prepared an angle-plate like that shown in Fig. 1. This plate has inserted in its face a number of hardened, ground and lapped bushings, the holes in which are fitted to a standard quarter-inch plug. In using this plate in connection with the sine bar, the bar is placed on the plate and the standard plug inserted through the button and into a bushing; then the bar is set approximately to the required angle and lightly clamped. The exact vertical height of the bushing in which the plug is placed being known, it is only necessary to make one measurement in setting the second button. The more common method without the use of the angle-plate described would be to place a height block under the lower button and adjust the second button to the correct height by means of a height or surface gage.

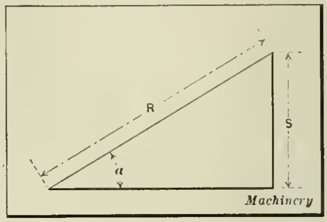

Fig. 6. Diagram showing Sine Bar Basic Principles

Another use for the sine bar having holes through the buttons is shown in Fig. 4. This is in the setting of a milling machine vise or piece of work on the milling machine table or elsewhere, where it would be inconvenient to indicate the buttons direct. This is accomplished by the use of the attachment shown in Fig. 3. This attachment is made from 3/16-inch B. & S. ground stock, machined to the form shown and hardened and ground on the edge *A*. In this strip is the quarter-inch hole *B* which is intended to fit over a stud placed in one of the holes in the sine bar button, while at *C* is an elongated slot which takes a clamping screw entering the center hole in the sine bar. In setting up the bar to a given angle, the edge *A* is placed on a surface plate and the sine bar adjusted in the regular way until the proper angle is secured, after which it is clamped into position by the screw which passes through it and the elongated slot in the plate. When setting up a vise on the milling machine, to produce a certain angle, the sine bar is held in the vise jaws as shown in Fig. 4, and the vise is swung until the blade passing by the contact point of an indicator *A* shows the vise to be set properly.

Sine Bar Principle Applied to an Angular Plate

Fig. 5 shows another application of the sine bar principle embodied in a convenient adjustable angle-plate for use in laying out, machining and inspecting angular work. Two hardened, ground and lapped bushings are placed in the position shown at *A* and *B*, the center distance between which is preferably to be in even inches, and their height from the base, when set square as shown, to be equal. In setting up a plate of this kind to a given angle, standard plugs are inserted in the two bushings and the measurement *D* ascertained with a height gage. After this, the sine of the angle, multiplied by the center distance between the two plugs, is added to the measurement *D*, and the plug in bushing *B* set accordingly, after which the setting is preserved by clamping the two halves of the angle-plate by bolts on each side of the fixtures, one of these bolts being shown at *E* in the illustration. In order to make the fixture more convenient, a table of direct-reading sines of degrees can be stamped on the surface *C*, and the arc *G* may also be graduated to degrees, while a pointer may be placed on the arm *H* for setting to approximate angles.

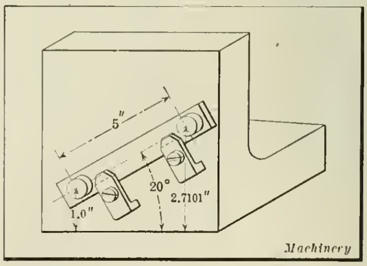

Fig. 7. Sine Bar applied to Simple Angle-plate

CONSTANTS FOR 5-INCH SINE BAR (Continued)

M	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	43°	44°
0	2.5000	2.5752	2.6496	2.7232	2.7959	2.8679	2.9389	3.0091	3.0783	3.1466	3.2139	3.2803	3.3456	3.4100	3.4733
1	.5012	.5764	.6508	.7244	.7971	.8690	.9401	.0102	.0794	.1477	.2150	.2814	.3467	.4110	.4743
2	.5025	.5777	.6520	.7256	.7984	.8702	.9413	.0114	.0806	.1488	.2161	.2825	.3478	.4121	.4754
3	.5038	.5789	.6533	.7268	.7996	.8714	.9424	.0125	.0817	.1500	.2173	.2836	.3489	.4132	.4764
4	.5050	.5802	.6545	.7280	.8008	.8726	.9436	.0137	.0829	.1511	.2184	.2847	.3499	.4142	.4774
5	2.5063	2.5814	2.6557	2.7293	2.8020	2.8738	2.9448	3.0149	3.0840	3.1522	3.2195	3.2858	3.3510	3.4153	3.4785
6	.5075	.5826	.6570	.7305	.8032	.8750	.9460	.0160	.0852	.1534	.2206	.2869	.3521	.4163	.4795
7	.5088	.5839	.6582	.7317	.8044	.8762	.9471	.0172	.0863	.1545	.2217	.2879	.3532	.4174	.4806
8	.5100	.5851	.6594	.7329	.8056	.8774	.9483	.0183	.0874	.1556	.2228	.2890	.3543	.4185	.4816
9	.5113	.5864	.6607	.7341	.8068	.8786	.9495	.0195	.0886	.1567	.2239	.2901	.3553	.4195	.4827
10	2.5126	2.5876	2.6619	2.7354	2.8080	2.8798	2.9507	3.0207	3.0897	3.1579	3.2250	3.2912	3.3564	3.4206	3.4837
11	.5138	.5889	.6631	.7366	.8092	.8809	.9518	.0218	.0909	.1590	.2262	.2923	.3575	.4217	.4848
12	.5151	.5901	.6644	.7378	.8104	.8821	.9530	.0230	.0920	.1601	.2273	.2934	.3586	.4227	.4858
13	.5163	.5914	.6656	.7390	.8116	.8833	.9542	.0241	.0932	.1612	.2284	.2945	.3597	.4238	.4868
14	.5176	.5926	.6668	.7402	.8128	.8845	.9554	.0253	.0943	.1624	.2295	.2956	.3607	.4248	.4879
15	2.5188	2.5938	2.6680	2.7414	2.8140	2.8857	2.9565	3.0264	3.0954	3.1635	3.2306	3.2967	3.3618	3.4259	3.4889
16	.5201	.5951	.6693	.7427	.8152	.8869	.9577	.0276	.0966	.1646	.2317	.2978	.3629	.4269	.4900
17	.5214	.5963	.6705	.7439	.8164	.8881	.9589	.0288	.0977	.1658	.2328	.2989	.3640	.4280	.4910
18	.5226	.5976	.6717	.7451	.8176	.8893	.9600	.0299	.0989	.1669	.2839	.3600	.3747	.4291	.4921
19	.5239	.5988	.6730	.7463	.8188	.8905	.9612	.0311	.1000	.1680	.2350	.3011	.3661	.4301	.4931
20	2.5251	2.6001	2.6742	2.7475	2.8200	2.8916	2.9624	3.0322	3.1012	3.1691	3.2361	3.3022	3.3672	3.4312	3.4941
21	.5264	.6013	.6754	.7487	.8212	.8928	.9636	.0334	.1023	.1703	.2373	.3033	.3683	.4322	.4952
22	.5276	.6025	.6767	.7499	.8224	.8940	.9647	.0345	.1034	.1714	.2384	.3044	.3693	.4333	.4962
23	.5289	.6038	.6779	.7512	.8236	.8952	.9659	.0357	.1046	.1725	.2395	.3054	.3704	.4344	.4973
24	.5301	.6050	.6791	.7524	.8248	.8964	.9671	.0369	.1057	.1736	.2406	.3065	.3715	.4354	.4983
25	2.5314	2.6063	2.6803	2.7536	2.8260	2.8976	2.9682	3.0380	3.1069	3.1748	3.2417	3.3076	3.3726	3.4365	3.4993
26	.5327	.6075	.6816	.7548	.8272	.8988	.9694	.0392	.1080	.1759	.2428	.3087	.3736	.4375	.5004
27	.5339	.6087	.6828	.7560	.8284	.8999	.9706	.0403	.1091	.1770	.2439	.3098	.3747	.4386	.5014
28	.5352	.6100	.6840	.7572	.8296	.9011	.9718	.0415	.1103	.1781	.2450	.3109	.3758	.4396	.5024
29	.5364	.6112	.6852	.7584	.8308	.9023	.9729	.0426	.1114	.1792	.2461	.3120	.3769	.4407	.5035
30	2.5377	2.6125	2.6865	2.7597	2.8320	2.9035	2.9741	3.0438	3.1125	3.1804	3.2472	3.3131	3.3779	3.4417	3.5045
31	.5389	.6137	.6877	.7609	.8332	.9047	.9753	.0449	.1137	.1815	.2483	.3142	.3790	.4428	.5056
32	.5402	.6149	.6889	.7621	.8344	.9059	.9764	.0461	.1148	.1826	.2494	.3253	.3801	.4439	.5066
33	.5414	.6162	.6902	.7633	.8356	.9070	.9776	.0472	.1160	.1837	.2505	.3163	.3811	.4449	.5076
34	.5427	.6174	.6914	.7645	.8368	.9082	.9788	.0484	.1171	.1849	.2516	.3174	.3822	.4460	.5087
35	2.5439	2.6187	2.6926	2.7657	2.8380	2.9094	2.9799	3.0495	3.1182	3.1860	3.2527	3.3185	3.3833	3.4470	3.5097
36	.5452	.6199	.6938	.7669	.8392	.9106	.9811	.0507	.1194	.1871	.2538	.3196	.3844	.4481	.5107
37	.5464	.6211	.6951	.7681	.8404	.9118	.9823	.0519	.1205	.1882	.2550	.3207	.3854	.4491	.5118
38	.5477	.6224	.6963	.7694	.8416	.9130	.9834	.0530	.1216	.1893	.2561	.3218	.3865	.4502	.5128
39	.5489	.6236	.6975	.7706	.8428	.9141	.9846	.0542	.1228	.1905	.2572	.3229	.3876	.4512	.5138
40	2.5502	2.6249	2.6987	2.7718	2.8440	2.9153	2.9858	3.0553	3.1239	3.1916	3.2583	3.3240	3.3886	3.4523	3.5149
41	.5514	.6261	.7000	.7730	.8452	.9165	.9869	.0565	.1251	.1927	.2594	.3250	.3897	.4533	.5159
42	.5527	.6273	.7012	.7742	.8464	.9177	.9881	.0576	.1262	.1938	.2605	.3261	.3908	.4544	.5169
43	.5539	.6286	.7024	.7754	.8476	.9189	.9893	.0588	.1273	.1949	.2616	.3272	.3918	.4554	.5180
44	.5552	.6298	.7036	.7766	.8488	.9200	.9904	.0599	.1285	.1961	.2627	.3283	.3929	.4565	.5190
45	2.5564	2.6310	2.7048	2.7778	2.8500	2.9212	2.9916	3.0611	3.1296	3.1972	3.2638	3.3294	3.3940	3.4575	3.5200
46	.5577	.6323	.7061	.7790	.8512	.9224	.9928	.0622	.1307	.1983	.2649	.3305	.3950	.4586	.5211
47	.5589	.6335	.7073	.7802	.8523	.9236	.9939	.0634	.1319	.1994	.2660	.3316	.3961	.4596	.5221
48	.5602	.6348	.7085	.7815	.8535	.9248	.9951	.0645	.1330	.2005	.2671	.3326	.3972	.4607	.5231
49	.5614	.6360	.7097	.7827	.8547	.9259	.9963	.0657	.1341	.2016	.2682	.3337	.3982	.4617	.5242
50	2.5627	2.6372	2.7110	2.7839	2.8559	2.9271	2.9974	3.0668	3.1353	3.2028	3.2693	3.3348	3.3993	3.4628	3.5252
51	.5639	.6385	.7122	.7851	.8571	.9283	.9986	.0680	.1364	.2039	.2704	.3359	.4004	.4638	.5262
52	.5652	.6397	.7134	.7863	.8583	.9295	.9997	.0691	.1375	.2050	.2715	.3370	.4014	.4649	.5273
53	.5664	.6409	.7146	.7875	.8595	.9307	3.0009	.0703	.1387	.2061	.2726	.3381	.4025	.4659	.5283
54	.5677	.6422	.7158	.7887	.8607	.9318	.0021	.0714	.1398	.2072	.2737	.3391	.4036	.4670	.5293
55	2.5689	2.6434	2.7171	2.7899	2.8619	2.9330	3.0032	3.0725	3.1409	3.2083	3.2748	3.3402	3.4046	3.4680	3.5304
56	.5702	.6446	.7183	.7911	.8631	.9342	.0044	.0737	.1421	.2095	.2859	.3413	.4057	.4691	.5314
57	.5714	.6459	.7195	.7923	.8643	.9354	.0056	.0748	.1432	.2106	.2770	.3424	.4068	.4701	.5324
58	.5727	.6471	.7207	.7935	.8655	.9365	.0067	.0760	.1443	.2117	.2781	.3435	.4078	.4712	.5335
59	.5739	.6483	.7220	.7947	.8667	.9377	.0079	.0771	.1454	.2128	.2792	.3445	.4089	.4722	.5345
60	2.5752	2.6496	2.7232	2.7959	2.8679	2.9389	3.0091	3.0783	3.1466	3.2139	3.2803	3.3456	3.4100	3.4733	3.5355

M	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°
0	3.5355	3.5967	3.6567	3.7157	3.7735	3.8302	3.8857	3.9400	3.9932	4.0451	4.0957	4.1452	4.1933	4.2402	4.2858
1	.5365	.5977	.6577	.7167	.7745	.8311	.8866	.9409	.9940	.0459	.0966	.1460	.1941	.2410	.2866
2	.5376	.5987	.6587	.7176	.7754	.8321	.8875	.9418	.9949	.0468	.0974	.1468	.1949	.2418	.2873
3	.5386	.5997	.6597	.7186	.7764	.8330	.8884	.9427	.9958	.0476	.0982	.1476	.1957	.2425	.2881
4	.5396	.6007	.6607	.7196	.7773	.8339	.8894	.9436	.9967	.0485	.0991	.1484	.1965	.2433	.2888
5	3.5406	3.6017	3.6617	3.7206	3.7783	3.8349	3.8903	3.9445	3.9975	4.0493	4.0999	4.1492	4.1973	4.2441	4.2896
6	.5417	.6027	.6627	.7215	.7792	.8358	.8912	.9454	.9984	.0502	.1007	.1500	.1981	.2448	.2903
7	.5427	.6037	.6637	.7225	.7802	.8367	.8921	.9463	.9993	.0510	.1016	.1508	.1989	.2456	.2910
8	.5437	.6047	.6647	.7235	.7811	.8377	.8930	.9472	4.0001	.0519	.1024	.1517	.1997	.2464	.2918
9	.5448	.6058	.6657	.7244	.7821	.8386	.8939	.9481	.0010	.0527	.1032	.1525	.2004	.2471	.2925
10	3.5458	3.6068	3.6666	3.7254	3.7830	3.8395	3.8948	3.9490	4.0019	4.0536	4.1041	4.1533	4.2012	4.2479	4.2933
11	.5468	.6078	.6676	.7264	.7840	.8405	.8958	.9499	.0028	.0544	.1049	.1541	.2020	.2487	.2940
12	.5478	.6088	.6686	.7274	.7850	.8414	.8967	.9508	.0036	.0553	.1057	.1549	.2028	.2494	.2948
13	.5489	.6098	.6696	.7283	.7859	.8423	.8976	.9516	.0045	.0561	.1066	.1557	.2036	.2502	.2955
14	.5499	.6108	.6706	.7293	.7869	.8433	.8985	.9525	.0054	.0570	.1074	.1565	.2044	.2510	.2963
15	3.5509	3.6118	3.6716	3.7303	3.7878	3.8442	3.8994	3.9534	4.0062	4.0578	4.1082	4.1573	4.2052	4.2517	4.2970
16	.5519	.6128	.6726	.7312	.7887	.8451	.9003	.9543	.0071	.0587	.1090	.1581	.2060	.2525	.2978
17	.5529	.6138	.6736	.7322	.7897	.8460	.9012	.9552	.0080	.0595	.1099	.1589	.2067	.2533	.2985
18	.5540	.6148	.6745	.7332	.7906	.8470	.9021	.9561	.0089	.0604	.1107	.1597	.2075	.2540	.2992
19	.5550	.6158	.6755	.7341	.7916	.8479	.9030	.9570	.0097	.0612	.1115	.1606	.2083	.2548	.3000
20	3.5560	3.6168	3.6765	3.7351	3.7925	3.8488	3.9039	3.9579	4.0106	4.0621	4.1124	4.1614	4.2091	4.2556	4.3007
21	.5570	.6178	.6775	.7361	.7935	.8498	.9049	.9588	.0115	.0629	.1132	.1622	.2099	.2563	.3015
22	.5581	.6188	.6785	.7370	.7944	.8507	.9058	.9596	.0123	.0638	.1140	.1630	.2107	.2571	.3022
23	.5591	.6198	.6795	.7380	.7954	.8516	.9067	.9605	.0132	.0646	.1148	.1638	.2115	.2578	.3029
24	.5601	.6208	.6805	.7390	.7963	.8525	.9076	.9614	.0141	.0655	.1157	.1646	.2122	.2586	.3037
25	3.5611	3.6218	3.6814	3.7399	3.7973	3.8535	3.9085	3.9623	4.0149	4.0663	4.1165	4.1654	4.2130	4.2594	4.3044
26	.5621	.6228	.6824	.7409	.7982	.8544	.9094	.9632	.0158	.0672	.1173	.1662	.2138	.2601	.3052
27	.5632	.6238	.6834	.7419	.7992	.8553	.9103	.9641	.0167	.0680	.1181	.1670	.2146	.2609	.3059
28	.5642	.6248	.6844	.7428	.8001	.8562	.9112	.9650	.0175	.0689	.1190	.1678	.2154	.2617	.3066
29	.5652	.6258	.6854	.7438	.8011	.8572	.9121	.9659	.0184	.0697	.1198	.1686	.2162	.2624	.3074
30	3.5662	3.6268	3.6864	3.7448	3.8020	3.8581	3.9130	3.9667	4.0193	4.0706	4.1206	4.1694	4.2169	4.2632	4.3081
31	.5672	.6278	.6873	.7457	.8029	.8590	.9139	.9676	.0201	.0714	.1214	.1702	.2177	.2639	.3089
32	.5683	.6288	.6883	.7467	.8039	.8599	.9148	.9685	.0210	.0722	.1223	.1710	.2185	.2647	.3096
33	.5693	.6298	.6893	.7476	.8048	.8609	.9157	.9694	.0219	.0731	.1231	.1718	.2193	.2655	.3103
34	.5703	.6308	.6903	.7486	.8058	.8618	.9166	.9703	.0227	.0739	.1239	.1726	.2201	.2662	.3111
35	3.5713	3.6318	3.6913	3.7496	3.8067	3.8627	3.9175	3.9712	4.0236	4.0748	4.1247	4.1734	4.2208	4.2670	4.3118
36	.5723	.6328	.6923	.7505	.8077	.8636	.9184	.9720	.0244	.0756	.1255	.1742	.2216	.2677	.3125
37	.5734	.6338	.6932	.7515	.8086	.8646	.9193	.9729	.0253	.0765	.1264	.1750	.2224	.2685	.3133
38	.5744	.6348	.6942	.7525	.8096	.8655	.9202	.9738	.0262	.0773	.1272	.1758	.2232	.2692	.3140
39	.5754	.6358	.6952	.7534	.8105	.8664	.9212	.9747	.0270	.0781	.1280	.1766	.2240	.2700	.3147
40	3.5764	3.6368	3.6962	3.7544	3.8114	3.8673	3.9221	3.9756	4.0279	4.0790	4.1288	4.1774	4.2247	4.2708	4.3155
41	.5774	.6378	.6972	.7553	.8124	.8683	.9230	.9765	.0288	.0798	.1296	.1782	.2255	.2715	.3162
42	.5784	.6388	.6981	.7563	.8133	.8692	.9239	.9773	.0296	.0807	.1305	.1790	.2263	.2723	.3170
43	.5795	.6398	.6991	.7573	.8143	.8701	.9248	.9782	.0305	.0815	.1313	.1798	.2271	.2730	.3177
44	.5805	.6408	.7001	.7582	.8152	.8710	.9257	.9791	.0313	.0823	.1321	.1806	.2278	.2738	.3184
45	3.5815	3.6418	3.7011	3.7592	3.8161	3.8719	3.9266	3.8900	4.0322	4.0832	4.1329	4.1814	4.2286	4.2745	4.3192
46	.5825	.6428	.7020	.7601	.8171	.8729	.9275	.9809	.0331	.0840	.1337	.1822	.2294	.2753	.3199
47	.5835	.6438	.7030	.7611	.8180	.8738	.9284	.9817	.0339	.0849	.1346	.1830	.2302	.2760	.3206
48	.5845	.6448	.7040	.7620	.8190	.8747	.9293	.9826	.0348	.0857	.1354	.1838	.2309	.2768	.3213
49	.5855	.6458	.7050	.7630	.8199	.8756	.9302	.9835	.0356	.0865	.1362	.1846	.2317	.2775	.3221
50	3.5866	3.6468	3.7060	3.7640	3.8208	3.8765	3.9311	3.9844	4.0365	4.0874	4.1370	4.1854	4.2325	4.2783	4.3228
51	.5876	.6478	.7069	.7649	.8218	.8775	.9320	.9853	.0374	.0882	.1378	.1862	.2333	.2791	.3235
52	.5886	.6488	.7079	.7659	.8227	.8784	.9329	.9861	.0382	.0891	.1386	.1870	.2340	.2798	.3243
53	.5896	.6498	.7089	.7668	.8236	.8793	.9338	.9870	.0391	.0899	.1395	.1878	.2348	.2806	.3250
54	.5906	.6508	.7099	.7678	.8246	.8802	.9347	.9879	.0399	.0907	.1403	.1886	.2356	.2813	.3257
55	3.5916	3.6518	3.7108	3.7687	3.8255	3.8811	3.9355	3.9899	4.0408	4.0916	4.1411	4.1894	4.2364	4.2821	4.3265
56	.5926	.6528	.7118	.7697	.8265	.8820	.9364	.9896	.0416	.0924	.1419	.1902	.2371	.2828	.3272
57	.5936	.6538	.7128	.7707	.8274	.8830	.9373	.9905	.0425	.0932	.1427	.1909	.2379	.2836	.3279
58	.5947	.6548	.7138	.7716	.8283	.8839	.9382	.9914	.0433	.0941	.1435	.1917	.2387	.2843	.3286
59	.5957	.6558	.7147	.7726	.8293	.8848	.9391	.9923	.0442	.0949	.1443	.1925	.2394	.2851	.3294
60	3.5967	3.6567	3.7157	3.7735	3.8302	3.8857	3.9400	3.9932	4.0451	4.0957	4.1452	4.1933	4.2402	4.2858	4.3301

Machinery

Tables for Sine Bar Setting

The accompanying tables are useful for obtaining the correct setting of a 5- or 10-inch sine bar to produce a given angle. The method of using the tables is as follows: first, find the angle desired in the top row of figures and then look up the minutes in the left-hand column; the desired reading will be found at the intersection of the two columns. When used for a 5-inch sine bar, the figures may be read direct; if used for a 10-inch bar, the readings must be multiplied by 2 to give the correct figure.

Example:—Referring to Figs. 6 and 7, let a in Fig. 6 represent the angle of 20 degrees, R the radius of 5 inches or the distance between the centers of the buttons on the sine bar, and S the vertical height to set the center of one button above the other in order to get the desired angle. To find the height S look under the column headed "20 degrees" opposite 0 minutes and obtain the figure 1.7101, which gives dimension S. Fig. 7 shows a sine bar strapped to an angle-plate and set as above, 1 inch being added to the measurement 1.7101, as the lower button is 1 inch above the lower edge of the plate as shown by the dimensions given.

Many other applications may be made of the principles explained in this article, and the tables will be found useful in obtaining settings without resorting to the use of trigonometry.

* * *

MAKING PHANTOM VIEWS OF MACHINERY PHOTOGRAPHICALLY

One of the most effective ways of illustrating the construction of a machine is to show it in so-called phantom views, that is, with the frame or containing box outlined while the interior works are in natural tones. The copy for such illustrations is generally worked up by an artist, using the working drawings. The process is slow, tedious and costly, and for these reasons is seldom resorted to by machinery builders for the purpose of illustrating the construction and operation of their machines.

Although not much employed, there is a simple and effective photographic process for making phantom views which is quite feasible to use for small machines. The principle is simple. The machine or apparatus to be shown in phantom view is set up on a surface plate completely assembled. The heights of centers of shafts and other parts are taken with surface gages, and horizontal distances are measured from an angle-plate, so that when the frame or box containing the mechanism is removed, the latter can be replaced in exactly the same position as before.

A photograph is made of the assembled mechanism, or rather an exposure is made on the negative of about one-third the time required to make the complete exposure. The lens

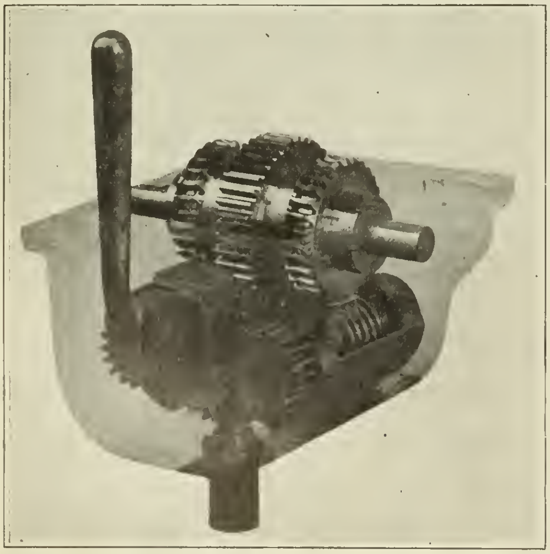

Fig. 1. Feed-box presented in Phantom View to show Construction

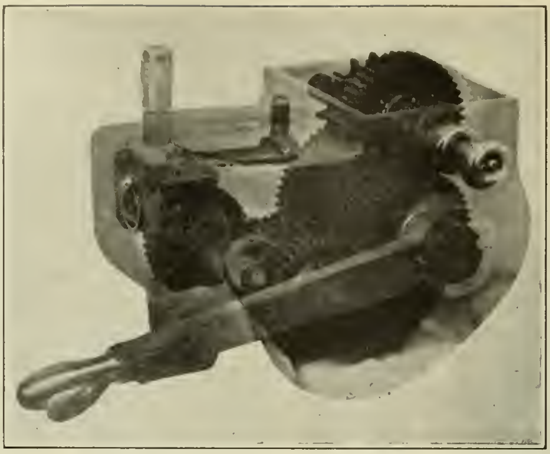

Fig. 2. Selective Type Sliding Gear Box photographed in Two Exposures to show Internal Construction

of the camera is closed and the machine is disassembled. The mechanism is then relocated on the surface plate by means of the surface gages and measurements from the angle-plate, so that it occupies exactly the same position with reference to the surface plate, angle-plate, and exposure on the negative as before. Then a second exposure is made with a full exposure, so that the interior mechanism is clearly shown in natural tones.

When the resulting negative is developed and printed, a print will be secured in which the frame or containing case faintly appears while the internal mechanism is clearly defined. It is evident that the method may be employed by anyone familiar with interior photography, who has some mechanical skill and the necessary means for setting up the machine and relocating the internal parts.

The accompanying illustrations, Figs. 1 and 2, show samples of phantom views kindly furnished for the purpose of illustrating this article by the Valley City Machine Works, Grand Rapids, Mich. Fig. 1 shows the case and interior of the single-lever feed control of a plain manufacturing milling machine, while Fig. 2 shows a selective type sliding gear feed change box. Both these views were reproduced without retouching, and hence show the exact photographic results obtained by the process described. It will be observed in Fig. 2 that the knob and gear at the upper right-hand portion of the view shows twice. This was due to the fact that in making a second exposure, the gear rolled over a short distance out of position before the exposure was fully completed. This serves to illustrate the effect obtained by double and triple exposures. This method of making phantom views is well known to machinery photographers in general, but is not as well known among the builders of machinery and those who have to make illustrated catalogues as it should be. It may be used profitably oftentimes to make difficult mechanical constructions clear, and wonderfully good results may be secured at a minimum cost.

* * *

SECOND QUEBEC BRIDGE DISASTER

The engineering world was startled in August, 1907, when the great cantilever bridge building to span the St. Lawrence River at Quebec fell, carrying upward of seventy men to their death. This disaster made engineers question the formulas for calculating the compressive strength of steel columns, and the result was the construction of a great testing machine at Pittsburg capable of imposing a load of 1,000,000 pounds and structurally fitted to test the compressive strength of full size columns. A few years later a second bridge was started by the Dominion government, of heavier design, which was to cost $17,000,000. The bridge was nearly completed, and on September 11 the 5000-ton center span was being hoisted in place when it fell into the river, killing eleven men. The cause of this latest disaster was due to a failure of one of the corner supports, which threw twisting and eccentric stresses on the members, causing rupture and total collapse.

LAPPING ARBOR CENTERS

The following on lapping arbor centers was prepared for a subscriber who wrote as follows:

> We have had considerable trouble lapping the centers of arbors, and would like to get any data available on an easier or quicker method of accomplishing this work.

There are two types of centers used in arbors. One is the straight vee or 60-degree angle and the other the rounded form which gives a line bearing. Of these, the rounded form shown at *B* in Fig. 1 is preferred by some small tool manufacturers. The reason that this type of center meets with favor is that an arbor provided with such centers can be used for either taper or straight turning with satisfactory results; furthermore, it will retain its accuracy for a greater length of time, as only a line contact is secured and it is not so easy for dirt to accumulate as in the straight 60-degree center.

There are various methods of lapping centers, the one used being governed to a certain extent by the type of center provided in the arbor. A few methods of lapping are shown in Figs. 2 and 3. The first method, shown in Fig. 2, illustrates how the lapping can be done in an ordinary speed lathe. The arbor to be lapped is held on the center, driven by a dog from the faceplate, and is supported on the outer end by means of a steadyrest. The lap is then held in the tailstock center of the lathe and is moved back and forth by hand, so as to prevent it from cutting grooves in the center. The lap should be made either from box-wood loaded with emery dust, or from copper charged with diamond dust. Unless the center has been carefully formed before hardening, and the hardening has been done in such a way as to prevent the center from distorting to any extent, this method of lapping is not entirely satisfactory.

Another method of lapping is illustrated in Fig. 3. Here the work is done in a sensitive drilling machine, by holding the arbor in a special fixture in an upright position and the lap in the chuck on the spindle. The spindle is then given an up and down movement to prevent cutting grooves in the center; it is advisable to cut grooves in the lap extending toward the point to assist the lapping compound in spreading along the surface of the lap. Cutting helical grooves in the lap also increases the rapidity with which the work is accomplished.

A still better method of lapping is to use a single-spindle valve grinder in which a much more satisfactory oscillating movement of the lap can be obtained. A drill press, however, could be fitted up with a device for accomplishing the same purpose. By securing an oscillating movement of the lap it will be found that the work is accomplished much more rapidly than when the lap is withdrawn and inserted into the center without any oscillating movement, and in addition there is less danger of scoring the center.

As has been previously mentioned, lapping of a center under the most favorable conditions is a tedious operation, and a highly satisfactory job cannot be obtained if the center is at all rough or distorted during the heat-treating operation. It will be found to be much more satisfactory to grind the centers. Considering first that the center is of the 60-degree type with a straight surface, there are two methods of grinding. That shown at *A* in Fig. 4 is to use a pencil wheel similar to that used for grinding gear-cutting hobs, and taper it down on the end to an angle of 60 degrees. This wheel should be rotated at a speed of not less than 10,000 R. P. M. In fact, the higher the speed the better the results. For this work, therefore, a No. 2 universal cutter and tool grinding machine provided with an internal grinding attachment could be fitted up. One end of the arbor could be supported and held on the driving center and the other end supported by a steadyrest, the pencil wheel being held in the place of the regular internal grinding wheel by making a special spindle for holding it. A pencil wheel of about 80 to 120 grain, grade O or P, should be used. Of course, the grade and grain of wheel will be governed largely by the condition of the center. If the center has been nicely finished before hardening, a very fine, hard wheel could be used and good results obtained, whereas if the center is rough and considerable material is to be removed in grinding, such a wheel would not give as satisfactory results.

Still another method of grinding an angular center would be to generate the center bearing as shown at *B* in Fig. 4. This also could be done on the same type of machine by simply setting the wheel slide at the required angle. This method of grinding will give much better results than that first mentioned. The center will be generated and can be made exactly to a 60-degree angle; in addition, a smoother surface will be obtained.

As has been previously stated, the straight center does not give as satisfactory results as one which is rounded off, and for grinding this center the pencil wheel could be formed by a radius diamond truing device and then brought in on the work the same as in grinding a 60-degree center.

The length of time required for lapping or grinding a center depends, of course, to a considerable extent on the method used and the finish required. Lapping a center in a speed lathe is a slow and tedious operation; lapping in a drill press with an up and down movement is a little faster; whereas lapping in a valve grinder is faster still. To lap a center correctly would require anywhere from fifteen minutes to a half hour, depending on the method used; whereas in grinding a center by the methods previously described the time could easily be cut to half or probably less. To grind two centers in an arbor by the generating process would require approximately ten minutes. To grind a rounded center with a form wheel would probably take about the same time, and if a satisfactory wheel were used it would not be necessary to true the wheel up after grinding each center. This method of forming wheels to definite shapes for grinding is being used more and more, and the grinding of tooth shapes of gears and hobs is a good example of the possibilities of form-wheel grinding.

Improvements are constantly being made, however, in the

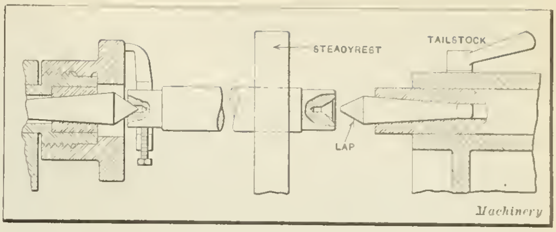

Fig. 2. Method of lapping Arbor Centers in a Speed Lathe

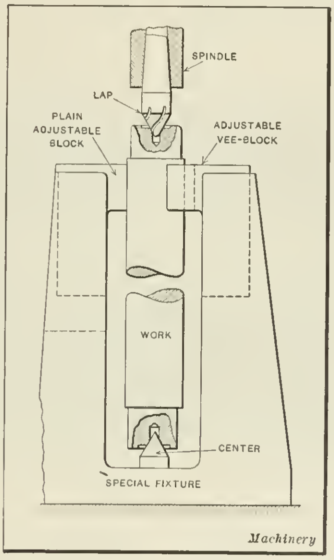

Fig. 3. Method of lapping Arbor Centers in a Drill Press

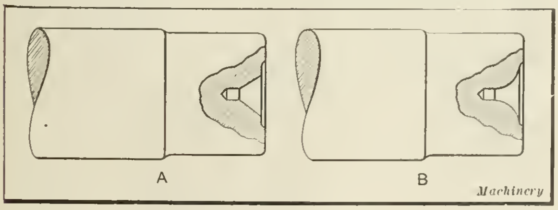

Fig. 1. Two Types of Centers for Arbors

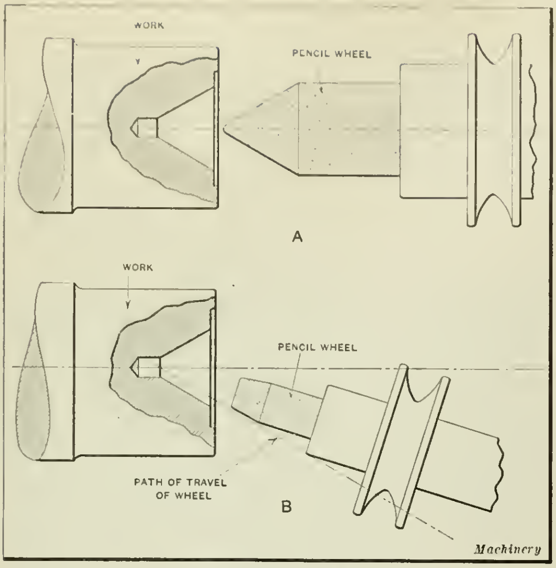

Fig. 4. (A) Form-grinding an Arbor Center; (B) Grinding an Arbor Center by the Generating Process

binders and methods of manufacture of grinding wheels, which tend to make possible the use of formed wheels for grinding shapes that heretofore could not be accurately finished after hardening with dispatch. D. T. H.

* * *

FORM GRINDING

It is not necessary that the face of the grinding wheel always be straight, as it is possible by the use of special truing fixtures and devices to shape the face of the wheel in a manner which makes it possible to grind forms in various kinds of work.

In form grinding, as in form milling, it is essential that the shape be continuous and uniform. It is impossible, of course, to grind under-cuts or varying shapes in a given form. Not every shape can be ground, any more than can every round piece of work be finished by the grinding process. Sharp corners should be avoided, not because of the inability of the truing device to shape a sharp corner, but rather because the small particles of grain and bond of the wheel which go to form the corner will not stand up and grind long enough to maintain such a shape. This follows because there is so much work required of so few particles of wheel that naturally they wear out and break away very quickly.

Still another factor, which must be considered in form grinding, is the varying depth of wheel face of the shape being ground. The wheel acts differently, of course, all along the form, depending on the distance that the cutting particles are from the center of the wheel, since irregular shapes in the face of the wheel cause the wheel to vary in diameter all along the width of the form, and if this variation in these diameters amounts to enough to vary the peripheral speed of the wheel materially at various points in the form, the wheel acts differently, and a uniform finish or rate of production cannot be maintained.

So that really the limitation in form grinding is governed by three things: The capacity of the attachment in producing varying shapes, the physical possibility of the grinding wheel to maintain a given form, and the depth of the hills and valleys in the face of the wheel, caused by the form, which affect the peripheral speed of the cutting particles.

The wheel must be trued frequently on form grinding to maintain the shape, especially where there are abrupt changes in the contour, such as sharp corners, small radii or deep cuts. Long sweeping curves or shapes which blend well into each other maintain their form more uniformly and for a greater length of time than do the more irregular shapes with sharp corners and angles. There are probably a great many machining operations now performed by other processes which could be readily accomplished by form grinding, effecting a saving in cost and producing a more accurate job with a finer degree of finish. The use of the grinding machine for this class of work is increasing as people come to realize the possibilities in shaping work which requires accuracy and good finish.

Flat work ground on a surface grinding machine can be formed just as well as round work on a cylindrical grinding machine. The only difference in these two methods of grinding is in the manner of handling the work. On the surface grinding machine the work is moved under the wheel on a reciprocating table; on the cylindrical grinding machine the table cannot be moved, and the wheel with the shape formed in it must be fed straight into the work.

One illustration of the usefulness of the formed wheel in producing shaped parts is in the crowning of pulleys. The crown can be made accurate within 0.001 inch on either diameter at the edges of the pulley, and the height of the crown can be much less than were it turned. The amount of power which can be transmitted through a belt running on pulleys crowned by a form grinding wheel is greater than can be transmitted by crowned pulleys formed by ordinary turning. Greater accuracy, the lesser height of the crown, and the fact that the face of the pulley has a uniform curve, cause the belt to adhere closely at every point along the face of the pulley.—*Howard W. Dunbar in Grits and Grinds.*

* * *

SHORT TIME FOR MACHINERY

The South Carolina Cotton Manufacturers' Association recently resolved to comply with the attorney general's construction of the law to the effect that the legal hours of labor in that state apply to machines. The opinion applied specifically to automatic cotton looms, which it has been the custom to allow to run during the lunch hour. Such slight attendance as the machinery needed was given by arrangements allowing the lunch hour at another time for the few employes who were needed for that purpose, their hours not being extended by the duty. According to the plain intent of the opinion, there must be the same hours for machines as for wage earners in South Carolina. A machine can work but 60 hours, and two men cannot be given the work of attending the same machine for 120 hours. There is a plain waste of capital needed for the larger number of machines, and there is a loss of work which might be given if it were lawful to work the existing machines longer hours. The interest of the general public does not lie in the creation of work or multiplication of jobs in this manner, but in the increase of product, and the tendency toward lower prices, resulting from the best use of the time of both men and machinery.

The case is not singular, as it might be thought. The same question arose over the automatic looms of the mills at Fall River. There the workers struck, not for shorter hours or higher wages for themselves, but for a reduction of the product of the machines. The case is not exactly the one sometimes alleged against capital, that machines and patents are held idle. There the machine or the patent which is best adapted for the use is employed, since it is not reasonable to use the worse when it is possible to use the better. Repeatedly it has been shown that the closing of factories and the disuse of inferior machinery or patents have been followed by an increase of product. That is to the interest of capital, and therein the interest of capital and that of the consuming public are identical. The matter of profit is less important than the production of goods, and if the production of goods should reach the sky—as it would not—there would be little objection to profits rising similarly. But increase of wages caused by waste of capital, and resulting in decreased production of goods, and increase of prices through increase of costs, are contrary to the public interest, and not so much to the interest of wage earners as labor leaders think and teach. Attorney General Peeples' opinion ought to be tested in the courts. If it is the law, it ought not to be allowed to remain the law. It is necessary to draw the line somewhere regarding legislation only nominally in the interest of labor, and actually contrary to the interest of every other portion of the community.—*New York Times.*

TRUNNION DRILL JIG WITH MILLING ATTACHMENT

The trunnion drill jig shown in Fig. 1 has mounted upon it a straddle-milling attachment for straddle-milling two bosses and cutting two oil slinger grooves in the lower half of an automobile crank-case. The crank-case is rigidly held in adequate supports in the drill jig, so that the light milling operation can be conveniently performed at the same time. The use of the jig for milling is also desirable, because the bosses must be in an accurate position in relation to the drilled holes. This drill jig was designed and is giving satisfactory results at the factory of the Knox Motors Co., Springfield, Mass.

In Fig. 1 the drill jig is shown in the loading position. The jig templet plate *A* has to be removed when the crank-case is being loaded onto the trunnion drill jig, as shown in the illustration. The crank-case is located by setting the outline to permanently located lines on the face of the jig. When the correct position is obtained, the crank-case is firmly clamped by four straps.

After the crank-case is clamped into position, the templet jig *A* is replaced, being held down by the hand-nut *B* and located by a keyway in its under surface and a key in the main body of the drill jig. While in the position shown in Fig. 1, the holes are drilled and tapped through the templet jig *A*, and this jig is allowed to remain in place, acting as a clamp, while the drilling and milling are being done with the jig in the position shown in Fig. 2. After the completion of the foregoing operation, the drill jig is indexed to the position shown in Fig. 2. While in this position, twenty-two holes are drilled in the crank-case, and after these are completed the milling is done.

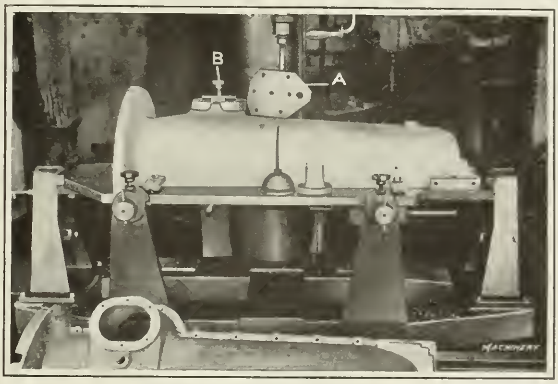

Fig. 1. Trunnion Drill Jig in Loading Position, showing Templet Drill Plate

The milling attachment for this drill jig consists of two members *D* and *C*. Part *C* consists of a body member for the milling attachment. In it are cut vertical ways in which the cutter carrying member *D* travels up and down. The movable member *D* carries a horizontal cutter-arbor having a gang of three cutters *J* and *G* on each end. In the center of this arbor is a bevel gear which meshes with another bevel gear carried by a vertical shaft, the upper end of which terminates in a Morse taper shank *E*. The movable member *D* is held normally in the upper position by springs.

In operation, the drill spindle is brought down in contact with the taper shank *E* until it is seated into the taper drill socket. Then the drill spindle is rotated, and the milling arbor, of course, rotates also through the bevel gears. The drill spindle is fed downward the same as for drilling, and in so doing the entire member *D* is lowered until the right-hand set of cutters *G* is brought into contact with the boss to be milled at the right-hand side of the crank-case. The cutters continue to be lowered until they come against a previously set stop, in which position the milling of the right-hand boss is completed.

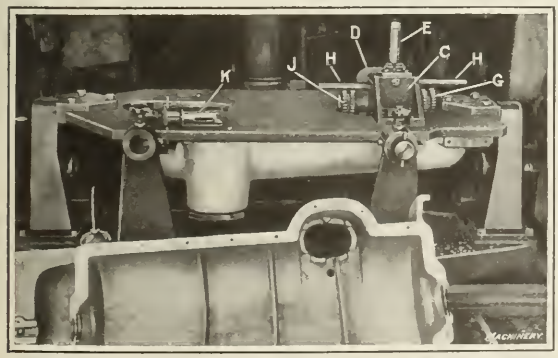

Fig. 2. Jig in Drilling and Milling Position, showing Milling Attachment

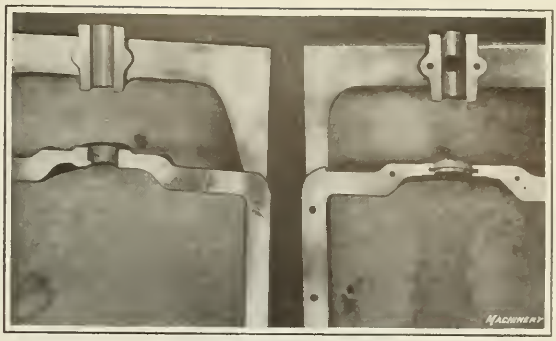
Fig. 3. One End of Crank-case before and after drilling and milling

To proceed with the milling of the left-hand boss, it is necessary to loosen the straps that hold the milling fixture in place, grasp the handles *H* and lift the milling attachment over to the left-hand side of the drill jig, where there are dowel-pins which accurately locate it in its correct relative position. The operation is repeated in the same way as for the right-hand boss, except that cutters *J* are used instead of cutters *G*. This milling attachment is never removed from the drill jig, except as explained, for milling the right- and left-hand bosses. The movable member *D* is moved up out of the way by spring pressure when a new crank-case is being placed in the jig. It would be possible, of course, to equip this drill jig with two milling attachments, one at each end, so that it would not be necessary to move the attachment from one side to the other, but as the changing of the fixture from one side to another was such a simple matter, it was not deemed advisable to go to the extra expense that this would involve.

Another point worthy of mention is the simple and efficient style of index plug that is employed on this drill jig. The construction of this index plug is clearly shown at *K*, Fig. 2. It consists of a circular plug with a concentric slot cut in it, the width of which is just the thickness of the drill jig plate. When the plug is in place and the drill jig is turned over, the slotted end is made to straddle the thickness of the drill jig plate which securely and accurately holds the jig in the correct position.

In Fig. 3 are shown two views of one end of the crank-case before and after drilling and milling. The exact nature of the straddle-milling and groove-milling is clearly shown. V. B.

* * *

It has recently been announced that the Navy Department intends to re-engine ships in the service that are now equipped with direct-connected turbines. The first two to be so reconstructed will be the destroyers *Henley* and *Mayrant*. These are to be equipped with geared turbine units, for which contracts have been placed with the Westinghouse Machine Co. of East Pittsburg, Pa. Geared turbines have been decided upon because of the fact that they are lighter and take up less space than direct-connected units, are much better mechanically because of their small size, and materially reduce steam consumption at all speeds, and especially at cruising speeds. This reduces the fuel consumotion and increases the steaming radius, which is an important feature.

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GAGING AND INSPECTION METHODS

Modern developments in the machine shop have reached a point where problems of gaging and inspection are no longer left to haphazard systems evolved by this or that man, but are scientifically planned with a view to insuring a high production with interchangeability of parts. Many gages which have been used in times past have been of little use because they were not designed in such a way as to show variations. A "Go" and "Not Go" gage is all very well, but one which indicates the amount of variation in the work at the same time is still better. The present tendency is toward gages of an indicating type which give a reading by means of which it can be readily determined whether the tools are cutting large or small; hence the tools can be set to correct any error in one direction or the other.

The setting of tolerances and the determining of limits for work and inspection gages are of primary importance, requiring extreme care, unerring judgment and wide knowledge of manufacturing conditions, machine tools used and the sequence of operations on the work. It follows, therefore, that methods of gaging should go hand in hand with tool design. Inspection methods have kept pace with the progress in gaging, both in the testing of work in process and finished work. The daily and sometimes hourly inspection of the gages themselves and the care used to keep them in shape for accurate work have both been influential in securing the results which are obtained from present-day interchangeable manufacture. A system of gaging and inspection which does not take into consideration the wear on the gages and which does not include a rigid inspection of work gages at frequent intervals will fail to produce satisfactory results, no matter how carefully the original gages may have been made.

* * *

THREAD MILLING

Some valuable lessons have been learned by American manufacturers as the result of their experience in making shrapnel and high-explosive shells. One of these is the great efficiency of the thread milling cutter as compared with the single-point thread tool or taps and dies. Early in the game, some of our inexperienced concerns tried to thread shrapnel noses with single-point tools or taps to fit Whitworth thread gages. These attempts were commercial failures. It was practically impossible to hold single-point tools to the shape required and get the kind of thread demanded by the inspectors, and comparatively few taps and dies will cut Whitworth threads with the accuracy and speed required.

Thread milling solved the difficulties. The milling cutter made to the approved standard Whitworth thread section holds its shape and cuts rapidly. A shell mouth threaded with a milling cutter operated in a thread milling machine leaves little to be desired as regards accuracy, shape and smoothness of cut. No trouble is experienced in doing work that will meet the requirements of the inspectors armed with thread gages and a critical disposition.

Thread milling may be done with efficiency in a first-class engine lathe equipped with a cutter-head mounted on the carriage and provided with means for driving the cutter. While a makeshift arrangement of this sort is not to be generally recommended, the results are so highly satisfactory that one having used thread milling equipment on manufactured work ordinarily done with single-point tools could hardly be tempted to go back to the old time-consuming and inefficient way.

* * *

INTERCHANGEABLE PLANER WORK

One of the lessons learned by some in high-pressure production of machine tools to fill war orders is the economy of accurate machine work, especially planer work. Lathe beds may be planed very accurately on first-class planers by skilled mechanics, or they may be planed quite inaccurately by poor workmen on second-class machines. In the rush to produce machine tools, the tendency was to cut down the planer time, with the result that much more time was required on the erecting floor to correct the faults of planing. This obviously is bad management. One hour spent on the planer making a job right is as effective as five hours spent by the scraper to correct a poor job. When skilled erectors could not be obtained, the value of first-class planer work became more evident than ever.

A skilled workman on a good planer can readily produce plane surfaces parallel and in line with lateral dimension correct to within one-half thousandth inch limit, plus or minus. A scraping cut with a planer tool to make a surface true and of the required dimensions can be taken in a fraction of the time required by a skilled fitter to remove the metal with the file and scraper. In fact, good planer work obviates the need of scraping except to remove the iron dust and to harden the surface. Scraping is employed as a means for giving a beautiful finish, but as a corrective process in machine tool building it should not be greatly needed.

* * *

DIRT AND DISORDER IN SHOPS

Nothing is more depressing to an orderly mind than the sight of dirt and disorder in a machine shop. A shop in which castings are strewn promiscuously on the floor mixed with scrap, chips and waste, and where tools litter the work-benches and stands, is invariably associated with inefficiency and slovenly practice. It is true that a machine shop is a hard place to keep clean and orderly, but the expense and effort required are well repaid. Men work better and produce more when employed in cheerful surroundings where order reigns. The subjective influence is invariably for the better. A disorderly shop indicates a disorderly superintendent and begets disorderly habits in the workmen. A clean shop with tools kept right and castings neatly piled is potentially a safe shop, and inspires orderly methods.

An old shop need not necessarily look disreputable. The labor of one man rightly directed will accomplish wonders in brightening the windows, banishing dirt, sweeping away cobwebs and keeping the gangways free from obstructions. A patch of green grass in front neatly trimmed and a few vines trained to grow on the broken walls will repay a hundred times the cost. The man who sneers at these things as being "sissified" and out of place does not appreciate how powerfully they appeal to the esthetic side of man's nature or what a force they are in attracting desirable employes. Clean up regularly and keep the shop in order is a good rule to prevent accidents and fires and to promote general efficiency.

NOTES ON THE MACHINERY INDUSTRY ON THE CONTINENT

MACHINE TOOL BUILDING IN FRANCE, ITALY AND SWITZERLAND—WAGES AND COSTS OF MATERIALS

BY ALEXANDER LUCHARS*

THERE are not more than three or four machine tool builders in France at present—and at the outbreak of war there were only two of consequence. The facilities of these were totally inadequate to provide a fraction of the tools required, so America was virtually the only source of supply for machine tools. One of the two plants referred to has since been taken over by Schneider & Cie for the manufacture of special machinery, and the other, a lathe factory, is producing shells principally, so that virtually no machine tools are now being made in France or are likely to be made until the war ends.

I have heard a good deal about the increased output and great profits of American machine tool factories on account of war orders, but nothing at home approaches an example which I found in Paris. A manufacturer of gears whose shop I visited in July, 1914, and who was then employing about fifty men, obtained some huge government contracts for shells, and in connection with them a trifling loan from the government of 16,000,000 francs, which, with the help of friends, enabled him to enlarge his plant, so that he now employs 4500 hands—a large proportion of whom are women. What this enormous plant is to produce after the war is not yet evident. The difficulty of obtaining accurate information in Europe is shown by the figures given me as to the number of hands employed by this concern. One informant placed it at 12,000, another at 10,000 and a third at 8000; but careful inquiry showed that the actual number was about 4500. That is enough, without exaggeration. The same statement applies to figures on the increase in the cost of living in France. One highly intelligent French business man assured me that the cost of food had doubled, but I found that the advance was really about 30 per cent. The price of food in restaurants has increased about as much.

Some figures given me representing the sales of American machine tools in France are worth mentioning. The sales of the representative of one American manufacturing concern (not a dealer) during the two years of the war, in France and England, are said to have been 60,000,000 francs. The head of another firm which has a number of American agencies told me it had placed orders in America amounting to 35,000,000 francs.

France is a limited market for machine tools under normal conditions, and our manufacturers of course should not look for a continuation of anything like the business which has been passing during war time. In general, they do not appreciate how limited the market is for machine tools, and especially for large tools of a special character, so that when they have placed their agencies with a French concern and have not received the amount of business they looked for, they have been more inclined to blame the agent than the market.

Munitions Profits Dwindling

The enormous profits made in the manufacture of shells and other war material at the beginning of the war have dwindled, and some of the work is actually being turned out at a loss. Following are the prices of shells of the sizes most largely used:

Mm.	Inches	Prices 1914	Prices Now
75	2.95	15.00 Fr.	4.35 Fr.
105	4.13	22.00	12.50
120	4.73	28.00	12.50
150	5.9	32.00	18.50
155	6.10	36.00	20.00

The above quotations are for steel shells, and include machining, testing and gaging, but not material. The following table gives prices of shells made of "semi-steel," that is cast iron and scrap steel:

Mm.	Inches	Prices 1914	Prices Now
120	4.73	17.50 Fr.	11.00 Fr.
155	6.10	17.50	9.00

* Publisher of MACHINERY.

Some firms have sub-contracts for machining the 120-millimeter semi-steel shells at 3.75 francs each and are making a profit. The price paid by the government for machining only, is 7 francs. The price paid for the chips from these shells went, during the first six months of 1916, from 2.50 francs per 100 kilograms to 8.20 francs per 100 kilograms, and since has dropped to about 6.50 francs per 100 kilograms.

The first contracts for forging the loose head or ogive of 75-millimeter shells were given covering a period of about one year, not including heat-treatment, at 1.85 franc per shell with transport to and from the shop paid by the government. Today shops offer to do them, including heat-treatment, at 1.10 franc per shell; and some shops having a capacity of at least 6000 per day are seeking them at 65 centimes each, including the heat-treatment.

For fuses, 16.20 francs was paid for machining only, in 1914. Now the price is 6.80 francs. Detonators, for which 6.57 francs was formerly paid, are now 2.20 francs, including furnishing the metal; and 1.80 franc without the metal. Inspection of shells is much more rigid now than ever before. The prices have declined not only on account of competition, but also because the government inspectors saw the enormous profit in the work and gradually cut down the figures.

The first series of 3000 75-millimeter rifled trench cannon was placed at 1200 francs each for machining only; total labor cost, including jigs, tools, etc., 285 francs per cannon (based on a series of 1000 cannon). The second series was placed at 850 francs, for machining only. The labor cost was 325 francs per cannon. This model was more difficult to make, as the breech-block was screwed on instead of being forged integral with the barrel, and there were two copper slides set in the barrel.

At the beginning of 1915 the price for breech-blocks of 220-millimeter siege guns, machined after heat-treatment, was 1850 francs each. In November, 1915, the price for the same piece was 965 francs. The labor cost in each case was about 200 francs.

The first series of breech-locking rings of the 220-millimeter gun, machining only and not including heat-treatment, was placed at 1750 francs each. The second series was placed at 1290 francs. The pieces were made in series of 7 batteries (28 pieces). The labor cost, including tools, jigs, etc., was about 390 francs. The first series of breech-locking levers and firing levers of the 75-millimeter gun (not including heat-treatment) was placed at 146 francs for series of 300; second series in lots of 1500 at 112 francs; labor cost, including jigs, tools, etc., about 56 francs.

The reduction in prices paid for shells in the allied countries is an indication that the Allies have caught up with the demand. After two years of unparalleled exertion, they appear to have reached a point that the Germans were forty years preparing for. There are other indications of this condition besides the present prices of munitions. One is the enormous quantities of shells piled along the lines of the railways for miles in the rear of the firing lines. Everyone knows that it was the abundant supply of ammunition, as well as the men and the trained organization, which enabled the Germans to win during the early part of the war, and it is the more than abundant supply of ammunition, the constantly increasing supply of men from Great Britain and the close working relations of the Allies that have been turning the tide of battle. A French officer said that at the beginning of the war there was no ammunition for the cannon they had, and when they obtained ammunition they needed more guns. Now they have plenty of both.

I was told on good authority that no contracts for French shells or rifles had recently been placed out of France. The large contracts placed in the United States by the French government are said to have been for Russia, for which country France has been purchasing enormous amounts of war mate-

rial that is now supplementing the supplies that Japan has been furnishing, and partly account for the recent success of the Russian armies.

Wages and Prices of Materials in France

Wages in France vary according to location. The following wages are paid in a shop just outside Paris:

Position	Average Pay per Hour	Average Pay per Month	Average Pay per Month on Basis of 1 Franc per Hour
Inspector	0.79 franc	235.08 francs	275.37 francs
Assistant	0.52 "	155.10 "	187.38 "

In December, 1915, these men were all put on a basis of one franc per hour, to which are added the usual premiums and bonuses.

In the Department of Jura and in that region the maximum pay for both men and women is 7.50 francs per day of ten hours. The minimum for skilled men is 7 francs per day and tool-room men average 10 francs per day.

In the Paris district, which controls the pay of workmen as far north as Dunkirk and within a radius of about thirty miles in other directions, toolmakers were paid before the war from 90 centimes to one franc per hour, and since the war are paid 1.80 franc per hour. Lathe hands are now paid from 45 centimes to 1.40 franc per hour. Some shops about twelve miles out of Paris are paying 20 centimes per hour more to non-mobilized men, while those mobilized are paid the same rates as in Paris. In Amiens and the region of the Somme lathe hands are paid 65 to 70 centimes per hour. Schneider & Cie at Creusot pay 40 to 80 centimes per hour, and many of the workmen are refugees sent there by the government. There are said to be some 80,000 hands in the Schneider works in different parts of France.

In shell and fuse works the proportion of women employes ranges from 60 to 80 per cent. In such works most of the employes, except foremen and toolmakers, are usually women. From these figures the percentage runs down to 10. Women are generally paid wages varying from 5 to 6 francs a day with a premium, which increases the pay 2 or 3 francs. The proportion of women in some shops where the work is not heavy is as low as 30 per cent, and the government is trying to increase this percentage to 40, so that except on heavy work there will be no shops employing over 60 per cent of men. I have seen women employed turning out 120-millimeter shells, but in such cases they had hoisting apparatus and other appliances to help them with handling heavy material. Others were able to handle 75-millimeter shells without any such help.

The following table shows wages paid for various occupations in 1914:

Occupation		Wages per Day of 8 Hours, Francs Min.	Max.
Adjusteur de precision	Fitter, precision work	10.00	15.00
" ordinaire	Fitter, ordinary	7.50	10.00
Chaudronnier en cuivre	Coppersmith	7.50	12.00
" fer	Boilermaker	7.50	12.00
Chauffeur	Stoker	7.50	10.00
Conducteur, machines-vapeur	Engine driver	7.50	10.00
Calqueur	Tracer	7.50	10.00
Dessinateur	Draftsman	10.00	17.50
" autographe	Draftsman-copier	8.00	14.00
Forgeron de precision	Smith, precision work	10.00	15.00
" ordinaire	Smith	7.00	10.00
Frappeur	Smith's striker	6.50	8.50
Fraiseur de precision	Milling machine operator	8.00	12.00
Heliographe	Blueprinter	6.50	8.50
Manoeuvre	Laborer	6.50	8.50
Photographe	Photographer	8.00	14.00
Raboteur de precision	Planer operator	8.00	12.00
Tourneur de precision	Turner, precision work	10.00	15.00
" ordinaire	Turner	7.50	10.00
Menuisier modeleur	Patternmaker	8.50	13.00

On January 1, 1915, these salaries were all increased by 25 per cent. In addition to that increase, workmen are paid for premiums and overtime.

Here are a few changes in the prices of material in France since the war:

	1914-15	1915-16
Coal	34 fr. per ton	128 fr. per ton
Machine oils	75 fr. per 100 kg.	320 to 380 fr.
High-speed steel:		
(American)	7.50 fr. per kg.	42 to 56 fr. per kg.
(English)	7 fr. per kg.	16 to 28 fr. per kg.
Mild steel (Bar stock up to 2 in. diam.)	38 fr. per 100 kg.	Jan., 1916, 68 fr. per 100 kg.
Bronze castings, first quality	4.20 fr. per kg.	Jan., 1916, 6.50 fr. per kg.

Business and Engineering Conditions in Italy

In Italy business activity is divided into three zones or belts. The northern belt, which includes the manufacturing section, is very prosperous—probably more so than at any other period of its existence. In this belt lie the large machinery and automobile plants, all of which are turning out munitions; and hundreds of works of all kinds, big and little, are furnishing supplies for the army and navy. Because of the amount of money thus placed in circulation, and also because the northern belt is close to the fighting line and vitally interested in the outcome of the war, all the people there are enthusiastic for it. In the middle belt, where there is less metal manufacturing, there is less enthusiasm for the war. In the southern belt, which is farthest from the fighting line, and which is almost entirely devoted to farming and kindred industries, business is poor, and the war is unpopular. Flour mills are tied up on account of the scarcity of coal and the lack of water to run them. The farther south you go the less popular the war is.

Many of the motors that require oil for fuel are not operated on account of its lack, and old steam engines are being resurrected and started up, although the price of coal in some sections is almost prohibitive.

The demand for war supplies has naturally created an unprecedented market for all kinds of appliances needed in their production, including machine tools, so that other lines are indirectly affected as in England. Before the war, business was poor, money scarce, and most of the Italian automobile manufacturers, of which there are about a dozen, big and little, were guessing hard about the future. Now their production is limited only by the number of hands and machines they can procure. The great plant of the Fiat Co. at Turin has been extended until it comprises a small city in itself, employing from 15,000 to 18,000 hands, turning out shells, motor trucks, aeroplane and submarine engines, and other war material. The Isotta e Franchini, the Bianci and other smaller automobile manufacturers are running to their full capacity on about the same class of products.

It is said that the Fiat Co. plans, when the war is over and the demand ceases for war material, to produce a great variety of small metal products in general use, all of which have heretofore been bought from Germany, and also to build a low-priced automobile in large quantities. Probably when those plans were made they had not heard of the new Ford prices.

The Ansaldo works near Genoa is another immense manufacturing establishment, that and the Fiat works being the two largest in Italy. The Ansaldo works employ about 16,000 hands (more than double the number in 1914), of whom about 1000 are women. This concern was founded by two English engineers to make and repair engines for the Italian railways, and until recent years the management was associated with Armstrong-Whitworth of Elswick and conducted on the same lines, having its own steel plant and foundries, and building warships, torpedo-boats, motors, engines, cannon and machine guns, besides a variety of railway material. It is now under Italian control entirely and has produced an enormous amount of war material for the Italian army.

Notwithstanding the war, some progress in peaceful engineering works has been made in Italy. Some 300,000-horsepower turbo-generators have been installed along the Italian riviera, the power from which is carried long distances. The trains through the Mont Cenis tunnel, which until recently was filled with smoke, are now being operated by electricity. An interesting fact I noted was that the construction of their strategic railroads and much of the engineering work by the Italian army, including the tunnels under the impregnable San Sabotino mountain, one of the Gorizia defenses, have been done by Italians who were trained in America. There are said to be about 300,000 of them in the Italian army.

There are several machine tool builders in Italy; two or three make lathes and one makes gear cutters—none of much importance. The Italians have been only fairly large buyers of machine tools in years gone by, not having been fully educated to the advantage of using high-priced labor-saving machinery, except in the automobile works. A large part of the

metal-working machinery sold in Italy has been bought from Germany (about $1,500,000 worth annually), and many of the large German manufacturers were represented in Italy. This has, of course, all been cut off, and will certainly not be resumed during the war, and perhaps not for some time after. England and America will be called on for the metal-working machinery required in Italy until friendly relations are resumed with Germany.

Conditions in Switzerland

Little Switzerland, surrounded by four nations at war, obliged to maintain a large standing army and with her principal sources of income cut down, occupies a position of great difficulty and satisfies none of her neighbors. France and Germany both claim that she is trading with their enemies, and her visé on a passport immediately places the bearer under suspicion of being one of the spies with which Switzerland is said to be liberally supplied. It is worth noting, by the way, that Germany has made up a black list of Swiss firms who supply her enemies.

The hotel and lace industries on which Switzerland is principally dependent being virtually dead, she naturally has turned to the production of war material, which means everything that is used by an army, and all such industries are booming. The native language in the larger part of Switzerland being German, a smaller part French and a still smaller part Italian, it might be expected that the natural sympathies of the Swiss would be divided in like proportion, but I observed that they sold their products impartially to any foreigners, provided they paid in Swiss money. Foreign money is taken at a discount only.

The troubles of our manufacturers over raw materials are fly specks compared with what the Swiss manufacturers encounter. To obtain material from England, which is almost their only source of supply, they must first obtain one permit from the Swiss over-seas trust in London, a second from the English war department, a third from the English ministry of munitions, and a fourth from the French authorities for permission to land the shipment in France. Then their material must be shipped on Swiss railway trucks, for which they obtain a fifth permit from the French railway authorities. Incidentally, if any of this material is used for manufacturing war materials for an enemy country, the manufacturers are fined four times the value of the shipment and their names are stricken off the list of licensed importers.

There are four or five lathe manufacturers in Switzerland, and a dozen smaller machine tool builders, some of whom build bench drills. The largest machine tool factory there is that of the Société Suisse des Machines Outils d'Oerlikon, at Oerlikon, near Zurich, building lathes, horizontal boring and milling machines and vertical drilling machines, but not of the highest grade. Two years ago they were considered unimportant; one year ago they were employing about 300 hands, and now they employ about 500. They have sold thousands of lathes in France, and probably other thousands in Germany, Austria and Italy. One French dealer told me he had bought over a thousand; but added, "Because we couldn't get American." The French are always polite.

The Oerlikon Machine Tool Co. was formerly a department of the Oerlikon Maschinenfabrik, a large concern employing about 2500 hands, manufacturing locomotives, electrical plants and appliances, sand disintegrators, turbo blowers, train lighting equipment and other peaceful material. This concern makes no war material and so keeps out of trouble.

The wages for machinists and other metal workers in Switzerland are naturally less than in the surrounding countries, and as many of the best workmen attempted to leave Switzerland to get the higher wages offered by foreign works, an order was issued by the Swiss war department forbidding the granting of furloughs to any soldiers—and, of course, all able-bodied men in Switzerland are soldiers—for the purpose of leaving the country. This made so much feeling among the workmen that strong pressure was brought to bear on the authorities, and Switzerland being a republic where politics have more influence than in some other countries, the order was modified.

THE DECAY OF METALS*

By decay of metals is meant changes of an unfavorable character that take place when in use or in storage, especially those that proceed completely through the mass of the metal. The simplest of these is the disintegration due to molecular change of the kind known in chemistry as allotropic. This is especially observable in tin, which becomes unstable at 64.4 degrees F. and may gradually change from a tough white metal into a gray powder. This condition is first manifested as small spots at which mounds of gray powder soon appear. In a short time, each spot becomes a hole, which rapidly perforates the metal. A peculiarity of this trouble is that it rapidly spreads from one place to another, like an infectious disease; it is therefore known as the "tin plague." In cold countries like Russia, the tin roofs of the affected areas are quickly destroyed when the process of decay is started. It seems as though the powder must be carried by the wind, and that wherever it settles it starts the tin decaying. Tin is also likely to undergo a molecular change at the temperature of boiling water. This is shown by the columnar structure that is frequently found in pieces of broken condenser worms. Allotropic changes occur also in lead, especially lead sheets subjected to the application of solutions containing lead salts. This change does not appear to be connected with the impurities in ordinary lead, as it seems to occur as readily with common sheet lead and the purest assay foil.

Decay may also be due to the movement of gases dissolved in a metal. This is the cause of the brittleness of nickel wires used as resistances in electric furnaces. The heating of the wire sets free the dissolved gases invariably contained in nickel. As the cooling between two periods of use is too rapid for a complete reversal of the process, a part of the gas remains undissolved between the grains of metal. As this alternate heating and cooling continues, the grains separate and the wire crumbles.

Severe cold working of a metal is apt to produce the form of decay known as seasoning cracking. Hard drawn brass rods and tubes occasionally crack, both in use and in storage, when transferred to a warmer climate or exposed to slight corrosion. This decay is due to the existence of severe internal stresses in the metal caused by the unequal deformation of the inner and outer layers. The cracks are commonly transverse. While seasoning cracking is generally hastened by exposure to temperatures above normal, heating sometimes prevents this form of decay. Seasoning cracking may also be caused by ammonia or other agents; when the chemical agent acts rapidly the cracking may occur with almost explosive violence. Very hard drawn rods of brass or bronze will sometimes fly to pieces when attacked with a solution of a mercury salt or of ferric chloride.

Sometimes cracking is started by superficial corrosion, the corroding agent separating the grains of the surface layer, acting in the same way as a crack. At the same time internal stresses may increase the liability of corrosion by opening up cleavages in the grains, thus effecting a path along which the corroding agent may enter, even though the stresses may not have produced any cracks.

Corrosion is accelerated by the contact of dissimilar metals. As a single metal in the annealed and cold-worked conditions differs in its electrical properties, the contact of the two favors corrosion, so that a metal which is locally cold-worked is particularly likely to corrode. For this reason the corrosion of a cold-rolled metal takes place in such a way that the rolling lines become clearly visible, pitting or grooves appearing in a direction parallel with that of rolling.

The corrosion of alloys that contain two or more solid constituents is of a special character. It usually starts in the form of minute pits, which are quite close to the minute masses of the compound and parallel to them in outline. This type of decay is most clearly observable in those alloys of copper and zinc that consist of two solid constituents—the yellow metals, including muntz metal, delta metal, manganese bronze, etc.

* Abstract of paper read before the Institute of Engineers and Shipbuilders, in Scotland, by Cecil H. Desch.

BRASS AND BRONZE AIR CONTAINERS

S. D. Sleeth, superintendent of the foundries of the Westinghouse Air Brake Co., Wilmerding, Pa., presented a paper before the American Institute of Metals at Cleveland, Ohio, September 11-15, in which he discussed the conditions necessary for the production of non-porous castings and gave the constituents of three alloys for containers that have to withstand internal air pressure, like air brake parts, etc. Density and strength are the two qualities necessary in a metal suitable for the retention of air or other gases under pressure, and while strength may be secured through proper design, density is a quality not so easy to obtain. Density of a brass or bronze casting is affected by a number of variables, among which are the design of the article to be cast, the design of the pattern with reference to its position in the flask, composition of the alloy, treatment of the metal in the furnaces and temperature of the metal when poured.

All cross-sections of the part should be of approximately equal thickness in order to prevent draws of heavy portions. If this is not possible, access to all large sections should be provided for the use of chills to prevent draws. If the cored cavities are large, the cores themselves will act as chills. Fillets should be as small as possible in order that excessive masses of metal shall not be concentrated at one point.

The use of chills is almost always necessary. Chills should be used on all enlarged sections in close proximity to smaller sections and connected thereto. If the sections are exceptionally large, sinking heads on top of the large sections should be used. The molds should be gated with a heavy upright pouring gate as near the pattern as possible. The gate leading from the pouring gate to the pattern should be made large at the pouring gate and then reduced sharply into the pattern. If it is left large where it joins the pattern, in all probability it will show a draw in the casting at the gate. As a rule, it is better to gate in a light part of the casting than in a heavy portion. If a sinking head is used, it should be placed on the heavy part.

The treatment of the metal in the furnaces is of vital importance. If proper allowance for oxidization on zinc, etc., is not made, the alloy required will not be produced. The metal must be taken from the furnace as soon as it reaches the proper heat, for if allowed to soak in the furnace, it will take up gases, and the castings made from it may be porous. In pouring certain packing ring mixtures, the Westinghouse Air Brake Co. considers the time so important that an alarm clock is used to insure the metal being poured at exactly the right moment.

The temperature at which the metal should be poured is also vitally important; no doubt many castings are lost due to carelessness in this matter. If poured too cold, it is almost impossible to obtain solid castings, especially at the gates. On the other hand, if poured too hot, castings may be porous throughout. Great care must be taken to see that no aluminum is used in the mixture, as a very small percentage of aluminum will cause the castings to leak. Antimony and iron will do the same, but not to so great an extent. Aluminum has a peculiar action on the metal. The castings will appear solid and will not show a draw, but when under pressure will leak all over.

The following compositions have been tried and found satisfactory for air containers:

Metals	No. 1 Alloy	No. 2 Alloy	No. 3 Alloy
Copper	72.50	82.00	83.00
Tin	1.75	7.50	11.50
Zinc	19.25	4.75	4.00
Lead	6.50	5.75	1.50
Total	100.00	100.00	100.00

No. 1 alloy is used for ordinary castings, such as cocks, pistons, bushings, etc. It is easily machined, but is not suitable for very high pressures. No. 2 and No. 3 alloys are suitable for high pressures and are harder to machine than No. 1.

* * *

The one-hundredth anniversary of the making of the first Remington rifle was celebrated in Ilion, N. Y., August 29, 30 and 31. The first Remington rifle was made by Eliphalet Remington in 1816 in his father's blacksmith shop.

RYERSON SAFETY-FIRST CONTEST

In the plant of Joseph T. Ryerson & Son, Chicago, Ill., the matter of safeguarding the workmen in every possible way has been given careful attention. Machines have been provided with guards; dangerous places have been plainly marked; large instruction signs have been posted in conspicuous places as well as safety bulletin boards telling of accidents and how to avoid them, and not infrequently the men receive further instructions and advice by letters in their pay envelopes; inspections of machinery, equipment, etc., are made every week. In addition, safety committees have been appointed to consider safety measures and enforce safety rules. The latest scheme adopted by this company to stimulate the interest in safety work is a safety-first contest, open to all workmen, to be effective from June 1, 1916, to May 31, 1917. This contest is an adaptation of the Dodge plan and is carried out under the following rules:

Rating Plan

Records are based on the fewest number of accidents which cause days lost after the day on which the accident occurs, and also on the fewest number of days lost after the day on which the accident occurs. A standard of 1000 points is set up for a perfect record. To attain this record, workmen or departments must have no accidents causing the loss of full days. To compute the standing of various departments and individuals, the following penalties are charged:

Penalties

For each accident causing a full day's absence after the day of the accident, a number of points is deducted from 1000 equal to the ratio of one man to the total number of men in the department. For instance, in a department with 100 men this will equal $1/100 \times 1000 = 10$ points.

For each day lost on account of accident after the day of the accident, a number of points is deducted from 1000 equal to the ratio of one day's time to the total number of days all men work in the department. For instance, in a department of 100 men working twenty-five days per month, or a total of 2500 working days, this will equal $1/2500 \times 1000 = 0.4$ point. No department, however, will be penalized for more than thirty days' lost time on any one accident.

For fatal accidents, or accidents causing loss of fingers, toes, limbs, eyes, or permanent disability, a penalty of thirty days' lost time is charged in the month the accident occurs.

After all penalties for accidents have been deducted from 1000, and all penalties for days lost have been deducted from 1000, the remainders will be added and divided by 2. After the results have been considered, the rewards, based on the records, are made as follows:

Rewards

The department having the highest record in a month is given the guardianship of a prize pennant, to be held by it for one month, and hung on exhibition in some suitable place.

All men who have worked one year in the department which for the year maintains the highest record are rewarded by sixteen hours' time off with full pay, equal to a Friday and Saturday. All men who have worked in that department less than one year, but nine months or more, are rewarded with ten hours' time off with full pay.

All men not working in the winning department but who have a record of 1000 points for the year, not having had an accident which caused a full day's loss of time, will be rewarded by sixteen hours' time off, with full pay, equal to a Friday and Saturday.

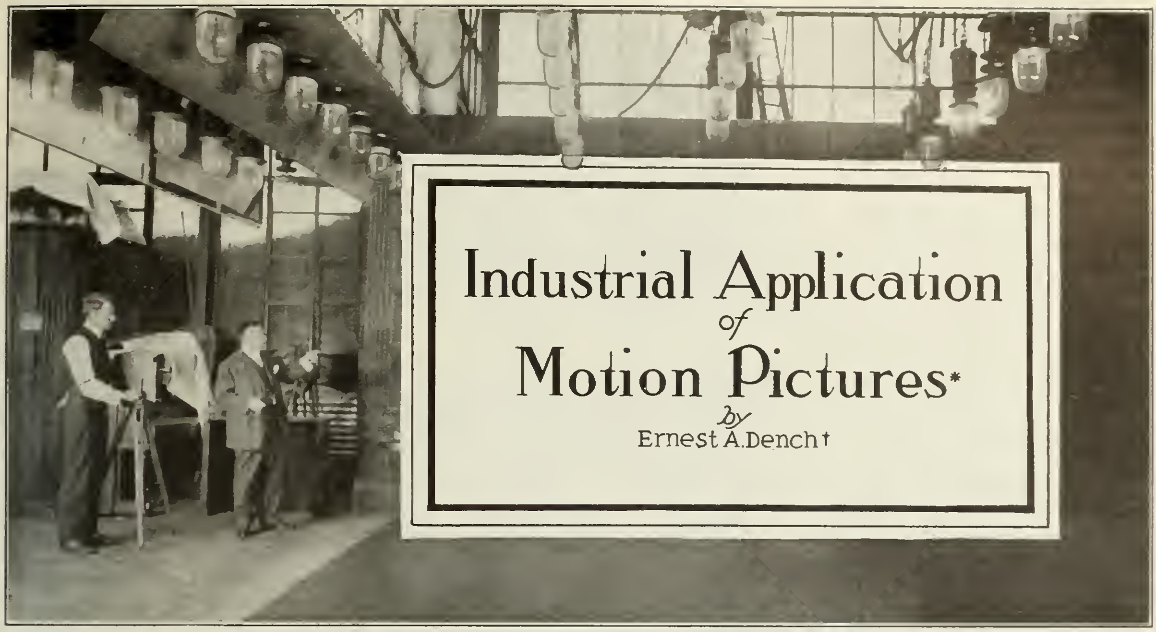
The rewards constitute either time off, as described above, or its equivalent in wages, whichever the management decides to be the best arrangement.

Foremen of the winning department for a month are rewarded by an addition of 5 per cent to their monthly bonus, or if they have no schedule, 5 per cent of their monthly wages.

The foreman of the department which wins the annual prize is rewarded by a prize to be chosen by the executive committee.

* * *

Newark, N. J., which celebrated the 250th anniversary of its founding by Robert Treat this year, is so near New York that its commercial importance is overshadowed. Comparatively few know that it has over 6000 manufacturing concerns and over 250 different lines of industry employing over 75,000 operatives. The capital invested in manufactures approximates $160,000,000, and the value of the raw material used yearly aggregates $130,000,000, the annual output being valued at $225,000,000. The chief industries are leather, machinery, iron and steel goods, shoes, corsets, chemicals, varnishes, thread, smelting, paints, hardware and clothing.



Industrial Application of Motion Pictures*

by Ernest A. Dench†

THE high degree of perfection which has been attained in the production and exhibition of moving pictures has made going to "movies" a popular pastime for a great many people. This is generally thought to be due to the fact that it is such an inexpensive form of amusement; but low cost would certainly fail to make an appeal were it not for the fact that it is possible to prepare films that show the most minute details of all scenes with an absolute degree of accuracy. Popularity of the "movies" and their ability to show details with absolute fidelity have led to their application by manufacturers for a great variety of purposes, and it is the intention of the following article to describe a number of typical instances, with the view of suggesting a wider application of an industrial development that has shown itself to be unusually effective.

Those who have made a study of the application of motion pictures in industrial work state that the following are requirements that must be fulfilled in order to secure satisfactory results: (1) In order to be of technical value, the films must be specially prepared for the purpose, with a full recognition of educational requirements; and they must comply with the fundamental necessity of showing the process in a manner that will make clear the exact nature of all the details involved. (2) Pictures must be supplemented by a technical explanation given by an expert in the subject that is being illustrated. (3) The film must be shown under conditions that will enable it to be stopped as required, so that in cases where the subject calls for fuller explanation this can be given. (4) All views must have a serious scientific or technical interest, as a film prepared for the purpose of amusing or entertaining an average audience would be quite unsuitable for the education of technical students.

The Film as an Instructor

One of the most obvious applications of motion pictures is in the educating of young men for industrial work, and it has been suggested that the method could be applied with exceptionally satisfactory results in explaining the work of a trade to boys who make application for apprenticeship, in order that they may fully understand the conditions under which they will have to work. Many such boys take up a trade without knowing in the least whether it is likely to prove congenial, and after a few months a number of them become discouraged and look for employment elsewhere. This has not only resulted in the loss of valuable time for the boy, but his employer has also suffered a financial loss, as it is generally known that the expense of training an apprentice during the early stages of his indenture amounts to much more than the value of his work.

It is felt that the motion picture, appealing to the eye as it does, would constitute a very satisfactory means of giving all boys who make application for apprenticeship an adequate knowledge of just the kind of work they will be called upon to perform, and that the ones who are likely to become discouraged and leave at an early stage of their career would thus be prevented from starting upon a course which would result in mutual loss to themselves and their employer. The Bureau of Commercial Economics has this subject under consideration, and if present plans are completed, it is the intention to show "trade teaching" films in such places as public schools, mission houses, settlement houses and other places where young men congregate, in order that knowledge of working conditions in various trades may become more general. The expense of preparing and showing these films will be provided by endowment funds and annuities.

For purposes of education, the use of motion pictures is by no means confined to apprentices. The Carnegie Institute of Technology, Pittsburg, Pa., presents a course in the metallurgy of iron and steel by the use of films prepared for that purpose; and the reader may judge how completely the subject is covered by the title of this film, which is "From Iron Ore to Finished Steel." The first pictures show the Mesaba District of Minnesota, where many celebrated iron ore mines are situated. Mammoth steam shovels are seen engaged in digging ore which is loaded onto lake boats at Duluth and shipped to various southern lake ports. After finishing the subject of mining, the scene changes to Farrell, Pa., at the works of the United States Steel Corporation, where various steps in the smelting, refining and rolling processes are clearly illustrated, as well as the recovery of numerous by-products. This is but one example of the use of motion pictures in the curriculum of technical institutions, but it illustrates the possibilities for this line of work.

Those institutions which are engaged in the technical education of young men are generally located in industrial centers, and part of the curriculum consists of making what are known as "inspection visits" to various industrial works, the idea being to show students the practical application of processes and manufacturing methods which they have studied in classrooms and laboratories. Where this method is followed, the

* For information relating to moving pictures and their industrial application previously published in MACHINERY, see "On Producing Mechanical Moving Pictures," February, 1915; "How Moving Pictures are Made," February, 1915; "Moving Pictures of Automobile Building," March, 1914; "The Moving Picture in the Machine Tool Business," January, 1914, and articles there referred to.

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choice of industries is naturally limited to those located within a reasonable distance; but in some cases the alternative has been adopted of preparing motion pictures of industries which may be selected without attention to their location, and showing these pictures in connection with lectures delivered in class-rooms, instead of taking the students to the factories. An advantage is found in the fact that the time required in going about from one plant to another is saved, and it is also said to be easier to hold the student's attention in a class-room than in a factory. The College of Mechanical and Electrical Engineering, Lexington, Kentucky, has prepared a motion picture course of this kind, which includes the following subjects: "Natural Resources of the Canadian Rocky Mountains"; "Construction and Operation of the Panama Canal"; "Electrification of the Butte, Anaconda & Pacific R.R."; "Motor Construction and Direct Motor Drive"; "Schenectady Works of the General Electric Co."; "Pittsfield Works of the General Electric Co."; "Manufacture of Curtiss Steam Turbines"; "Mining Iron Ore"; "Making Wire and Wire Fencing"; "Manufacture of Pipe, Tubes and Pipe Fittings"; "Use of Concrete in Road Making"; "Manufacture of Steel, Tin Plate and Tin Products"; "America in the Making"; "Playgrounds and Welfare Work of the Carnegie Steel Co."; "Welfare Work in Mining Districts."

The European war has produced some unusual labor difficulties which have been solved in part, at least, by the application of motion pictures. Crippled men have been classified according to their injuries and suitable employment found for men of each class. Then, in certain cases, motion pictures have been used to illustrate the movements required for performing the new work, this having been the means of teaching the men their new duties very rapidly.

Studying Efficiency by Means of Motion Pictures

Many manufacturers have tried timing their men on certain operations, but in many cases it has been found difficult, if not impossible, to secure reliable data, as no two mechanics work in the same way. The results obtained in timing two mechanics may be equal, and yet the manufacturer may feel certain that neither employe is turning out his work in a short enough time; but the evidence of the stop watch does not afford any means of deciding why men are incompetent. The micro-motion cinematograph, on the other hand, provides a record which may be taken to the office of the efficiency engineer and studied at leisure, in order that each move made by the workman may be carefully analyzed to show just where he is at fault. The disadvantage in making time and motion studies is that the workman knows he is being watched; but it is probable that the error from this cause is about neutralized by taking observations on a number of different men, as some will endeavor to make the best possible showing with the view of improving their standing with the firm, while others will work slowly with the idea of preventing an unduly high piece-work rate being placed upon an operation.

In making a motion picture time study, sixteen separate pictures, or "frames," as they are technically called, are obtained for each foot of film; and each picture represents an exposure of 1/32 second. If the time and motion study is to be conducted successfully, two clocks should be used, one of which is an ordinary alarm clock and the other a clock especially constructed for the purpose. Frank B. Gilbreth, of New York City, has developed a special clock for this purpose which has only one hand that covers the dial every six seconds. With this clock, time intervals may be noted down to 0.001 minute, the dial of the clock being subdivided into one hundred parts. The alarm clock serves to show the time taken in completing the job, while the special clock enables each motion to be accurately timed. These clocks are placed on a table or bench, so that they may be shown in the film that records the movements of the workmen, and it is important that all tools and appliances should be so placed that the workman will have every advantage in making a satisfactory showing.

In conducting tests of this kind, the efficiency engineer has the films developed and studies each frame through a magnifying glass, which enables him to detect the difference between a necessary motion and one that is useless. This is found beneficial because each movement may be thoroughly studied, whereas if the film were run off on a screen in the usual way it would not be possible to stop it at any particular place when it was desired to study the movements.

Emphasizing Necessity of Careful Packing by Use of Motion Pictures

In developing export trade, it is absolutely necessary for manufacturers to pay careful attention to the question of packing their goods for shipment. This fact was emphasized by Consul James Oliver Laing of Karachi, who suggested that motion pictures would afford many valuable object lessons in bringing this point home to American manufacturers. To quote Mr. Laing, "If a single photograph of a smashed packing case or of a lighter full of goods being landed brings the story home to a manufacturer, a moving picture showing how the case came to be smashed or how goods are put into or taken out of the lighter would be many times as effective." Everyone knows that cases are sometimes smashed, and a single photograph merely shows the result, while moving pictures would emphasize the relation of cause and effect. For instance, suppose a shipper of flour could see a lot of Levantine stevedores swing a loop full of sacks over the side of a ship and let it down on the run to a flat boat bobbining about on the waves. The sight of what happens when the boat suddenly rises to meet several hundred pounds of muslin sacked flour would be an object lesson to any shipper. Similarly, if an American furniture merchant could see a moving picture of his packing cases being dropped from a cart tail to a stone pavement by a gang of Maltese dock hands, he would appreciate the necessity of providing substantial packing cases for his goods.

How Motion Pictures Can Assist the Sales Manager

The manufacturer of heavy and cumbersome machinery and other products is placed at a decided disadvantage in showing his goods to prospective customers. His salesmen cannot take samples to the customer's factory cr office, and it is difficult, if not impossible, to have his product shown at conventions, trade shows or similar gatherings of men whom he desires to interest in his product. For such manufacturers, motion pictures are a great aid in improving selling efficiency. Until recently salesmen in the employ of manufacturers of such products depehded upon their selling ability aided by photographs, drawings and data in regard to the operation of machinery or other equipment which they were selling. Where the "prospect" wished to see a machine in operation, it was customary for the manufacturer to pay his traveling expenses to visit the plant, but this practice proved exceedingly expensive and often took much, if not all, of the profit from the deal. The modern method is to have the salesman provided with films showing all parts of the machine, the assembled machine in operation and details of the manner in which it works. The salesman is equipped with a small portable projecting machine with which he can show these films, and in this way he is able to show his customer every detail of a machine in which he is interested. There is no loss of time traveling to and from the factory, and no danger of a deal falling through as a result of salesmen being provided with insufficient information. Many American manufacturers are now using this method with extremely gratifying results.

The Reo Motor Car Co., Lansing, Mich., had a film made which serves three useful purposes. This picture shows manufacturing operations in the company's factory and illustrates how various important parts of the car are made. A private motion picture theater has been erected in the company's office building, in which this picture is regularly exhibited to employes—especially salesmen—in order to keep these processes fresh in their minds. The result is that they are able to talk with assurance that carries conviction, due to having a thorough knowledge of the goods which they have to sell. This film has also been found valuable for sales demonstration purposes, and with certain minor changes has been made suitable for showing to the general public.

Other motor car manufacturers have made considerable use of moving pictures. For instance, the Ford Motor Co., Detroit, Mich., had a film developed to show how a complete Ford car

was assembled in two and one-half minutes and driven away on its own power. The Pierce-Arrow Motor Car Co., Buffalo, N. Y., also uses a film which shows in a convincing manner the power and capability of its pleasure cars and trucks. As it is not always possible to conduct an adequate demonstration of a motor truck in the street, this film proves a valuable adjunct to the sales organization. Anyone who contemplates purchasing a car at the Los Angeles branch of the Studebaker Corporation cannot help being favorably impressed by the films which are shown in that office. They show the new Studebaker "Six" climbing up Big U mountain, a location which is favored by Nature for the purposes of motion picture producers. Everything goes well until the car has completed half of its trip up the incline; then it begins to slide back, but the wheels finally secure a grip, and after raising a good deal of gravel and stone, the car completes its ascent. The American Laundry Machinery Co. recently developed a film which shows various operations in modern laundering, and this film is offered free to any responsible person engaged in the laundry business.

Advertising with Motion Pictures

More for the purpose of advertising than anything else, the Winchester Repeating Arms Co., of New Haven, Conn., induced those two crack shots, the Topperweins, to demonstrate their wonderful marksmanship with rifles, pistols and shot guns before the moving picture camera. At the end of the film spectators are also given a number of views in the Winchester plant, where the well-known "Red W" line of arms and ammunition is manufactured.

Where machinery manufacturers resort to the use of moving pictures in a publicity campaign, the general practice is to have pictures made to show processes involved in manufacturing the product and finished machines engaged in the performance of those classes of work for which they are intended. Such pictures show a prospective customer both the care which is taken in manufacturing the machine and the features of its design which are likely to prove of exceptional benefit to him. In such pictures no attempt is made to introduce comedy or dramatic incidents, but an ingenious scenario writer can sometimes conceive an interesting story which is worked into the film, thus making it more entertaining to the average spectator and giving power to attract and hold interest. In many commercial undertakings there are interesting events that can be utilized by an expert in producing films for use in advertising this system. It must be clearly understood, however, that such films are, as a general thing, only applicable for advertising machines like

Fig. 1. Pig Iron stored in Maxwell Foundry

Fig. 2. Drilling Operation on Maxwell Cylinder Block

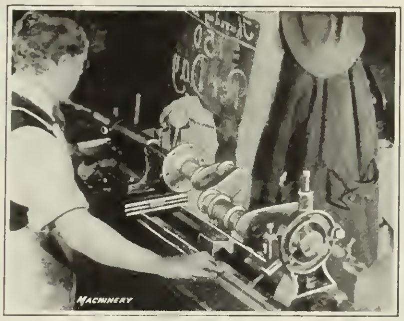


Fig. 3. Machining a Maxwell Crankshaft

Fig. 4. Testing Finished Maxwell Cars

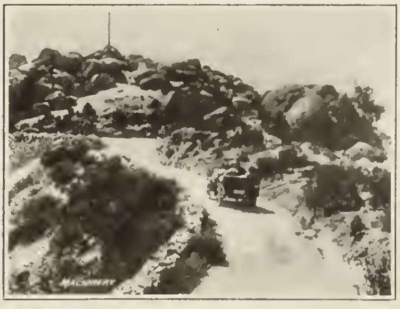


Fig. 5. Maxwell Motor Car on the Road

automobiles that have a general market, and would not be of value in advertising machine tools and other forms of manufacturing equipment.

This form of film was recently used by the Maxwell Motor Sales Co. in carrying on an advertising campaign. The film started in this company's factory, where the spectator was shown various steps in the manufacture of a Maxwell car; and this section was followed by pictures showing a tour through California, in which a human interest story was cleverly incorporated. This film was shown in over five thousand different towns in America, Canada, Australia and England, and it is estimated that it was seen by fully two million people. This circulation was attained through cooperation with dealers who made arrangements with local moving picture theaters and presented free tickets to all who desired to make use of them. The dealers reported that these films proved to be of great assistance in "boosting" sales, and that they were the means of finding many new customers.

Another important use of moving pictures is at various trade shows. It is a common practice for machinery manufacturers to ship heavy machinery to such exhibitions and hire the required amount of floor space to show it in operation. This is an expensive matter, as it calls for shipping charges, rent for floor space and traveling expenses of men sent to erect and operate the machines. But even when all this trouble and expense have been taken, the result obtained is often unsatisfactory, owing to lack of space, inadequate facilities, etc. To overcome these difficulties, motion pictures are now being used as a substitute, and the results are highly satisfactory. In all buildings where such exhibitions are held, electric light is available, and it is an easy matter to construct a temporary dark-room in which pictures can be exhibited. Films used in this way can be made to show a manufacturer's product to the best advantage, and so he is certain of showing prospective customers the best results which they can hope to secure from the use of his machine.

Cost of Producing Industrial Motion Pictures

The production of good films of industrial motion pictures means a great deal more than merely obtaining a batch of explanatory views. The first step taken by the manufacturer who desires to obtain the best possible results is to secure the services of a reputable motion picture producer. The term "reputable" is used intentionally, as there are many producers who are none too scrupulous, and who make a regular practice of charging for superfluous "footage," which is designated as "padding" in the motion picture industry. The extra cost of such material is not represented merely

by the extra cost which the manufacturer has to bear, as the introduction of such views in his films detracts greatly from the interest, and so robs him of much of the publicity value which he would otherwise secure. The great thing is for the films to have a continuous snappy action, for if it is unduly drawn out, the spectator is likely to lose interest. If material for one reel is strung out to occupy two reels, it simply means that an audience is bored for forty minutes instead of being entertained for twenty minutes. In making all films there is sure to be a certain amount of useless material introduced, but such views are cut out of the films before they leave the producer's laboratory.

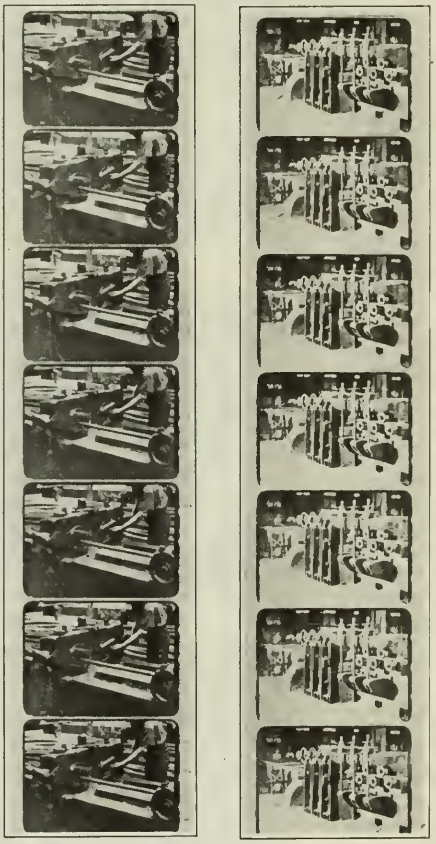
It goes without saying that moving pictures are intended to be shown quite rapidly, and if the film is burdened with a mass of explanatory matter, it requires greater mental concentration to absorb the idea, and, consequently, the value of the advertising is lessened. For this reason, the fewer and shorter the sub-titles used in a film the better the picture will be. It is well to bear in mind that it is what a spectator sees—not what he reads—that leaves a lasting impression; and so motion picture producers should aim to convey the required ideas by the action in the film wherever this is possible, instead of showing "cut-ins" which explain the idea in words. Advertising experts usually agree that the use of moving pictures is not a paying proposition as regards direct returns secured for the expenditure; but their use in creating a demand for a new product is said to be highly satisfactory. Of course, this is another case in which the statement applies solely to the advertising of products which have a general market; in the case of machine tools and other classes of manufacturing equipment, the use of moving pictures should be confined to showing machines to those who are likely to become purchasers, and here the efficiency of the method is naturally much higher.

In starting to prepare a film for publicity purposes, the best plan is to have the representative of a reputable film producer call at your plant in order that you may explain your views and show him just what phases of the work you desire to have covered. With this information in hand, he will proceed to lay out a film, and if it is planned to introduce some form of story, it will also be necessary to draft the scenario in which one or more scenes will be allowed for each process of manufacture, according to its relative importance. A "scene" is understood to refer to any portion of the film which can be made without moving the camera, and for unimportant details five feet of film may be made to suffice, while the showing of important processes may require as much as fifty feet of film. Where sub-titles are used, each word requires about one foot of film, so that, in addition to being unsatisfactory for the reasons already referred to, it will be seen that the introduction of many sub-titles involves considerable expense.

A competent camera man commands from $10 to $20 a day, and is paid for time when weather conditions delay the work of production, so the producer will include this item when making his estimate. Lighting conditions in a plant may be unsuitable for photographic purposes, and in such cases the producer will have to figure on installing a portable electric lighting outfit for doing his work. The producer must also figure on the cost of raw materials, waste footage of film, the work of developing negatives and printing positives, office expenses and overhead, to all of which he must add his own legitimate profit. Taking these items into consideration, the average cost of an industrial film is in the neighborhood of $1 a foot, or $1000 for a reel of average length. This only includes the work of producing and developing the negative, ten cents a foot being charged for each positive that is made. Whether more than one positive will be needed depends upon circumstances, but if the film is to be shown in various parts of the country at the same time, it will be necessary, of course, to arrange for a number of positives.

Fig. 6. Fire Drill

Fig. 7. Motion Study



Figs. 8 and 9. Drawing and Straightening Shelby Tubing

Fig. 10. Power Plant

The time required to complete the actual work of "filming" is frequently of the utmost importance, as delays caused in the rate of production in busy factories may be more important than the actual cost of making the film. The shortest possible time in which a camera man can record 1000 feet of film is eighteen minutes, but this does not allow for a single stop. Let us suppose the camera man is to show fifteen separate details for a one-reel picture, and that seven of these details are to be taken in the plant with the aid of a portable arc light to provide the necessary illumination. This means that he has to set his camera in fifteen different positions, but as he will frequently run a "close-up" as well as a full scene of each process, it will be seen that it is necessary to make thirty stops. He is trying to give good service and knows that if he hurries unduly and "shoots" the scene without planning the method of securing the best results, the final effect is likely to be extremely crude. If a single scene is unsatisfactory, it can be retaken; but if fifty feet of film is involved in this scene, it means an extra outlay of about $50. Based on the experience of those who have been making industrial films for some time, it is safe to say that five minutes for each scene is about the average time that camera man should take, so the making of a one-reel film should occupy about 1¼ hour.

Fig. 11. Mining Iron Ore used in making Shelby Seamless Tubing

Fig. 12. Bessemer Converters used in refining Steel

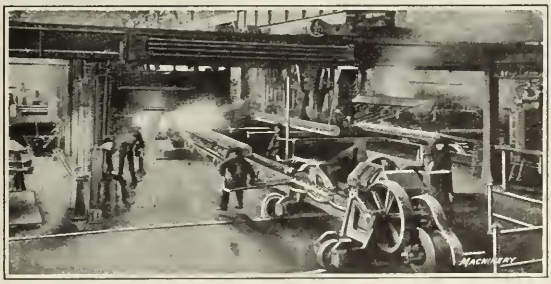


Fig. 13. Making Shelby Seamless Steel Tubing

Making films for the comedy or dramatic photoplay is more involved and expensive than for the work which has just been described. The first essential is to secure a good story, and based on his experience as a scenario writer, the author is prepared to say that a fee of $100 is not unusual for this part of the work. The writer of industrial motion picture scenarios must have a keen appreciation of advertising value and the ability to develop a dramatic incident to the maximum of its possibilities. After the idea has been developed, a cast of actors and a talented director must be employed to produce a play, if it is to have a distinct professional touch. It is probable that the interior of the plant cannot be used for some of the scenes, and this will incur the expense of fitting out a studio to resemble the plant's interior. The cost of producing such photoplays naturally varies with the different conditions which are encountered, but all the essentials mentioned should be provided at a cost somewhere between $1.25 and $3 per foot. This works out at a cost of $1250 to $3000 for producing a negative for a reel. When a negative has once been produced it is always available for use, but it is a mistake to permit a "print"—which is another name for a positive—to remain in constant use for more than six months, for after that period it generally enters the "rainy" stage, when it no longer leaves a good impression.

Equipping a Private Motion Picture Theater

There are several conditions which may make it desirable for a manufacturer to have a motion picture theater in his own plant. It has already been mentioned that some manufacturers—particularly builders of automobiles—find it desirable to show moving pictures for the benefit of their employes and of prospective customers. Then there are many factories that assist their employes in the maintenance of club rooms in the factory, and there are few forms of entertainment that will be more appreciated than good motion pictures. In either case, one of the first requirements is to provide a room in which pictures can be shown to the best advantage. In selecting space which can be converted into a satisfactory photoplay theater, the following points should be borne in mind. First, the room should be lofty, well ventilated and large enough to comfortably accommodate the full number of people who are likely to be present. Second, it should be free from all such obstructions as pillars and other supports. Third, it should be on the ground floor, as fire regulations in many states prohibit giving motion picture shows on the upper floors of a building. Fourth, there should be at least four exits, which must open outward in order to conform with fire laws. Fifth, it is advisable to divide the rows of seats into sections, so as to provide two aisles, one at each side; and these aisles should be not less than three feet wide.

If the building is constructed of wood, this does not necessarily make it unsuitable; but in order to guard against fire risks, the walls and ceiling should be covered with some form of fireproof material, such as metal ceiling. It is essential for the chairs or benches to be fastened to the floor as a precaution against congestion in the event of a fire panic; and it is customary to allow a floor space of four and one-half square feet for each person. Before installing a private theater, the best plan is to go over the details of installation with a representative of your fire insurance company, as ordinary fire insurance policies can hardly be expected to cover this special risk. In various parts of the country, fire underwriters insist upon the projection machine being enclosed in a fireproof booth, so that if there is an outbreak of fire, it will not spread to other parts of the building. This involves an expense of about $65, but the protection provided is well worth the investment. The booth is generally constructed of galvanized iron and made large enough to give the operator plenty of room to work; it is shipped in parts and may be easily set up with nuts and bolts.

The following outlines the best forms of projecting machines and gives their approximate costs: (1) The Edison "Kinetoscope" may be safely recommended, because it can be easily manipulated with little experience and stands up well under hard service; it is made in two models, one of which sells for $155 and the other for $250. (2) The distinguishing feature of the "Cameragraph" No. 6-A is that it is provided with a special device which lessens danger from fire; this machine costs $250. (3) The "Simplex" has many desirable features in its construction, which include simplicity of design and protection against fire hazards; the cost is $300. (4) The "Edengraph" is noteworthy on account of the fact that it

produces perfect projection when operated by an experienced attendant, several special features being provided that are not found on other machines; the selling price is $250. (5) The "Motiograph" is popular, owing to its durability and to the broad guarantee which is given to the manufacturers of this machine. In addition, there are several miniature machines on the market, but their use is limited because of the fact that it is only possible to obtain satisfactory results when the picture is thrown on a small screen located close to the machine. They are intended for use at home or for the use of traveling salesmen. Among a number of satisfactory equipments of this type, the following may be mentioned: (1) Bang's "Home Entertainer," which costs $70. (2) The "Baby Simplex," constructed on the same principles as standard machines and which is simple to operate; excellent results are obtained with the five- by seven-foot screen located twenty feet from the machine; the cost is $65. (3) The "Pathescope," which throws a picture six feet on a screen three by four feet in size; this instrument has been approved by the National Board of Fire Underwriters.

In operating a projecting machine it is necessary to use electric arc carbons, and these may be bought to best advantage in cases containing 1000. After providing the machine, the next point is to furnish a suitable screen on which to project the pictures. In the byegone days, a bed sheet or table cloth was used, but there are now special screens that give far more satisfactory results. Among these may be mentioned the Silver Fiber, which is superior to cloth screens in that no clouds or other defects appear on the film. The Silver Fiber screen and curtain are attached to a frame that may be easily placed in position; the material is sold at fifty cents a square foot, $20 being charged for the frame. Next comes the employment of a skillful operator to run the machine, for if the film flickers or gets out of focus, the audience is more than likely to become disgusted and leave before the entertainment has been completed.

A regular motion picture operator commands a salary of from $15 to $25 a week for an eight-hour day. A manufacturer may have a man in his employ who is well versed in electrical work, and it is often possible to have him taught the fundamentals of operating a motion picture machine, so that he will be able to combine this with his regular work.

In selecting a suitable lens, the size of the room, type of projecting machine, length and height of screen, and distance from operating booth to screen must be taken into consideration. It is false economy to purchase a cheap lens; and when ordering a lens the details just referred to should be given, in order that the order may be filled intelligently. The picture should be focussed exactly in the center of the screen to avoid the necessity of having spectators compelled to sit in an unnatural position. The standard speed at which pictures are projected is sixteen "frames" per second, and there are sixteen of these frames to each foot of film. The operator should be provided with a tool outfit which will include cement for mending broken films, files for sharpening carbons, an outfit of reels, and machine oil for lubricating all bearings and other running parts of the machine. Most motion picture machines are operated by electric light, but in those cases where electricity is not available, calcium carbide may be used to generate acetylene gas for the purpose. An acetylene generating outfit can be bought for $35, and it is important to note that the gas can be generated without provision of forced pressure; the generator can be put in operation in five minutes and has a capacity of generating gas with a candlepower of 700.

Selection of Suitable Films

Where a motion picture theater is provided in a factory to furnish entertainment for employes during the evenings, too much attention cannot be paid to the selection of those films that are likely to prove most entertaining. Out of the large number of films which are available every week, it is quite possible to select those which will provide a satisfactory program; and while there are both good and bad photoplays, the good ones predominate to such an extent that the selection is an easy matter. It is also important to note that the same film is of uniform quality, regardless of whether it is shown in New York City or in a small village in some rural community; there are no second-rate companies in the movies which are sent on the road. It is important, however, to note that films should be changed at regular intervals, for the spectator's interest cannot be held by a film which he has seen before. In most towns there is a film exchange from which the films may be rented, and while the average feature commands from $50 to $100 a day when it first appears, the price eventually drops to about $10. Films may be obtained at a considerably lower cost than the last figure mentioned, but they are not of a quality which will produce the same enjoyment as films which show the work of superior talent.

* * *

SELF-ANNEALING OF BRASS

It is a familar fact that hard drawn brass when held in storage for any considerable length of time shows a decided tendency to lose its hardness or spring temper. In a few cases where the temperature has been abnormally high, these changes have come about in a comparatively short time. In many instances where brass wire had been employed because of its hardness or spring temper, it became quite useless, although it had not been in active service, but was held in storage. In some lines of work where brass springs are used, the present tendency is to discard the brass and use steel springs which do not exhibit changes due to age.

W. Arthur of the Frankford Arsenal, Philadelphia, pointed out in a paper presented at the annual meeting of the American Institute of Metals, September 11-15, in Cleveland, Ohio, that in the manufacture of cartridge cases, self-annealing and seasoning cracking must be taken into consideration. It is often necessary to store ammunition for a number of years. Any deterioration due to age becomes a matter of grave concern. Since the walls of the cartridge case must be made quite thin owing to weight requirement, it is necessary to leave them with a hard drawn temper. The internal pressure to which they are subjected is very great. The necks of the cases must hold the bullet securely, and the head must not allow the primer to loosen. Any expansion of the case in firing would probably result in its sticking in the chamber of the gun. In the case of machine guns this is a serious matter.

Illustrations were shown of cartridge cases that had cracked while in storage; in one case, the head had cracked off entirely, while in another a longitudinal crack extended from the head one-third the length of the case. The significance of seasoning cracking and self-annealing is serious, and it should receive the best attention of metallurgists. It is to be hoped that the near future will bring forth data that will enable users of brass who have difficulties of this sort to cope with them more intelligently.

* * *

Electrochemical and electrometallurgical products enter into almost every phase of our industrial life, and their manufacture has been increasing by leaps and bounds. The chief products made by the aid of the electric current are aluminum, phosphorus, silicon, sodium, graphite, chlorine, oxygen, hydrogen, ferro-alloys, copper, titanium, vanadium and other alloys, calcium carbide, carborundum and other abrasives, caustic soda, caustic potash, sodium, peroxide, chloride of lime or bleaching powder, carbon bisulphide and muriatic acid. According to a report issued by the United States Bureau of Census, the value of electrochemical products has increased from $18,450,000 in 1909 to $29,600,000 in 1914, an increase of over $11,000,000. This does not include iron and steel made in the electric furnace, which also falls under this class. The extent to which we are dependent on electrochemical products is little realized. The manufacture of these products has been steadily increasing, but today the supply is far short of the demand, due in many instances to the inability to obtain permission from the government to use more power at Niagara Falls, the great electrochemical center. Of thirty-six establishments reporting in 1914 the manufacture of electrochemical products, eighteen were located in New York, four in Michigan, three in California, two each in Pennsylvania and West Virginia, and one each in several other states. Most of the plants in New York state are at or near Niagara Falls.

TABULATED TOOL DRAWINGS

SYSTEM OF MAKING DRAWINGS OF TOOLS AND KEEPING RECORDS OF TOOLS MADE

BY C. A. KUHN*

IN all large factories doing considerable tool work, as in the automobile line, there are many tool drawings which are of similar design but of varying dimensions. These tool drawings are principally of small tools, such as reamers, taps, arbors, gages, etc. Various methods are in use to prevent a duplication of drawings and at the same time provide the shop with adequate information for manufacturing the tools. One of the most simple of these in common use is to have a large sheet, showing at the top a drawing of the tool wanted, with letters designating the various dimensions, as shown in Fig. 1. The tabulations are filled in with all the necessary dimensions and give complete information as to sizes; then, when an order is issued for any tool shown on the drawing, sent to the tool-room as a working drawing. The confusion caused by the use of the previously mentioned system is eliminated when this method is used, but the other disadvantages remain, with the additional fault that mistakes are likely to be made in copying the entries on the print. These could be prevented, of course, by checking, but this entails additional work. Again, on some of the tools it is necessary to note an exceptional treatment, such as hardening, grinding, polishing, etc. To mark this on the master sheet would require a footnote or something similar. In making out the blocked-in prints, these notes are sometimes ignored, resulting in an incorrect tool. Another drawback to the system is that it is necessary to search for a desired entry, owing to the fact that

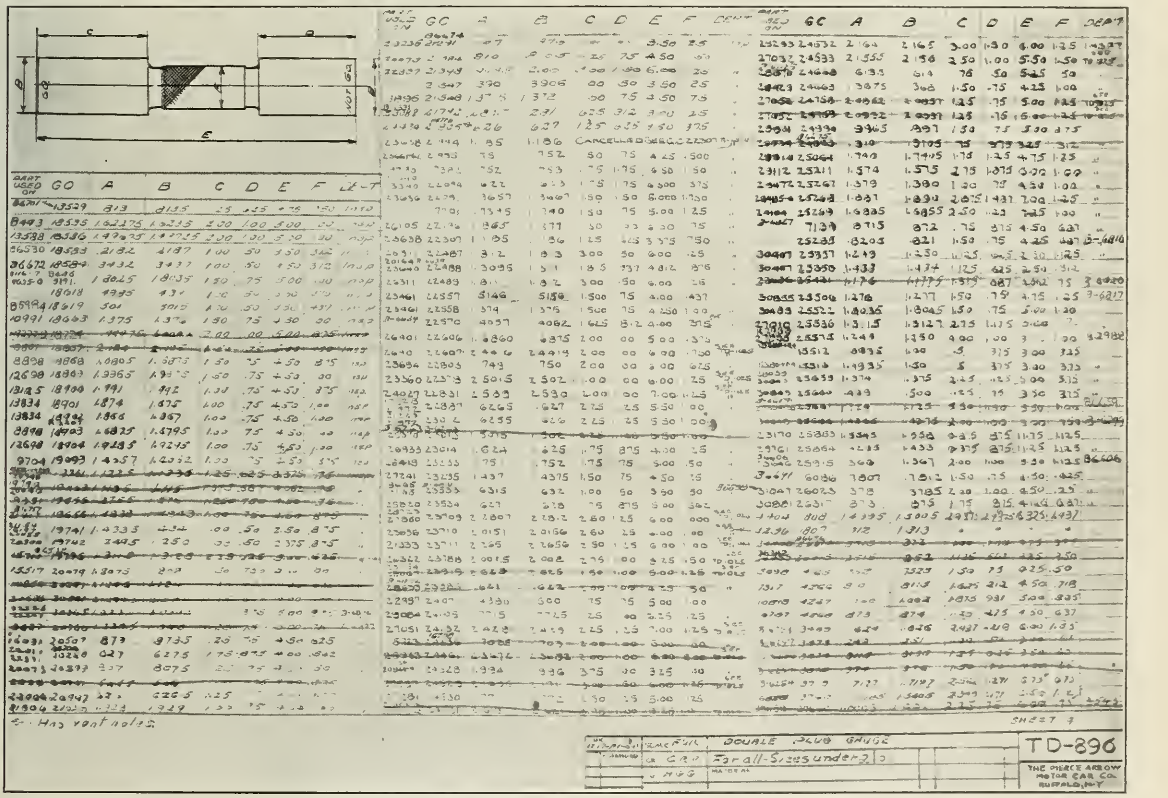


Fig. 1. Tabulated Drawing for Limit Plug Gage

the entire sheet is blueprinted and all entries are crossed out except those required.

This method, however, has its disadvantages, one of which is that in a short time the sheet becomes so crowded with figures that a draftsman, in looking it over, may pass by the dimension wanted and make an additional entry through failure to note the original. Another difficulty is that a draftsman cannot picture in his mind's eye just how the tool will look when completed. This is a serious fault, which has resulted in several freakish and unworkable tools being made. The tabulations also confuse the toolmakers and are objectionable to most of them.

Another system in vogue is to use the master tabulated sheet shown in Fig. 1 in the tool designing department only, and a blocked-in blueprint in the tool-room. Then when an order is issued for the tool-room, the various dimensions are copied from the master tabulated sheet and entered on the corresponding blank spaces shown in Fig. 2. This print is then

the entries are recorded in the order of issuing them and not according to size, which is obviously the information needed by the drafting-room in looking up data for any new work.

In order to eliminate all the objections and at the same time maintain a correct record of tools of this kind, the following system has been established in one of the country's largest automobile factories with good results. An individual tracing, as shown in Fig. 3, is made of each tool, and although this may seem unnecessary, it is really not as big a proposition as it appears, as most of the drawings are very simple. In the lower right-hand corner above the drawing number of the individual sheet, the number of the master sheet is recorded. The important dimensions (which are usually the diameter or length), as well as the number of the individual drawing and the distinguishing mark of the tool, are entered on a slip of paper and placed in a Rand visible file (see Fig. 4), which is used as a permanent record.

The construction of the panel units in this file is such that the celluloid tubes can be readily moved about and replaced

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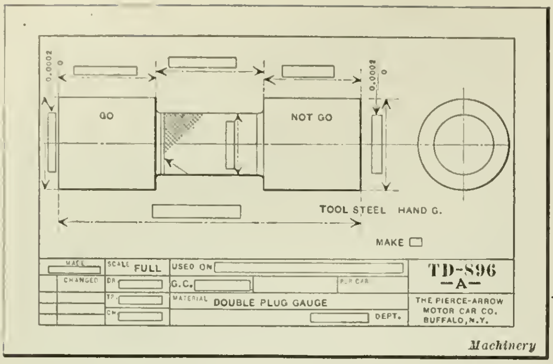


Fig. 2. Common Type of Blocked-in Drawing for Use in Shop

or removed entirely, as desired. The units used are hung on rings erected on a central standard. These rings have a number of holes in which the hinges of the panel units swing. The rings can be changed and larger ones substituted, so that more panels can be used when necessary, and expansion can thus be readily taken care of as the index grows. The file at present consists of forty sheets, in connection with the standard for the index. The method of making the entries is extremely simple, as they can be made in less than a minute on the typewriter and are easily read. The slips are filed in order of size, so that any entries can be found in a minimum amount of time. Should an entry be cancelled, it is a slight matter to remove the slip and advance all remaining entries to fill the vacant space. This system works out very satisfactorily without having any of the disadvantages incident to the method mentioned in the foregoing, and being capable of expansion, it may be continued indefinitely.

Doubtless the writer may be criticized to some extent for advocating a separate drawing for each piece of work; in defense of this, the following statement is made. It has been found by experience that in order to have tools made that are suitable for manufacturing a certain part, it is necessary for the draftsman to make an individual drawing of each, in order to obtain the correct proportions. This necessitates at least a pencil drawing to scale, from which the dimensions may be transferred to the master sheet. To make a tracing of this tool drawing does not require more than an hour or so. In a factory the size of the one using the system referred to, the number of orders for these so-called tabulated tools is so large that the amount of time consumed in entering the dimensions on a blocked-in print would soon be considerably greater than that required to make a tracing. These tracings are checked and placed in a file so that they can always be used for reference. There is also an added advantage if some existing tool is to be used, as this can be easily determined by reference to the tracing. This is more apparent on manufacturing than on inspecting tools, but as the system mentioned covers 106 different types, something equally satisfactory for all must be used, which requirements are filled by this system.

* * *

Parts of machines that are under bending stress when in use and that must fit adjacent parts, should be fitted when possible under the same conditions as when in use. For instance, the tool clapper of a planer, though usually a heavy cast-iron block, is appreciably distorted when the four clamping bolts are set up tightly on a tool. If the clapper were made to fit closely in the box with no stress on the clamping bolts it would probably stick when a tool was fixed in place. Hence the desirability of first clamping a piece firmly on the clapper before scraping the sides.

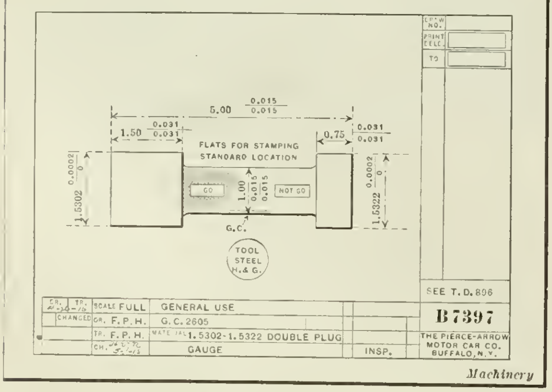


Fig. 3. Simple Drawing of Plug Gage

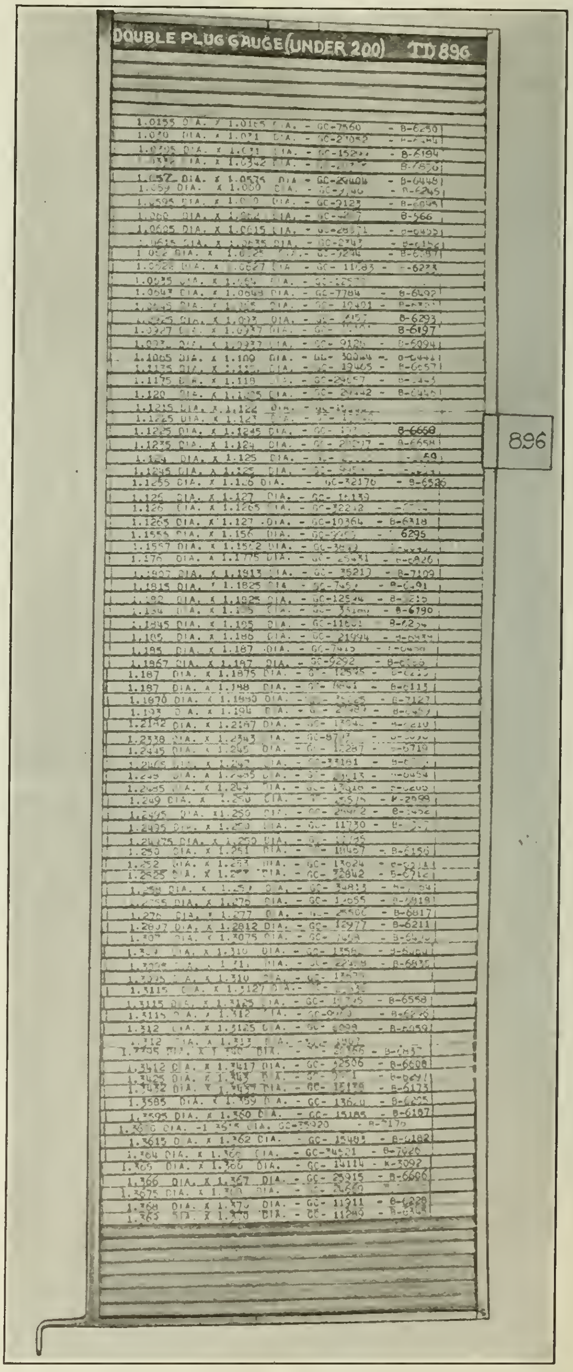


Fig. 4. One Unit of Permanent Filing System used for Tool Work

MACHINE TOOL BUILDING CHART

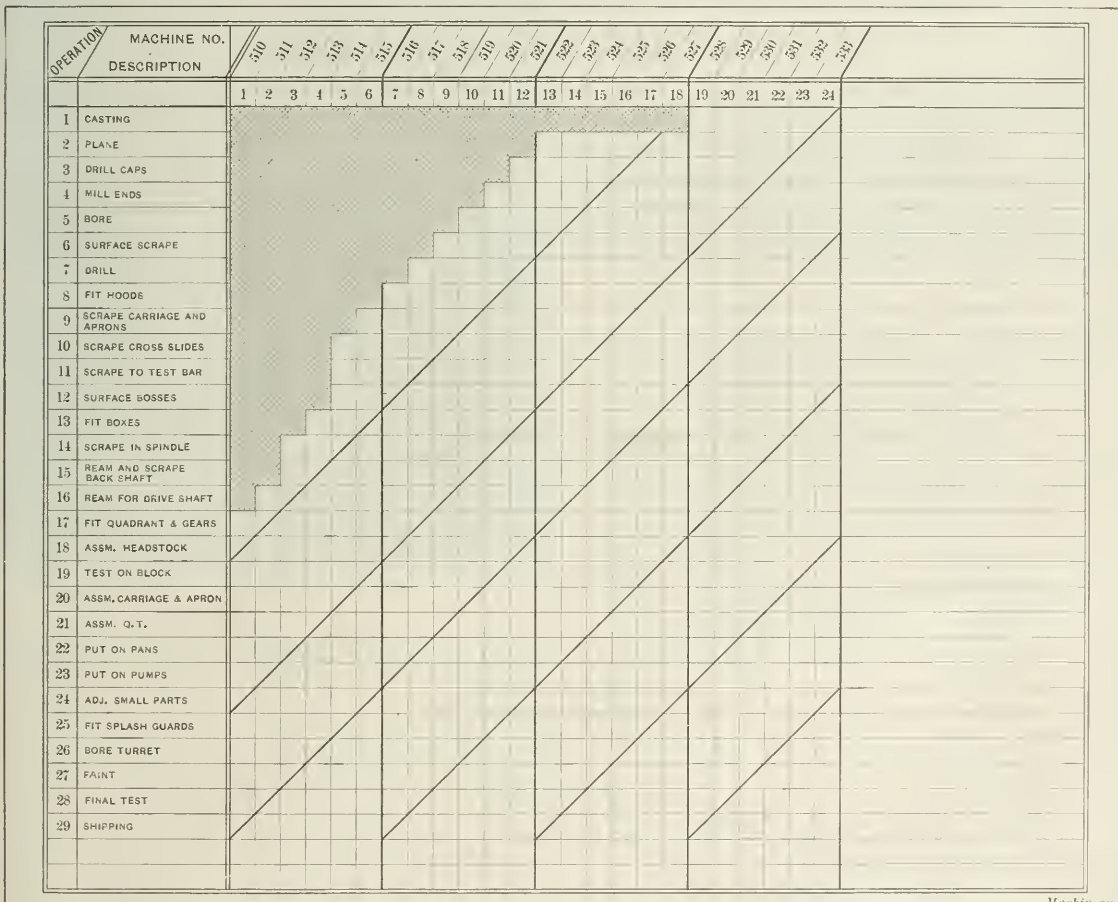
There are several ways of keeping track of the conditions of production in the shop when building machines in lots. But no matter how good a system is employed, it is desirable to have some graphic means of showing the daily progress to the superintendent or general manager. The board or chart that shows graphically progress and delays from day to day of operations acts as a spur on the manager, who, in turn, is likely to stimulate the activity of the men and thus bring the lagging work up to date.

The accompanying chart shows the plan of a large blackboard installed in the office of C. L. Libby, superintendent of the International Machine Tool Co., Indianapolis, Ind., to facilitate the production of the Libby turret lathes. At the left of the chart are the principal operations arranged substantially in the order in which they are generally done. These consist of casting, planing, drilling caps, milling ends, boring, surface scraping, drilling, fitting hood, scraping carriage and apron, scraping cross-slide, scraping to test bar, surfacing bosses, fitting boxes, scraping in spindles, reaming and scraping back-shaft, reaming for drive-shaft, fitting quadrant and gears, assembling headstock, testing on block, assembling carriage and apron, assembling turret, putting on pan, putting on pump, adjusting small parts, fitting splash guard, boring turret, painting, final testing, and shipping. At the top are the serial numbers of the turret lathes being put through.

Now suppose that a lot of twenty-four lathes is going through the shop. The first action is getting the castings from the foundry, and the chart shows that eighteen castings have been delivered, eighteen of the squares of the chart having been chalked in. The chart also shows that twelve of the castings have been planed, eleven have been drilled for the cap-screws, ten have been milled on the ends, nine have been bored, and so on. If one of the castings develops serious defects after being planed, drilled, milled or bored, it is rejected and the space on the casting line is erased until a new casting has been obtained to fill its place.

It will be noticed that the last operation that has been filled in is No. 16, "reaming for the drive-shaft," and this has been done on one machine only. No operations have been completed on the succeeding line. The general contour of the filled-in spaces approximates that of a 45-degree right-angle triangle. When the operations go through practically in the order planned and everything follows without serious hitch, this plan of progression is carried on throughout. In other words, the operations completed will be about in the order indicated by the diagonal line, and as the operations on a lot are completed they flow off the sheet at the lower right-hand corner, shipping being, of course, the last job.

Mr. Libby posts himself each day on the conditions of work in the plant, then returns to his office and with chalk fills in the squares of the operations completed. By this operation, he impresses on his mind the condition of work in the plant and at the same time makes a record for reference during the day. The record also acts as an incentive to everyone connected with the production department; when one of the foremen comes into the general manager's office and sees the conditions of the chart wherever his department is concerned, he is likely to spurt up if that section shows perceptible lagging behind the general ideal contour of the operation sheet.



Production Chart used by International Machine Tool Co. to record Progress in building Machine Tools

Another feature of the management of the International Machine Tool Co.'s plant is a shop "thermometer" placed over the gallery in the machine shop where it can be seen by all. This thermometer registers the monthly production and indicates the possible bonus to be earned. The average produc-

tion of machines is between twenty-five and thirty monthly. Should the production for three months average thirty a month, or ninety for the thirteen weeks, the shop bonus would be $4000. It drops quickly to $1600 when the production falls to seventy-eight.

The shop bonus plan stimulates cooperative work; instead of some of the heads of departments being at sword's points and trying to "do" one another, they feel that they must work for the common good if the shop is to earn the highest possible bonus in the three months' period.

* * *

URANIUM HIGH-SPEED STEEL TESTS

The Standard Alloys Co. of Pittsburg, Pa., has submitted tests of uranium high-speed steel lathe tools made under the direction of the Standard Chemical Co. on a commercial scale in a number of large shops in the Pittsburg district. The effect of uranium in high-speed steel alloys is claimed to be a remarkable increase in cutting efficiency and durability. The following report of tests of uranium high-speed steel in comparison with regular high-speed steel in common use is given below. The tools marked A, B, C and D are made of regular high-speed steel, while those marked Ua, Ul, U2, etc., are made of uranium high-speed steel. The regular high-speed steel tools were all made from the larger sizes of bars, while the largest uranium tool measured only 1 by 2 inches.

Tool Symbol	Feed, in Inches	Speed, Feet per Minute	Depth of Cut, in Inches	Length Turned before Grinding Tool, in Inches
Material, Locomotive Axle, 0.40 Per Cent Carbon				
Ua	3/32	103	3/8	5
A	3/32	103	3/8	2
Material, Locomotive Crankpin, 0.40 Per Cent Carbon				
Ua	1/16	74	5/8	12
A	1/16	74	5/8	2
Ua	1/16	64	5/8	8
A	1/16	64	5/8	2
Material, 12-inch Shaft, 0.50 Per Cent Carbon				
Ul	1/16	75	1/4	17
B	1/16	75	1/4	4
D	1/16	75	1/4	1
Material, 8-inch Shaft, 0.40 Per Cent Carbon, 89 Inches Long				
Ul	1/16	51	5/8	178[1]
C	1/16	35	5/8	7/8
Material, 6-inch Shaft, 0.40 Per Cent Carbon				
Ul	1/32	75	5/8	18
U2	1/32	75	5/8	24[2]
B	1/32	75	5/8	11
Material, 10-inch Shaft, 0.40 Per Cent Carbon				
U4	1/16	60 to 65	5/8	8
U2	1/16	65	5/8	7 1/2[3]
Material, 12-inch Shaft, 0.40 Per Cent Carbon				
Ul	3/64	55	5/16	16
U5	3/64	55	5/16	15
B	3/64	55	5/16	2 1/2
Material, 12-inch Forging, 0.40 Per Cent Carbon				
U8	1/16	45	5/8 to 3/4	87[4]
U8	1/16 to 1/10	38	15/16	127[5]
U8	1/16	60	1 1/16	12

The uranium high-speed steels used in the foregoing tests have a uranium content ranging up to 1.02 per cent.

* * *

It has been estimated that a tunnel under the English Channel can be constructed for $80,000,000. Its advocates claim that of the 2,000,000 passengers who crossed the channel in both directions during the year, at least 65 per cent, or about 1,300,000 would use the tunnel. So if each were charged 10s. ($2.40), the income from this source would be $3,120,000 a year. Adding to this $325,000 for the transportation of baggage, $200,000 for postal service, and $4,000,000 for freight traffic, the total revenue would be $7,645,000. Allowing for running expenses $2,000,000 per annum, this would leave $5,645,000 as the annual net earnings.

[1] The tool was run over the shaft twice and the depth was changed to 5/8 inch on the second cut.
[2] Speed increased to 90 feet per minute after cutting 13 inches; ran 11 inches further without breaking down.
[3] The speed was increased to 80 feet per minute after running 4 inches, and the tool traveled 3½ inches further before breaking down.
[4] The tool was working most of the time with the nose in scale.
[5] The cutting time was three hours, and after cutting 105 inches the speed was increased to 65 feet per minute. The tool continued to cut for 22 inches before breaking down.

GRADUATING ON THE GEAR SHAPER

The fact that the Fellows gear shaper built by the Fellows Gear Shaper Co., Springfield, Vt., may be used effectively for graduating circles is not generally known, and the practice of the Cleveland Machine Tool Co., Cleveland, Ohio, which uses a Fellows gear shaper for graduating the circles of the circular attachment provided for the Cleveland horizontal boring machine, will be of general interest.

Fig. 1 shows a regular Fellows gear shaper set up for graduating the periphery of a 30-inch Cleveland circular table. The graduation marks required are three in number, a full line

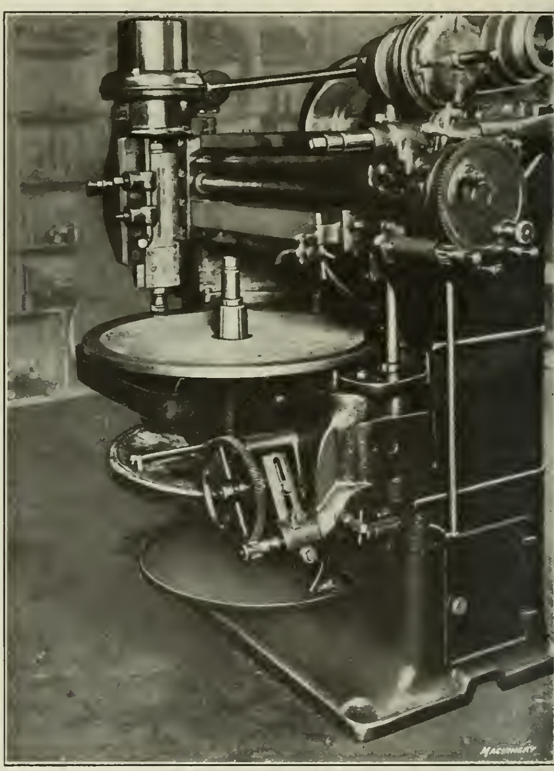


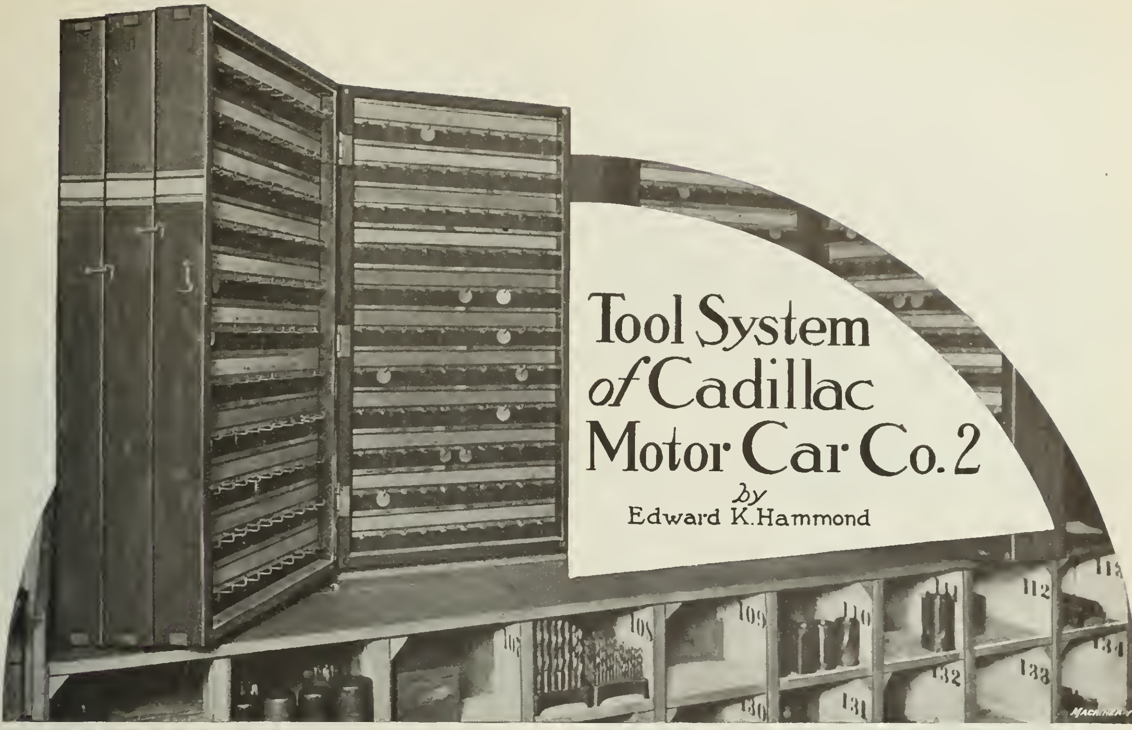
Fig. 1. Graduating Circular Table with a Fellows Gear Shaper

being used for the degree markings, which are designated 0, 5, 10, 15, 20, 25, etc.; the intermediate degrees are marked with shorter lines, while the half degrees are marked with still shorter lines.

Fig. 2 shows the cutter used for graduating. For this case the cutter is made with forty teeth and has a diameter of 1.667 inch. The diameter of the table to be graduated is 30 inches, the ratio of the two diameters being as 1 to 18. The number of graduations required on the periphery is 720; therefore, the graduating cutter must be geared to rotate eighteen times while the work revolves once. Fig. 2 shows how the cutter is made: the long lines for the degrees marked 0, 5, 10, 15, etc., extend clear to the end of the cutter; the intermediate degree line teeth are ground off so that the length cut is about two-thirds of that of the marked degrees, while the half degrees are ground back still further.

Fig. 2. Cutter used for graduating on Shaper

In operation, the cutter works exactly the same as though cutting teeth, except that no tooth curves are generated. The teeth in the cutter are sharp vees, and the depth of cut, of course, is only a few thousandths inch. This method of graduating circles is efficient, the time being only about one-fourth that required when cutting the same graduation on a milling machine. Moreover, the operation is automatic, practically no attendance being required.



Tool System of Cadillac Motor Car Co. 2

by
Edward K. Hammond

IN dealing with the ordering, making, distributing and accounting of all such special tools as jigs and fixtures, the problem of the maintenance supplies and tool service department is somewhat different from that encountered in handling standard commercial tools, although the basic problem is the same. As in the case of commercial tools, the point of primary importance is to see that all shops are kept supplied with the tools which they require without any delay in delivery. What was said in regard to the work of the department in handling standard tools applies equally to the work of dealing with special tools, in so far as commercial considerations are concerned. It is obvious that the work of the department must be carried on along the most economical lines, and that careful records must be kept of all tools to see that they are not lost or damaged while in use. The chief distinction between the work of the maintenance supplies and tool service department in handling special tools and commercial tools is that the former is largely a problem of toolmaking, while the latter is a question of purchasing tools under the most advantageous terms. The following article outlines the work of the department in the ordering, making, distributing and accounting of special tools.

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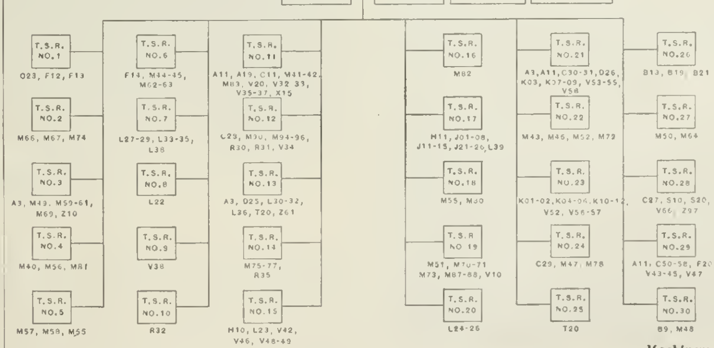


Fig. 1. Diagram showing Relationship of Maintenance Supplies and Tool Service Department to Other Departments of Factory of Cadillac Motor Car Co.

In order to explain the operation of the system which is used, it will doubtless be the best plan to start from the point where the engineering department has approved the design of a part for an automobile of a new model, and has authorized the making of tools for use in its manufacture. The authorization of the engineering department for the making of all special tools is issued on one of the forms reproduced in Fig. 2. One copy is sent to the office of the tool engineer, accompanied by a set of drawings of the new car part, and it is his work to design all special tools which will be required in manufacturing this part. The first step taken by the tool engineer is to compare the new part with the car part which it supersedes, in order that use may be made of any special tools by making certain changes in their construction. The points governing the decision as to whether old tools are to be made over or whether it is necessary to design entirely new tools for the purpose are details of the work of the tool engineer which do not properly come within the scope of the present article.

In any case a complete set of tool drawings will be made, the method of procedure being for the tool engineer to study the part to be machined, decide upon the methods of machining to employ, and then make rough sketches of the tools which are followed

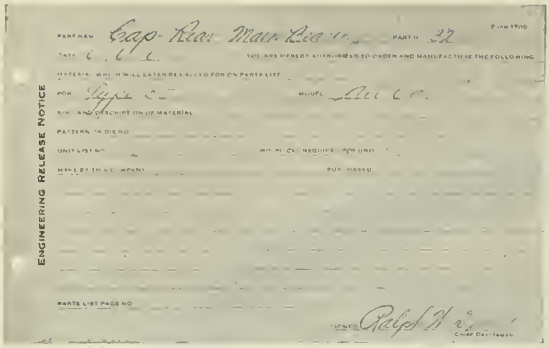


Fig. 2. Form used by Engineering Department in authorizing making of Tools for Use in manufacturing Car Parts of a New Model; Size 8 by 5 Inches; One Copy on Blue Stock

by the draftsmen in making the final tool drawings. The decision as to whether new tools are to be made, or the construction of existing tools modified to meet the new requirements, will govern the procedure of the tool engineer in issuing orders for tool drawings. The form which he uses is shown in Fig. 3, and reference to this illustration will make it evident that provision is made for ordering new drawings or making changes in existing drawings by either crossing out the word "make" or "change," so that the order will meet the requirements of existing conditions.

The tool order is made out in quadruplicate. The first and second copies are sent to the drafting-room, and the first copy

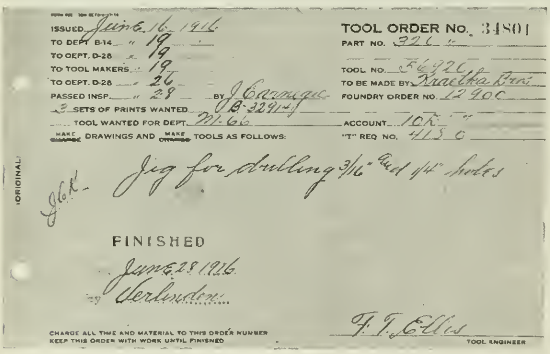


Fig. 3. Form used by Tool Engineer in ordering Tool Drawings and Tools; Size 8 by 5 Inches; Four Copies on White, Blue, Yellow and Red Stock

remains with the work until the tools have been completed. The second copy is a drafting-room memorandum which represents the authority of this department to make the tool drawings; and after such drawings have been completed the memorandum is filed for future reference. The third copy is the tool engineer's memorandum of the transaction; this copy is kept in his "drafting-room file" until the drawings have been completed, after which it is transferred to the "tools being made file" until the work has been finished. The fourth copy of the tool order is sent to the office of the maintenance supplies and tool service department, where it is classified under the proper account; and the job is then entered on a list

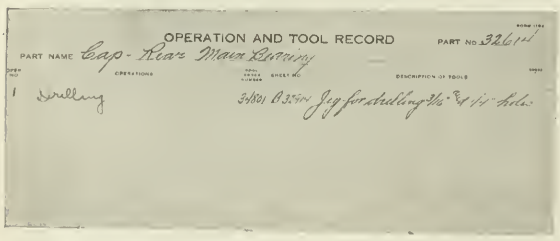


Fig. 4. Form used by Tool Engineer in maintaining Permanent Record of Machining Operations and Tools on all Car Parts; Size 10 by 8 Inches; One Copy on White Stock

of tool order numbers with their classifications, which is sent to the time office for its guidance in classifying time tickets and material orders. The fourth copy of the tool order is then sent to the foreman of the department which will make the car part that requires the use of the special tool in its manufacture, this memorandum merely serving as a notice to the foreman that his future tool requirements are being cared for.

When the tool engineer decides that a tool should either be made or changed for use in machining a certain part, and has written a tool order covering same, an entry is made on a permanent record which is kept on cards of the form shown in Fig. 4. It will be seen that this form is laid out with spaces at the top for the number of the part that the special tools are used to manufacture, and the name of this part; the part

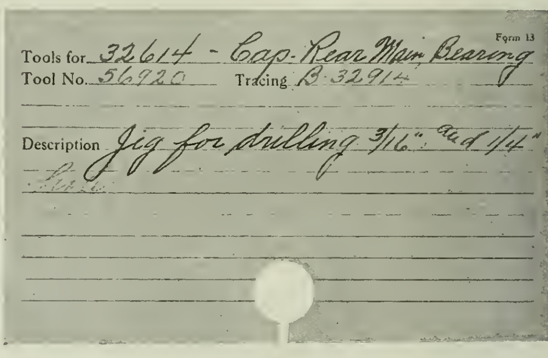


Fig. 5. Form used by Drafting-room in keeping Record of Drawings and Blueprints of Tool Drawings; Size 5 by 3 Inches; One Copy on Yellow Stock

number serves as the key by which the permanent record card is filed. The lower space on this form is laid out with sections for the operation numbers, the names of the operations, the tool order numbers on which the tools were made, the tool drawing numbers and descriptions of the tools. A brief consideration will make it evident that this card represents an outline of the machining operations performed on the part in question, and a list of all tools used in handling the work, so that by referring to this permanent record the tool engineer is able to give information in regard to all operations and tools which he has recommended for use in any given case. A similar record, though less complete than that kept by the tool

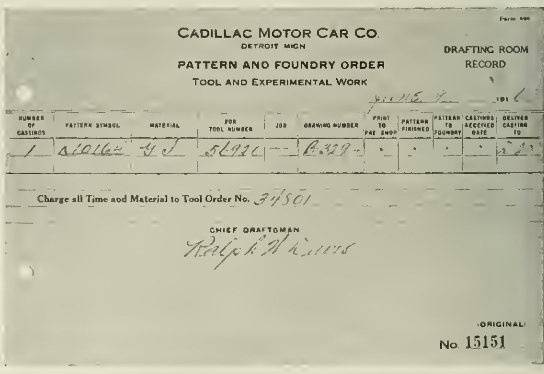
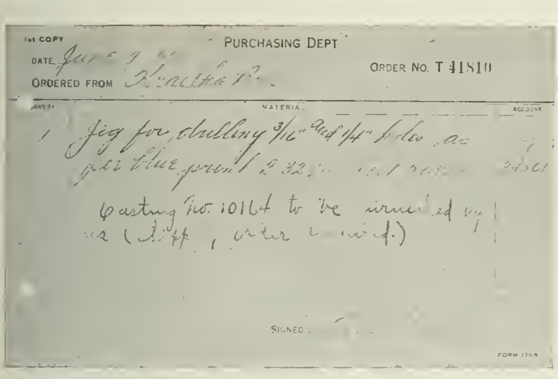


Fig. 6. Form used by Drafting-room in ordering Patterns and Castings; Size 8 by 5 Inches; Five Copies on Pink, Green, White, Yellow and Blue Stock

engineer, is maintained by the drafting-room for the purpose of locating the tool drawings for tools used in manufacturing any given part. At the time the first and second copies of the tool order are received in the drafting-room, a card is made out for the drafting-room file on a form shown in Fig. 5. These cards are filed by the part number, and when an inquiry is made in regard to tool drawings, this file enables the drawings to be located without delay.

Ordering Patterns and Castings

It will be obvious that the making of such special tools as jigs and fixtures will call for the use of a variety of patterns and for castings made from these patterns. Ordering these patterns and castings is part of the work of the drafting-room, the orders being issued as soon as a decision has been reached in regard to the final design of the tools. The form used by the drafting-room in ordering patterns and castings is shown in Fig. 6, five copies of this form being required. The first of these is a drafting-room copy which is kept in a temporary file until the patterns and castings have been completed, after which it is transferred to a permanent file where it is available for future reference. The second and third copies are sent to the pattern shop, and the first of these represents an order for making the patterns. The third copy is also kept in the pattern shop until the work has been completed, and at

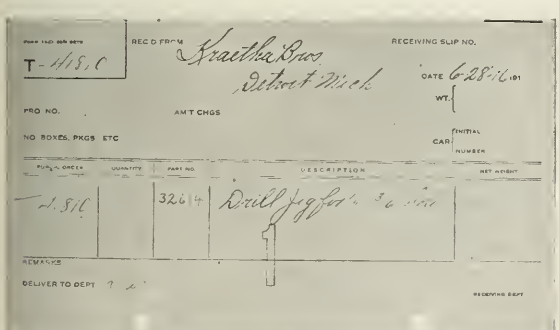


1st COPY PURCHASING DEPT
DATE June 9
ORDERED FROM Kraetke Bros.
ORDER NO. T 41810
QUANTITY MATERIAL
1 Jig for drilling 3/16" and 1/4" holes as per blue print
Casting No. 10164 to be furnished
SIGNED
FORM 1266

Fig. 7. Form used by Maintenance Supplies and Tool Service Department to authorize ordering of Special Tools made by Outside Concerns; Size 8 by 5 Inches; Five Copies on Yellow, Pink, Blue, White and Green Stock

this time it is sent on to the foundry with the patterns, the form representing an order to the foundry to make the required castings. The fourth copy of the form is sent to the maintenance supplies and tool service department, where it is placed in a "current file" until the castings are received on a shipping order, after which they are delivered to the tool department. The fifth copy is sent to the tool-room, the purpose being to notify the foreman of this department that the castings have been ordered for making the tools; and as soon as the castings are received, the memorandum is destroyed.

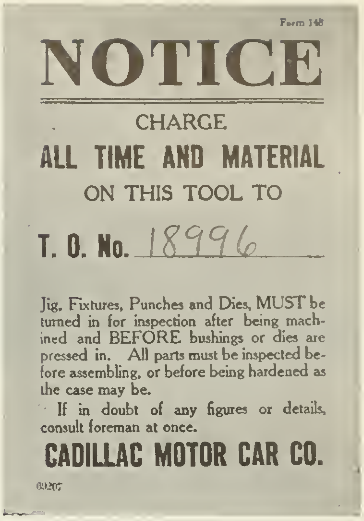
When the necessary drawings for a tool order have been completed in the drafting-room, the first copy of the tool order,



T-41810
REC'D FROM Kraetke Bros. Detroit Mich.
RECEIVING SLIP NO.
DATE 6-28-16
PRO NO. AM'T CHGS WT.
NO BOXES, PKGS ETC CAR INITIAL NUMBER
PURCH. ORDER QUANTITY PART NO. DESCRIPTION NET WEIGHT
41810 32614 Drill Jig for
REMARKS
DELIVER TO DEPT RECEIVING DEPT

Fig. 8. Form used by Receiving Department in recording Receipt of Tools from Outside Firms and Castings from Foundry; Size 8½ by 5 Inches; Three Copies on White Stock

Fig. 3, is returned to the tool engineer, who decides who shall make the tools called for. When a decision has been reached, he makes a notation on the order form in the space provided for that purpose and forwards the form, accompanied by two sets of blueprints of the tool drawings, to the tool order clerk in the maintenance supplies and tool service department. The tool order clerk makes an entry in a "tool order" record book by order number, and also records the blueprint in a "blueprint" record book with a notation of the tool order number. The tool order book is ruled in such a way as to provide spaces to show tool order number, tool number, date on which the order was received by the maintenance supplies and tool service department, quantity required, foundry order number, blueprint number, purchase order number if ordered from an outside firm, symbol number of car part on which tool operates, description of tool and by whom made, as well as date completed.

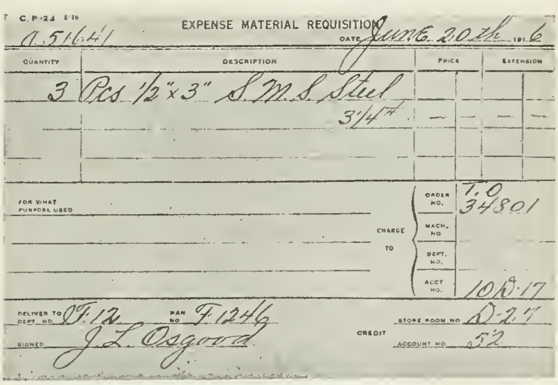


Form 148
NOTICE
CHARGE
ALL TIME AND MATERIAL
ON THIS TOOL TO
T. O. No. 18996
Jig, Fixtures, Punches and Dies, MUST be turned in for inspection after being machined and BEFORE bushings or dies are pressed in. All parts must be inspected before assembling, or before being hardened as the case may be.
If in doubt of any figures or details, consult foreman at once.
CADILLAC MOTOR CAR CO.

Fig. 9. Form pasted on Backs of Blueprints, constituting Order to Cadillac Tool-room to make Tools; Size 3 by 4¼ Inches; One Copy on White Stock

The blueprint record book shows the sheet number of the blueprint, with all order numbers pertaining to that print.

After the entries have been made in the tool order record book and the blueprint record book, the tool order, Fig. 3, with one complete set of blueprints, is turned over to a stenog-



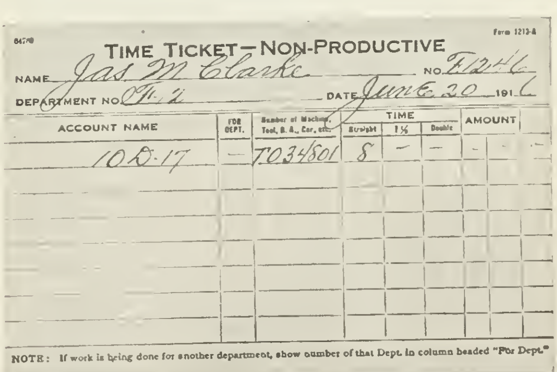
C. P.-24
EXPENSE MATERIAL REQUISITION
A 51641 DATE June 20th 1916

QUANTITY	DESCRIPTION	PRICE	EXTENSION
3	Pcs ½" x 3" S. M. S. Steel 3/4"	—	—

FOR WHAT PURPOSE USED
CHARGE TO: ORDER NO. T.O. 34801; MACH. NO.; DEPT. NO.; ACCT NO. 10 D 17
DELIVER TO DEPT. NO. 0F 12 MAN NO. F 1246
STORE ROOM NO. D 27
SIGNED J. L. Osgood CREDIT ACCOUNT NO. 52

Fig. 10. Form used by Tool-room Foreman in ordering Materials required for making Tools; Size 6 by 4 Inches; One Copy on Yellow Stock

rapher who writes a "T-requisition" on the purchasing department if the tool is to be ordered from an outside firm; and in all cases, the stenographer makes a complete set of record cards to be used as permanent records when the tool



Form 1213-A
TIME TICKET—NON-PRODUCTIVE
NAME Jas M Clarke NO. F 1246
DEPARTMENT NO. 0F. 2 DATE June 20 1916

ACCOUNT NAME	FOR DEPT.	Number of Machine, Tool, B. A., Car, etc.	TIME Straight	TIME 1½	TIME Double	AMOUNT
10 D 17	—	T.O. 34801	8	—	—	—

NOTE: If work is being done for another department, show number of that Dept. in column headed "For Dept."

Fig. 11. Form used by Tool-room Foreman in reporting Labor Charges on Tools to Cost Accounting Department; Size 6 by 4 Inches; One Copy on Blue Stock

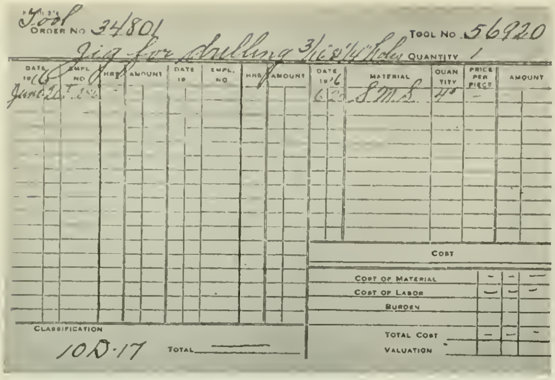


Fig. 12. Form used by Cost Accounting Department in recording Labor and Material Charges on Tools; Size 6 by 4 Inches; One Copy on Green Stock

has been completed, as outlined in detail in subsequent paragraphs. This set of record cards consists of those shown in Figs. 12, and 14 to 22. These cards, with the exception of the one shown in Fig. 12, are filed in what is known as the "shop box file" and are cross-indexed by tool and part symbol numbers, until the tool has been finished, at which time they are distributed to various permanent record files as explained later. The card shown in Fig. 12 is filed by the tool order number in what is called the "cost file," and all time, material and invoices pertaining to that particular tool order are posted thereon from time to time.

Ordering Tools Made by Outside Shops

The Cadillac Motor Car Co. has adopted the commonly used plan of having certain classes of work done by outside shops,

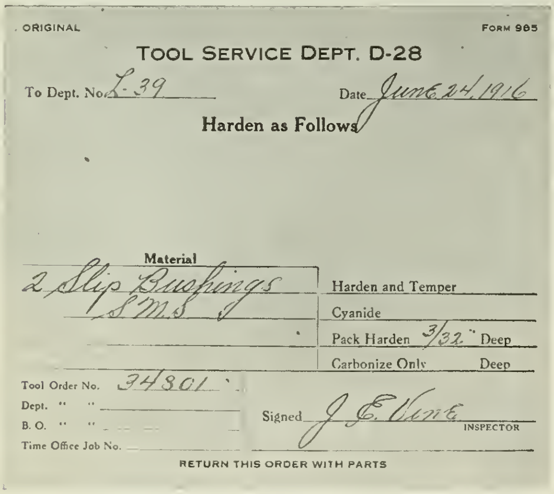


Fig. 13. Form used by Tool-room Foreman in ordering Heat-treatment of Tools; Size 6 by 5½ Inches; Three Copies on White, Pink and Blue Stock

and some of the tool work is handled in this way. The variety of cases which are dealt with naturally introduces a number of different conditions, but it frequently happens that castings for a jig or fixture will be made in the Cadillac foundry, and these castings will then be sent out for use in making the required tools. For the purpose of discussion, this condition will be assumed in describing the method of procedure which is followed. In connection with the article describing the practice in the purchase of standard commercial tools, it was mentioned that the maintenance supplies and tool service department has jurisdiction over all purchases of tools and other manufacturing supplies, the plan being for this department to make recommendations which are followed by the purchasing department in the actual issuing of orders. We will assume that it is required to order an outside firm to make a jig for drilling 3/16- and 1/4-inch holes in a given part, and that the casting for this drill jig is to be furnished by the Cadillac company. The maintenance supplies and tool service department will proceed by issuing a "T-requisition" to the purchasing department, calling upon it to order this work done, and the firm which is to do the work will be specified for the guidance of the purchasing department.

Fig. 7 shows the memorandum which is made out, and reference to this illustration will show that in addition to a description of the tool required, a notation is also made of the fact that the casting is to be furnished by the Cadillac company. Five copies of this form are required. The first is sent to the purchasing department, where it is used in issuing a regular purchasing order. The second copy is held in a "temporary file" on the desk of the tool order clerk in the maintenance supplies and tool service department, and when the order has been filled, this form is stamped "Filled," initialed

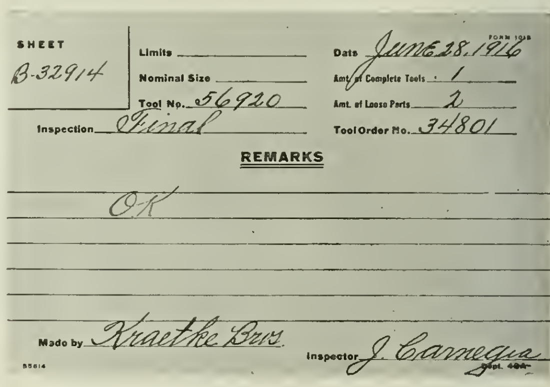


Fig. 14. Form used by Inspectors in reporting Results of Inspection of New Tools; Size 6 by 4 Inches; One Copy on White Stock

by the clerk, and filed for future reference. The third copy goes to the inspector in the maintenance supplies and tool service department to serve as a reminder that the tool is coming through and must be inspected in due course. After the inspection has been made and the tool found to be up to specifications in every way, this inspector's copy is destroyed and a permanent inspection card placed on file. The fourth copy is sent to the foreman of the department in which the tools are to be used, to serve as a further notification to him that his requirements are being cared for. The fifth copy is used by the tool "chaser" whose duty it is to follow up each order and see that it is progressing satisfactorily. When the tools are delivered to the factory, the receiving department makes out a receiving slip, using the form shown in Fig. 8, and the tools, together with this form, are sent to the inspector in the maintenance supplies and tool service department. This slip is signed and returned to the receiving room, where it serves as a receipt for the tools which have been delivered to the inspector. When the tools have been delivered, the tool

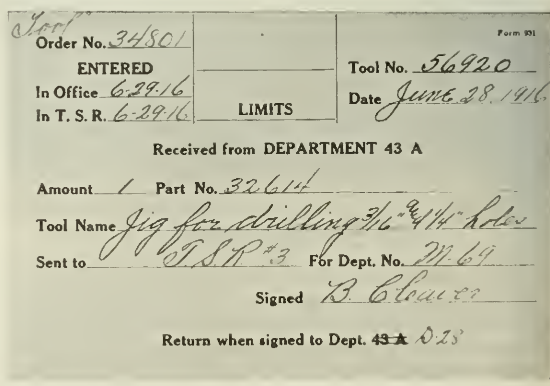


Fig. 15. Form used by Maintenance Supplies and Tool Service Department in obtaining Receipt from Tool Supply Rooms for New Tools; Size 6 by 4 Inches; One Copy on Blue Stock

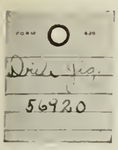


Fig. 16. Check Board Tag

chaser's interest in them ceases, and as soon as he has been assured of the fact, he can destroy his copy of the T-requisition slip.

It should be noticed that on the right-hand side of the form shown in Fig. 7, a column is provided to show the account to which the tool is to be charged, and in this column is a notation of the tool order number. This is shown for the guidance of the book-keeping department, to insure the invoice being forwarded to the maintenance supplies and tool service department to have the price O.K.'d, classified and posted on the cost card, Fig. 12, which is filed in the maintenance supplies and tool service department—by tool order number before the tool is completed, and by tool number after it has been completed.

Making Tools in Cadillac Tool-room

The description given in the preceding paragraphs refers to a case where it was decided to have the tool made by an outside firm; and it will be recalled that in issuing the order

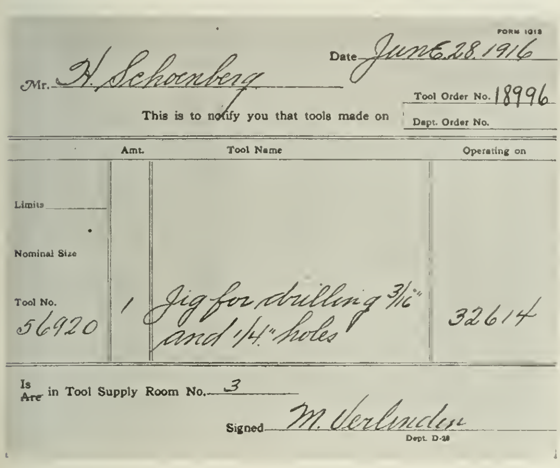


Fig. 17. Form used by Maintenance Supplies and Tool Service Department in reporting to Shop Foreman on Delivery of New Tools to his Tool Supply Room; Size 6 by 4⅞ Inches; One Copy on Blue Stock

for making the tool, the maintenance supplies and tool service department sent a "T-requisition" to the purchasing department, making use of the form shown in Fig. 7. But it does not always happen that tools are sent out to be made; in many cases the work is done in the tool-room maintained by the Cadillac Motor Car Co., and when handled in this way the method of procedure is slightly different. Instead of issuing orders to the purchasing department, as soon as the tool order and drawings have been received in its office, the maintenance supplies and tool service department proceeds by entering the proper tool order numbers on gummed labels shown in Fig. 9 and pasting one of these labels on the back of each tool drawing. The drawings are then sent out to the foreman of the tool-room, and their receipt is regarded as an order to proceed with the making of the tools. The way in which castings have been handled has already been described, and it will be assumed that the castings are available for use in the tool-room. The first copy of the tool order, Fig. 3, is sent to the tool department and kept with the work until completed, after record cards have been made by the stenographer, as previously explained.

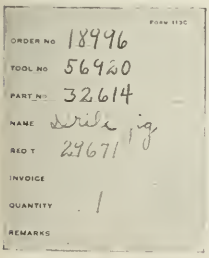


Fig. 18. Form used in reporting Completion of Tools to Cost Accounting Department

Other materials required for making the tools are ordered by the tool-room foreman on requisition slips of the form illustrated in Fig. 10. It will be seen that the requisition is dated, and that there are spaces on the form for noting the store-room

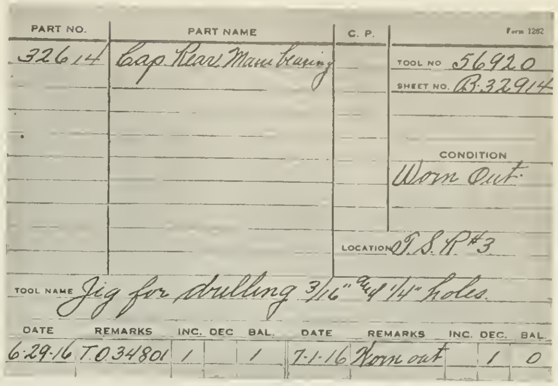


Fig. 19. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Tools by Tool Number; Size 6 by 4 Inches; One Copy on Green Stock

from which the material was drawn, the department to which it was delivered, and the accounts which are to be credited and debited, together with spaces for noting the tool order number, etc. The clock number of the man to whom the material is to be delivered is noted on the slip, which is signed by the foreman of the tool-room. These requisition slips are left in the store-rooms in exchange for the material, and at intervals of one-half hour they are gathered up by one of the messengers who make regular rounds in such a way that the slips will reach the cost accounting department in not less than one and one-half hour after they were left in the store-room. In the space at the middle of the form, notations are made as to the quantity and kind of material drawn out; the price of this material is entered on the slip by the cost accounting department, and the slip is then forwarded to the cost clerk in the maintenance supplies and tool service department, who posts them on the cost card, Fig. 12.

Reports of labor charges on tools made in the factory are also submitted to the cost clerk for use in calculating the total value of the tool. For the purpose of reporting the labor costs on each job, the foreman of the department in which the work is done turns in daily time tickets of the form shown in Fig. 11. At the top of these tickets, the names and time-

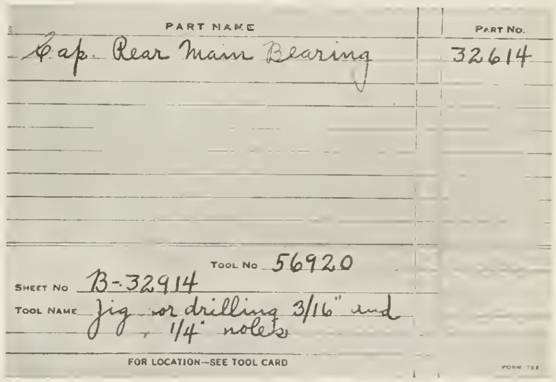
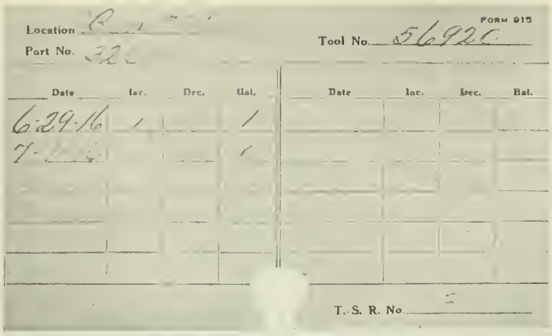


Fig. 20. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Tools by Part Number; Size 6 by 4 Inches; One Copy on Red Stock

clock numbers of the employes are recorded, together with the numbers of the departments in which they are employed and the date. In the space at the bottom of the form a record is kept of all labor costs to be charged against the tool order, and each day these time tickets are sent to the time office to be classified under their proper account, according to the list furnished by the maintenance supplies and tool service department. The rates are then extended and the slips are forwarded to the cost clerk in the maintenance supplies and tool service department, where the data are entered on the cost cards shown in Fig. 12, after which the time tickets,



Location
Part No.
FORM 915
Tool No. 56920

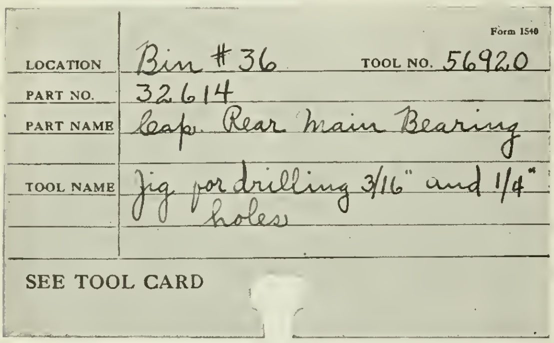
Date	Inc.	Dec.	Bal.	Date	Inc.	Dec.	Bal.
6-29-16	1		1				
7-			1				

T. S. R. No.

Fig. 21. Form used by Tool Supply Rooms in keeping Card File of Tools by Tool Number; Size 5 by 3 Inches; One Copy on Green Stock

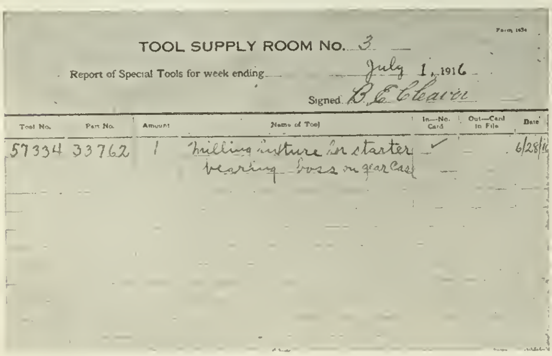
Fig. 11, are returned to the time office. The clerk who attends to the maintenance of the cost records is under the jurisdiction of the cost accounting department, although he works in the office of the maintenance supplies and tool service department. In addition to recording labor costs in the manner referred to, it will also be evident that the costs of all materials entering into the construction of the tools are entered on this card, data for the purpose being taken from the material requisition slips shown in Fig. 10.

With these data at hand, the cost accounting clerk is able to figure the total cost and valuation of the tool. On the opposite side of the card shown in Fig. 12, there is a form which provides for maintaining a record of the number of tools of each particular type which are on hand in the factory, and should it happen that one of these tools is worn out or broken, or if another tool of the same type is added to the supply, a notation is made to that effect so that information is available for the purpose of taking inventory. Similarly, if a tool is made outside, the invoice is forwarded from the bookkeeping department to the cost accounting department to be posted on the cost card.



Form 1540
LOCATION Bin #36 TOOL NO. 56920
PART NO. 32614
PART NAME Cap. Rear Main Bearing
TOOL NAME Jig for drilling 3/16" and 1/4" holes
SEE TOOL CARD

Fig. 22. Form used by Tool Supply Rooms in keeping File of Tools by Part Number; Size 5 by 3 Inches; One Copy on White Stock



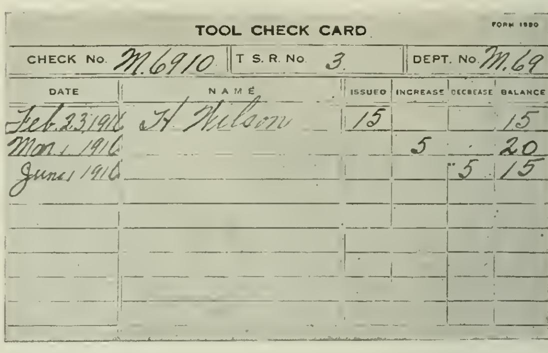
TOOL SUPPLY ROOM No. 3
Report of Special Tools for week ending July 1, 1916
Signed B. E. Cleaver

Tool No.	Part No.	Amount	Name of Tool	In—No. Card	Out—Card to File	Date
57334	33762	1	Milling fixture for starter bearing boss on gear case	✓		6/28/16

Fig. 23. Form used by Tool Supply Rooms in making Weekly Reports; Size 8 by 5 Inches; One Copy on Yellow Stock

Issuing Orders for Heat-treatment of Tool Parts

When it is necessary to heat-treat parts of tools, an order must be issued for doing this work, and in issuing such orders use is made of the form shown in Fig. 13. This form is made out in triplicate, the first and second copies being sent to the hardening department with the work, and the third copy being kept in the office of the maintenance supplies and tools service department until the parts have been returned. The first copy of the memorandum is returned with the work, and the second copy filed in the heat-treating department as a record of the work done; the first and third copies of the memorandum are then destroyed. In charging heat-treatment against the cost of the tool, it will of course be evident that use is made of the time ticket shown in Fig. 11 for reporting labor charges to the cost accounting department; and the material expense requisition shown in Fig. 10 is used when ordering materials for the process of heat-treatment.



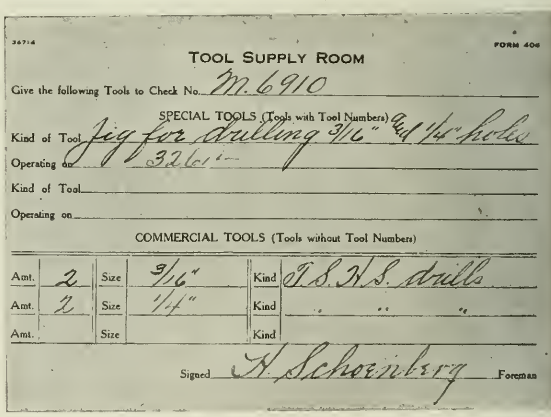
TOOL CHECK CARD
FORM 1980
CHECK NO. M6910 T. S. R. NO. 3 DEPT. NO. M.69

DATE	NAME	ISSUED	INCREASE	DECREASE	BALANCE
Feb. 23 1916	H. Wilson	15			15
Mar. 1 1916			5		20
June 1 1916				5	15

Fig. 24. Form used by Tool Supply Rooms in keeping Record of Workmen's Tool Checks; Size 5 by 3 Inches; One Copy on White Stock

How Records of Special Tools Are Kept

When all work on the tool order has been completed, the finished tool with the first copy of the tool order, Fig. 3, and the blueprints of the tool drawings are given to the special-tool inspectors in the maintenance supplies and tool service department. These inspectors are practical toolmakers and mechanics of wide experience, and are provided with all the latest improved tools necessary to make an exhaustive and thorough inspection of all special tools used to produce parts for Cadillac motor cars. When they have finished making the inspection, they report their findings on an inspection card, shown in Fig. 14, and pass the card, tool and drawings to the clerk whose business it is to see that the finished tool is delivered to the tool supply room connected with the department in which the tool is to be used. When this clerk receives the tool, he immediately stamps the tool order form, Fig. 3, "Completed" and gives it to the tool order clerk who records it as completed, and then forwards the form to the tool engi-



36714
FORM 406
TOOL SUPPLY ROOM
Give the following Tools to Check No. M6910
SPECIAL TOOLS (Tools with Tool Numbers)
Kind of Tool Jig for drilling 3/16" & 1/4" holes
Operating on 32614
Kind of Tool
Operating on
COMMERCIAL TOOLS (Tools without Tool Numbers)

Amt.	Size	Kind
2	3/16"	T. S. H. S. drills
2	1/4"	" " "

Signed H. Schornberg Foreman

Fig. 25. Form used by Shop Foremen in authorizing Tool Supply Room to deliver Tools to Men; Size 5¼ by 4 Inches; One Copy on Green Stock

Form 421

TOOL SUPPLY ROOM

Date July 3rd. 1916

Tool No. 56

is in good condition.

Release Check when turned in.

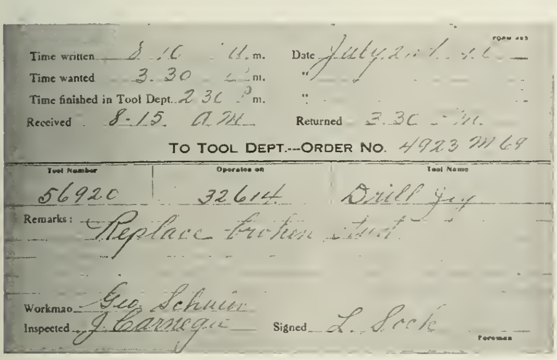
Signed

Received at window and checked by

Fig. 26. Form used by Shop Foremen in authorizing Tool Supply Room to return Checks in Exchange for Tools; Size 4 by 2⅝ Inches; One Copy on White Stock

neer. When he has disposed of the tool order, the clerk takes out the set of record cards which have been filed in the "shop box" and takes from them the card shown in Fig. 15, known as the "receipt card," also the tag shown in Fig. 16 which is used on the tool check board to indicate the hook assigned to the tool, and delivers them to the man in charge of the delivery of tools. A notice, Fig. 17, is also sent at this time to the foreman who will use the tool. The remainder of the set of cards are held on the clerk's desk until the receipt card is signed by the man in the tool supply room and returned.

When the receipt card is signed and returned, it is attached to the remainder of the sets of cards and given to the finished-tool record clerk, whose duty consists of taking the card shown in Fig. 18 and forwarding it to the cost clerk, which constitutes a notice that the tool has been completed and that he may close his cost card, and file it for inventory purposes. The record clerk next takes the cards shown in Figs. 19 and 20, which are known as the "tool" and "symbol" cards, respectively, and files them in separate files; the tool card is filed by the tool number and the symbol card by the symbol number of the motor part, thus constituting an effective cross-indexed file. The inspection card and the blue receipt card, Figs. 14 and 15, are filed together in a file labeled for that purpose. The cards shown in Figs. 21 and 22 are given to a clerk who makes daily trips to each of the tool supply rooms, and files them in filing cabinets for the convenience of the



Time written 8.10 A.M. Date July 2 1916

Time wanted 3.30 P.M.

Time finished in Tool Dept. 2.30 P.M.

Received 8.15 A.M. Returned 3.30 P.M.

TO TOOL DEPT.—ORDER NO. 4923 M 69

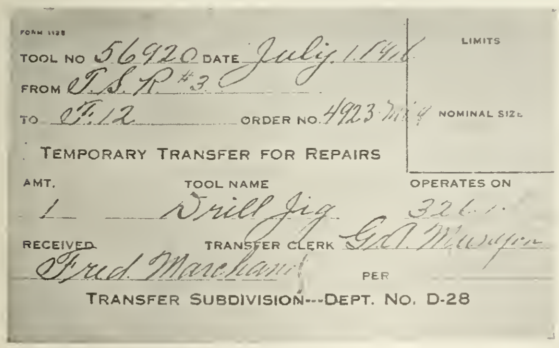
Tool Number	Operates on	Tool Name
56920	32614	Drill Jig

Remarks: Replace broken stud

Workman Geo. Schnier

Inspected J. Carnegie Signed L. Sock Foreman

Fig. 27. Form used by Shop Foremen in ordering Repair of Broken or Worn Tools; Size 7 by 4¼ Inches; One Copy on White Stock



FORM 1128

TOOL NO 56920 DATE July 1 1916 LIMITS

FROM T.S.R. #3

TO F. 12 ORDER NO. 4923 M 69 NOMINAL SIZE

TEMPORARY TRANSFER FOR REPAIRS

AMT.	TOOL NAME	OPERATES ON
1	Drill Jig	32614

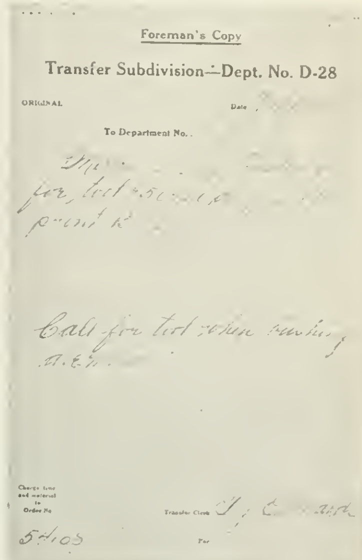
RECEIVED TRANSFER CLERK

Fred Marchand PER

TRANSFER SUBDIVISION—DEPT. NO. D-28

Fig. 28. Form used by Tool Supply Rooms in recording Temporary Transfer of Tools for Repair; Size 5 by 3 Inches; Three Copies on Yellow, White and Salmon Stock

man in the tool supply room. When the tool was delivered to the tool supply room, an entry was made in the "incoming" record book, which is checked by the clerk who puts the cards in the tool supply room files. Also, the tag shown in Fig. 16 was placed on the check board for convenience in checking the tool to a workman; and the placing of this tag is later verified by the man in charge of maintaining the check boards and the checks in order.



Foreman's Copy

Transfer Subdivision—Dept. No. D-28

ORIGINAL Date

To Department No.

Call for tool when ready

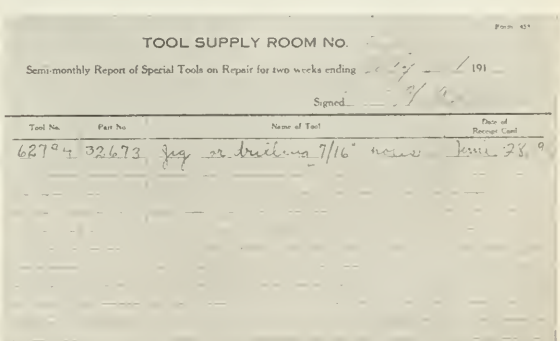
Charge time and material to Order No. Transfer Clerk

Per

Fig. 29. Form used by Foremen in ordering Replacement Parts for Special Tools sent for when Parts are ready to be put in Place; Size 5½ by 8½ Inches; Four Copies on White, Pink, Blue and Yellow Stock

Weekly Reports of Conditions in Tool Supply Rooms

It will be recalled that when the new tools were completed and sent down to the tool supply room, a receipt, Fig. 15, was obtained for them. At the same time an entry of the receipt of the tools was made in the "incoming" book which is kept in each tool supply room, and the small tag shown in Fig. 16 was hung on a hook on the check board ready for a tool check to be put over it when the tool is sent out to the shop. Then on the following day, a clerk went down to enter the tools on the card file in the tool supply room and to see that other parts of the work were properly looked after. Similarly, other entries are made in the "outgoing" book at the time that tools are sent up to the tool-room for repair or when permanent transfers of tools are made from one department to another. Once a week the tool supply room attendant examines these books in order to find out just how conditions stand. He examines both the "incoming" and "outgoing" books, and also makes sure that spaces have been provided



TOOL SUPPLY ROOM NO.

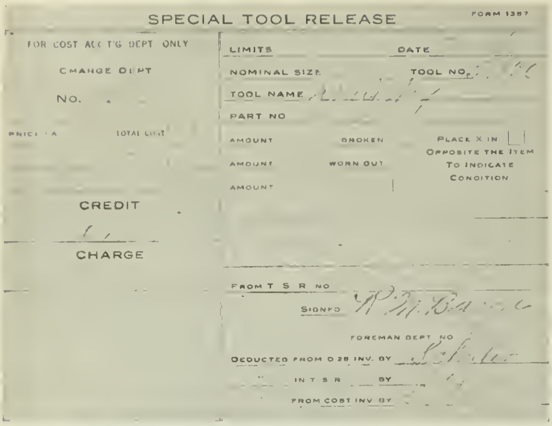
Semi-monthly Report of Special Tools on Repair for two weeks ending 191

Signed

Tool No.	Part No.	Name of Tool	Date of Receipt Card
62794	32673	Jig for drilling 7/16" holes	June 28

Fig. 30. Form used by Tool Supply Rooms in making Semi-monthly Reports of Special Tools sent out for Repair; Size 8½ by 5¼ Inches; One Copy on Yellow Stock

on the check board for all new tools delivered to the tool supply room, and that these tools have been properly entered on the card file. The results of this inspection are entered on a form shown in Fig. 23, and the report is sent to the maintenance supplies and tool service department. In cases where any discrepancies are discovered, an investigation is immediately started to find the cause of the trouble and to take steps to correct it.

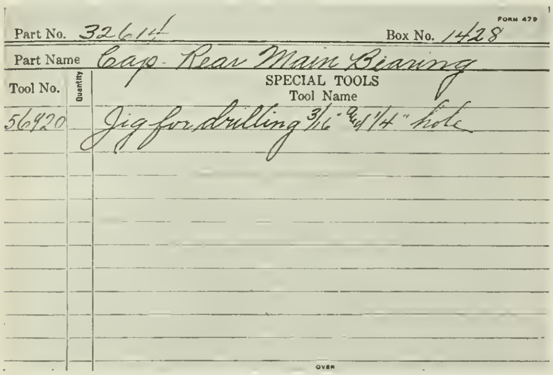


SPECIAL TOOL RELEASE FORM 1387
FOR COST ACC'T'G DEPT ONLY
CHARGE DEPT
NO.
PRICE
TOTAL COST
CREDIT
CHARGE
LIMITS DATE
NOMINAL SIZE TOOL NO.
TOOL NAME
PART NO
AMOUNT BROKEN
AMOUNT WORN OUT
AMOUNT
PLACE X IN OPPOSITE THE ITEM TO INDICATE CONDITION
FROM T S R NO
SIGNED
FOREMAN DEPT NO
DEDUCTED FROM O 28 INV. BY
IN T S R BY
FROM COST INV BY

Fig. 31. Form used by Maintenance Supplies and Tool Service Department in sending Cost Accounting Department Data on Discarded Tools for Use in Adjustment of Accounts; Size 6 by 4½ Inches; One Copy on Dun Stock

Checking Tools Out to the Factory

We have now followed through the process of toolmaking to the point where the finished tools have been delivered to the tool supply room, regardless of whether the work was done by an outside concern or in the tool-room in the Cadillac factory. It will also be remembered that a report, Fig. 17, was sent to the foreman who will have use for the tools, advising him that they are in his tool supply room and available for use. These tools are checked out to the men against the usual form of tool checks, and for the purpose of explaining all parts of this tool system, we will assume that the new tools will first be used by an employe who has just been hired. Before this man can obtain any tools from the tool-room he must be provided with a set of tool checks, the number given him usually being fifteen. The new man is taken to the tool supply room by his foreman and supplied with checks, a record of the number given to him being made on the card file maintained for this purpose. The cards are ruled with a form which provides spaces for the name and time clock number of the workman, the tool supply room number from which he will obtain tools, and the department number in which he is employed. One of these cards is shown in Fig. 24, and it will be seen that at the right-hand side spaces are provided for recording the number of checks with which the workman is provided. From time to time, special conditions may make it necessary for a man to have more checks given him; and, in other cases, the number of checks which he has may be reduced. In either case, the addition or deduction is noted on the form, and the balance entered in the right-hand column reserved for that purpose. All of these checks must be accounted for before the workman can obtain his final pay when leaving the employment of the company.



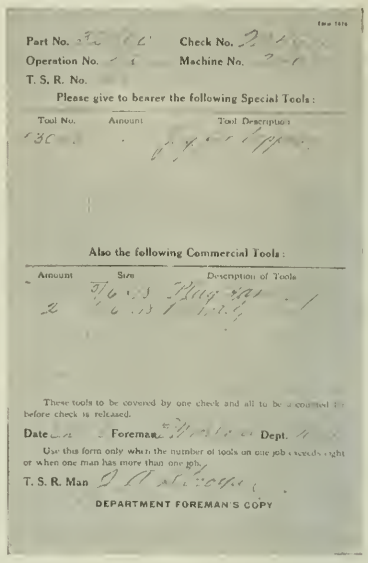
FORM 479
Part No. 32614 Box No. 1428
Part Name Cap-Rear Main Bearing

Tool No.	Quantity	SPECIAL TOOLS Tool Name
56420		Jig for drilling 3/16" & 1/4" hole

OVER

Fig. 32. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Sets of Tools used for Specified Operations; Size 6 by 4 Inches; One Copy on White Stock

When a workman is assigned to a new job the first thing he must do is to make application to his foreman for the tools that he will require. If the foreman finds that the man is calling for the proper tools, he makes out an order on a form shown in Fig. 25, specifying the tools which are to be given to the workman by the attendant in the tool supply room in exchange for the proper number of tool checks. These checks are hung on the check board in the usual way. After the workman has finished with the tools, he will desire to return them to the tool supply room and get his checks back, but as the attendant in this room is not a skilled mechanic, the workman is required to first take the tools to his foreman, and have him see that they have not been damaged before they are returned. After the foreman has examined the tools and found their condition satisfactory, he fills in a form shown in Fig. 26, stating that the tools are in good condition and that the attendant in the tool supply room is authorized to return the workman's tool checks in exchange for the tools which he is returning.

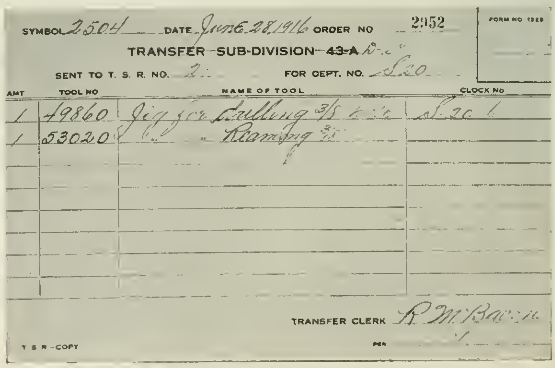


Part No. Check No.
Operation No. Machine No.
T. S. R. No.
Please give to bearer the following Special Tools:
Tool No. Amount Tool Description
Also the following Commercial Tools:
Amount Size Description of Tools
These tools to be covered by one check and all to be returned before check is released.
Date Foreman Dept.
Use this form only when the number of tools on one job exceeds eight or when one man has more than one job.
T. S. R. Man
DEPARTMENT FOREMAN'S COPY

Fig. 33. Form used by Shop Foremen in authorizing Tool Supply Room to deliver Sets of Tools to Men; Size 5¼ by 8 Inches; Two Copies on White and Buff Stock

Repair of Special Tools

When the special tools used in any of the shops have become worn or damaged in such a way that they are no longer capable of giving satisfactory service, they are returned to the tool-room for the purpose of making the necessary repairs. The decision as to whether or not the tools require repairing will be made by the foreman of the department in which they are used. When a tool is sent from the tool supply room to the tool-room to have such repairs made, it will be evident that an order must be issued for doing the work, and also that the tool supply room must have a record showing what tools have been sent out for repairs. Fig. 27 shows the form of order made out. In the upper half of this card it will be evident that spaces are provided for not only recording the date on which the work was sent out and the date when the tool will again be needed in the factory, but also for specify-



SYMBOL 2504 DATE June 28, 1916 ORDER NO 2352 FORM NO 1959
TRANSFER SUB-DIVISION 43-A
SENT TO T. S. R. NO. 2 FOR DEPT. NO. 120

AMT	TOOL NO	NAME OF TOOL	CLOCK NO
1	49860	Jig for drilling 3/8	
1	53020	Reaming	

TRANSFER CLERK
T S R COPY

Fig. 34. Form used by Maintenance Supplies and Tool Service Department in authorizing Temporary Transfer of Tools; Size 8¼ by 5¼ Inches; Four Copies on White, Yellow, Blue and Pink Stock


CHECK No. M-6620 Form 382

Has Drawn From.

Tool Supply Room No. 24

2- 3/8" Solid Hand Reamers

Signed P. Haugh

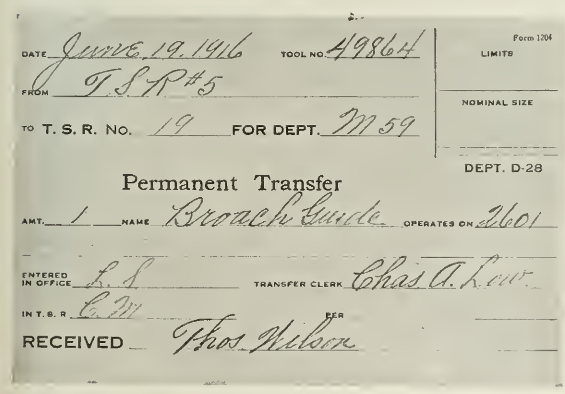
TOOL SUPPLY ROOM No. 24

Returned Date

Fig. 35. Form used by Tool Supply Rooms in reporting Withdrawal of Tools by Men employed in Departments not regularly served; Size 5 by 3 Inches; One Copy on Yellow Stock

ing the exact time of day in each case. This is an important matter, because it may frequently happen that damage done to a tool of which there is no reserve in stock will result in holding back production until repairs have been made. In repairing special tools, all work is done on a "blanket" order, No. 4923, and the insertion of this number in the space provided for the purpose shows immediately that the job consists of repairing a special tool. In the lower half of this form it will be noticed that spaces are provided for entering the name and number of the tool, together with the number of the part on which it operates. Under the heading "Remarks," the necessary instructions are given to indicate the nature of the repair that must be made.

It has been pointed out that when tools have been sent out for repair it is necessary for the attendant in the tool supply room to keep a record of the matter in order that he may not be called upon to deliver tools which are not in his possession. For the purpose of keeping this record, use is made of a form shown in Fig. 28, this form being made out in


DATE June 19, 1916 TOOL NO. 49864 Form 1204 LIMITS

FROM T.S.R. #5 NOMINAL SIZE

TO T. S. R. No. 19 FOR DEPT. M 59

DEPT. D-28

Permanent Transfer

AMT. 1 NAME Broach Guide OPERATES ON 2601

ENTERED IN OFFICE L. S. TRANSFER CLERK Chas. A. Low

IN T. S. R. C. M. PER

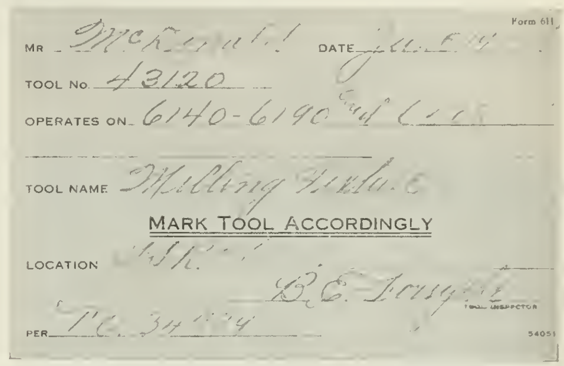
RECEIVED Thos. Wilson

Fig. 36. Form used by Maintenance Supplies and Tool Service Department in authorizing Permanent Transfer of Tools; Size 6 by 4 Inches; One Copy on Buff Stock

triplicate. The first two copies are sent with the tool to the maintenance supplies and tool service department; and the first copy goes on with the tool to the foreman of the tool-room in which the repair is to be made, while the second copy is filed in the office of the maintenance supplies and tool service department. The third copy of the form is kept on file in the tool supply room, where it serves as a record of the fact that the tool has been sent out for repairs. When the tool is returned to the tool supply room, the card on file is signed and sent to the maintenance supplies and tool service department, where it replaces the second copy of the form, being placed in a permanent file to record the repair work.

Making Repair Parts for Special Tools

When a tool is in constant use in the factory, a serious delay is caused by sending it out for repair, and such a procedure is avoided just as far as possible. One way in which trouble from this source is largely overcome consists of having repair parts for the tool made in advance, so that it is only necessary to send the tool up to the tool-room for a long enough period of time to have the new parts put in place. For instance, suppose it is found that the bushings in a drill jig have become slightly worn and ought to be replaced. The most obvious method would be to send the jig up to the tool-room where the bushings would be made and put into place; but this would involve having the jig out of the shop for a considerable length of time, and production would be seriously delayed by following such a course. The method actually employed consists of sending an order to the tool-room, giving the number of the tool and the number of the blueprint of the tool drawing, together with a statement of what parts need to be replaced. The tool-room then proceeds to make these parts, and when they are finished and ready to put into place it sends for the tool. In this way the tool is only out of the shop for a short length of time and the delay occasioned is not serious. Fig. 29 shows the form used in ordering tool repair


MR McDonald DATE Form 611

TOOL NO. 43120

OPERATES ON 6140-6190

TOOL NAME Milling Fixture

MARK TOOL ACCORDINGLY

LOCATION

TOOL INSPECTOR

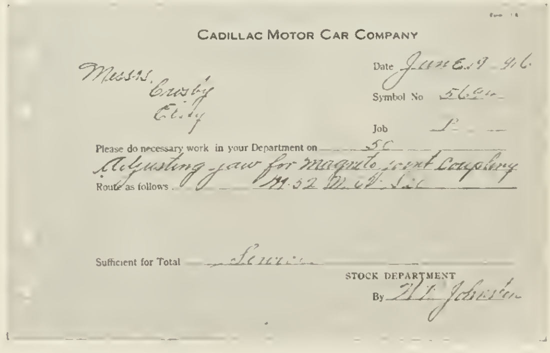
PER 54051

Fig. 37. Form used by Maintenance Supplies and Tool Service Department in ordering Supplementary Marking of Tools; Size 5 by 3 Inches; One Copy on Pink Stock

parts of this nature, this form being made out in quadruplicate. The first and second copies are sent to the foreman of the tool-room and serve as his order for making the parts in question. The third copy is filed in the maintenance supplies and tool service office until the job has been done, and the fourth copy is sent to the foreman of the department who placed the order for parts, to notify him that his order is being executed. These orders are all numbered, and all time and material is charged against that order number in the same manner as described in connection with the new tool orders.

Semi-monthly Report on Special Tool Repairs

In describing the work of repairing special tools, it will be recalled that stress was laid upon the importance of the time taken in doing the work. As a serious delay in the factory is likely to result where the time taken for repairing special tools is unduly long, it is important to check up the time actually required for tool repairing to see that there is no unnecessary loss of time. Semi-monthly inspections of the work


CADILLAC MOTOR CAR COMPANY

Messrs. Crosby Co. Date June 9 '16

Symbol No

Job

Please do necessary work in your Department on

Adjusting jaw for magneto joint coupling

Route as follows

Sufficient for Total

STOCK DEPARTMENT

By H. Johnson

Fig. 38. Form used by Stock Department in ordering Manufacture of Replacement Parts for Service Departments; Size 8 by 5 Inches; One Copy on White Stock

of the tool repair department are conducted for this purpose, and the conditions found are reported on the form shown in Fig. 30.

Discard of Worn Out Tools

As long as tools are in good working order they are charged against the maintenance supplies and tool service department; but as soon as they are broken or worn out this department is credited with the amount formerly charged against it, and a corresponding charge is made to the department in which the tools were used. When the usefulness of a tool is destroyed from either of these causes, it becomes necessary to make an adjustment of accounts, and data to form the basis of this adjustment are supplied on a form shown in Fig. 31. Referring to this illustration, it will be seen that at the left-hand side of the form, spaces are provided for the number of the department to which the value of the tool is to be charged, and also for the numbers of the accounts which are to be credited and charged with the cost of the tool. The space at the right-hand side of the form is filled in with a complete description of the tool, a statement as to whether it was worn out or broken, and with information which is used at the time an inventory is taken.

Sets of Tools for Special Operations

There are certain classes of operations which require the use of a considerable number of tools, and if a workman were required to have each tool out on a separate check, it would involve the necessity of supplying each of the men with an unnecessarily large number of checks. To avoid trouble arising from this cause, and also to simplify the method of handling tools, the expedient has been adopted of keeping such sets of tools in separate numbered boxes. This makes it possible for the entire set of tools to be delivered to a workman against a single tool check, thus greatly simplifying the work of the tool supply room. For the purpose of recording sets of tools of this kind, use is made of cards of the form shown in Fig. 32. One side of each of these cards carries a list of all special tools required for the operation, and on the other side of the card there is a list of all the standard commercial tools that are needed. It will be noticed that at the top notations are made of the number of the part for the manufacture of which the tools are required, and the box number in which the set of tools is contained. The cards are filed numerically by part number.

Drawing Out Sets of Tools

The practice of allowing a workman to draw out a complete set of tools on one check is only followed in cases where the number of tools required for a single operation exceeds eight, and where the workman is looking after more than one operation. When a man is assigned to a job of this kind, he must get an order from his foreman for the tools that he will require in doing the work, and such a tool order is made out on the form shown in Fig. 33. This order is made in duplicate, the first copy being held by the foreman and the second copy sent to the tool supply room, where it is filed in the same envelope with the workman's tool check and the copy of the transfer order shown in Fig. 34.

Drawing Tools from Tool Supply Room of Another Department

In the factory of the Cadillac Motor Car Co. there are thirty tool supply rooms, and each of these rooms is supposed to deliver tools and supplies to specific departments, the idea being clearly shown in diagrammatical form in Fig. 1. Charts are made out and blueprints of them posted throughout the factory, showing those departments to which each tool supply room is supposed to deliver materials and tools. But the rule in this connection is flexible, as it may happen that some department in the factory has urgent need for tools or supplies which are not in its proper tool supply room at the time they are required. When such a condition arises, a foreman may send his man to an adjacent supply room with an order for the tools which he needs. Delivery will be made on such an order, but the attendant in the tool supply room from which the tools are withdrawn will fill out one of the forms shown in Fig. 35 and deliver it to the tool supply room which should properly have handled the transaction, advising of the delivery of the tools to one of the departments served by this tool supply room. The purpose of sending this form is two-fold: in the first place, it serves to remind the attendant in the tool supply room that his stock of a given tool is out and must be replenished; and in the second place, it advises that men from departments which properly come under his jurisdiction have been drawing tools from another tool supply room. Should it happen that there was no necessity for withdrawing tools in this way, the attendant in the tool supply room will immediately take the matter up with the department foreman, so that the continuance of this irregular practice may be stopped.

Permanent Transfer of Tools

Occasionally a readjustment of the work in the factory calls for the permanent transfer of special tools from one tool supply room to another, and where this procedure is necessary, a record of the transaction is made on a card of the form shown in Fig. 36. Reference to this illustration will show that the card bears the date and tool number, together with the number of the tool supply room from which the tool was taken, and also the number of the room to which it was delivered. At the bottom, spaces are provided for a complete description of the tool. This transfer, when signed, constitutes authority for removing the tools from one tool supply room to the other, and also for changing the location on the tool card in the maintenance supplies and tool service office, after which it is filed by tool number.

Marking Additional Part Numbers on Special Tools

All the special tools used in the shops of the Cadillac Motor Car Co. are marked with a tool number, and also with the part number of the piece upon which they operate. So far, the matter is quite simple; but when motor cars of a new model are brought out, there will be a considerable number of special tools which can be used without alteration of any kind. But in order to bring the records up to date, it is necessary not only to add the part number of the new piece upon which the tool operates, but also to correct all records to show this addition. When the engineering department has decided upon a change of model and the work of providing the necessary tool equipment has been finished by the tool engineer, reports are sent to the maintenance supplies and tool service department; and a form shown in Fig. 37 is made out and given to the record clerk who adds the part number to all record cards, and then gives the notice to the toolmaker who sees that the tools are properly marked. Only such tools as are required for use on the model being manufactured are kept in the tool supply rooms. A tool storage is maintained in which are kept all obsolete tools. The bins in the storage room are numbered, and the location of each tool is carried on the tool record card filed in the maintenance supplies and tool service office. When it becomes necessary to use obsolete tools for making service repair parts, they are transferred temporarily to the tool supply room and returned to the storage room when the work has been done. The reason for this is that it would be undesirable to obstruct the tool supply room with tools that are only used occasionally.

Manufacturing Obsolete Parts for Purposes of Replacement

As all owners of motor cars know, and as anyone will readily understand by giving the matter brief consideration, it is necessary for automobile builders to maintain service departments in order to supply repair parts for obsolete models of motor cars which are still in use. A supply of such parts is kept on hand in the various service stations; and when the supply of any part is found to be running low, an order is sent in for additional parts of the same type. For manufacturing each part of the current model of a motor car, it is usually necessary to provide a number of tools of the same type; but when the car for which parts are used becomes obsolete, one of the special tools of each type will be set aside for the purpose of manufacturing replacement parts, while the remainder of the tools will either be changed to adapt them for use in the manufacture of parts of the current model, or else they will be discarded. A decision in this regard is made

by the tool engineer, whose experience enables him to decide whether it would be cheaper to modify the design of tools or to make new ones.

When one of the service departments sends in an order for replacement parts, the stock department issues an order for these parts, making use of the form shown in Fig. 38. This form is then sent to the maintenance supplies and tool service department, which refers to its card file of tools—the form shown in Fig. 19—which gives a complete list of the tools used in the manufacture of this part. The location of these tools in the storage rooms is then looked up, and all of this information is noted on the back of the form. An inquiry is then made of the foreman of the department in which the parts are to be made in regard to when he will be ready to do the work, and on that day the tools are delivered to his tool supply room on a temporary transfer form shown in Fig. 34. This form is made out in quadruplicate, and the trucker takes three copies with him when he goes to get the tools and transfer them from the storage room to the tool supply room, where the first copy is signed as a receipt for the tools and returned to the maintenance supplies and tool service department to be filed with the second copy of the form that was held as a memorandum of the transfer. The third copy is sent to the foreman of the department in which the tools are to be used, serving as a memorandum to advise him that the tools have been transferred to the tool supply room. The fourth copy is left in the tool supply room, and when the tools are checked out to the workman, this copy, together with the tool check, is put in an envelope bearing the symbol number of the part for the manufacture of which the tools are required. This envelope is kept in the tool supply room until the box of tools is returned, when the check is given back to the workman and the fourth copy destroyed.

Conclusion

The reader who is familiar with the performance of manufacturing operations on a scale such as that which exists in the factory of the Cadillac Motor Car Co. will be impressed by the fact that although means are provided for accurately recording all transactions involved in the ordering, making, distributing and accounting of special tools, the system has been worked out in such a way that there is no unnecessary complication. To the casual reader, it may appear that the use of so many forms must inevitably lead to confusion; but the filling in and transmission of many of these forms are merely incidental to the making and distributing of tools, and only a very small clerical force is required to look after all routine work of the maintenance supplies and tool service department. The benefits resulting from this system have made it quite evident to the management of the Cadillac Motor Car Co. that the expense involved in its installation and maintenance has been offset many times by the saving in lost and damaged tools, and the elimination of unnecessary delays in the process of manufacture which has resulted through having the entire tool problem placed under the jurisdiction of a central office.

* * *

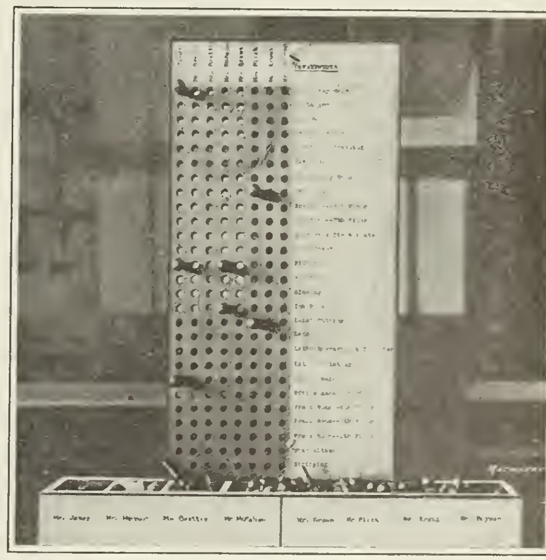
ADVANTAGE OF BALL BEARINGS FOR ELECTRIC MOTORS

A new booklet issued by the S. K. F. Ball Bearing Co. of Hartford, Conn., points out the advantage of ball bearings for electric motor armatures. The bearing adjustment remaining constant, keeps the rotor in the center of the magnetic field. This permits the motor manufacturer to employ air gaps with clearances so slight that they could not be considered on motors having the plain type of bearings. On induction motors a narrow air gap is of vital importance in the improvement of the machine efficiency and the motor power factor. Plain bearings after a period of service wear down, the amount varying with the load and service conditions. This wear, if long continued, finally permits the armature to touch the pole pieces, resulting perhaps in a stripped armature. But with ball bearings the armature is supported centrally and with practically no variation of position during the life of the motor. Thus the use of ball bearings improves motor efficiency and reduces the mechanical friction losses.

LOCATING BOARD FOR PLANT OFFICIALS

The accompanying illustration shows a clever and simple device for locating men in a large plant, whose work calls them into a number of different departments for a certain portion of the day. At first thought, to one who is familiar with the modern electric call system, this device may appear rather crude. However, it is being used very effectively in the large and splendidly equipped paper goods factory of Robert Gair Co., Brooklyn, N. Y. In this instance, the board is placed just outside the office of J. E. Jones, mechanical engineer, and directly in the path of his seven assistants whose names are given on the board. As the function of the mechanical engineer and his assistants is to keep the entire mechanical equipment of this large factory in repair, as well as to design and install new equipment, it is necessary for them to spend a great deal of their time outside the office. When they are out, it is essential to be able to locate them on a moment's notice, and it was for this reason that the locating board was devised.

The principle of this board is extremely simple, requiring but brief description. At the bottom is a tray containing eight compartments, each of which corresponds to the eight men in the department. In each compartment is a supply of plugs



Board for locating Men in a Factory, showing Three Men "plugged out"

of different colors to represent the different men. Starting with Mr. Jones' compartment and reading to the right, the colors of the plugs are as follows: red, white, black, green, brown, yellow, mahogany, and a combination of yellow and black. The holes are arranged in rows with a man's name at the top of each vertical row, and a department name at the right of each horizontal row.

By inspecting the illustration, it will be seen that Mr. Jones is going first to the carpenter shop, then to the finishing department, and then to the main office. Mr. MacMahon is going to the finishing department and then to the ink room. Mr. Flick is going from the embossing room to the label cutting department. As the man goes out the door, he slips plugs into the respective departments that he intends to visit. As he returns to the office he pulls out the plugs and returns them to the compartment bearing his name.

The device might be made somewhat more effective by having a flat top on the head of several of the plugs with successive numbers stamped thereon. By this method a man could indicate the sequence of his visits by placing the numbered plugs in the relative order in which he expects to make his visits. It might also be a good provision to include a row of holes horizontally labeled "Absent." In this case when a man expected to be away from his work for an entire day,

he could place a plug in the "Absent" column the night before, or whenever he was about to leave the factory, he might do likewise.

Several applications of the principle involved in this board may suggest themselves to the reader. A board of this nature ought to lend itself readily to the repair department of a large shop. As a man starts out for a certain department to spend anywhere from an hour to a whole day on a certain repair job, he might plug himself out on the board and make it a simple matter for the foreman to locate him at any time during the day. Thus the inefficient method of walking around the factory trying to locate a man and the loss of time involved can be done away with. V. B.

* * *

PRESS-ROOM LUBRICANTS

BY G. R. SMITH[*]

One of the chief factors of power press work is the use of the right lubricant for the right work. I have found a condition existing in many manufacturing plants that arises either through a false idea of economy or lack of study of existing conditions with a view to bettering them. While to the manufacturer with a small "now and then" class of production it might seem like needless expenditure, and no doubt would be in his case, to those who have a steady run on a certain class of work it is a point not to be lost track of. The lubrication of power press tools working on all kinds of operations and all kinds of materials should be made a careful study, as the life of the tools and machine, as well as the quality of work produced, is more dependent on this factor than almost any other entering into this mode of manufacturing. From long years of experience and careful study of certain conditions, I will endeavor to state a few rules and recipes that have given marked success and may be of great help to some others in a like field.

The practice of placing a barrel of machine oil in the press room and using it for all purposes, such as for oiling machines, as a drawing lubricant, as cutting and forming oil, etc., is one of the great steps in false economy. The composition of machine oil makes it especially adaptable for use on machines as a lubricant in journals, between collars, on ways, in shaft boxes, etc., but its composition also renders it very poor for cutting and drawing. Machine oil placed on small quick-action piercing punches and dies permits heating the steel and drawing the temper of the punch, causing the metal to flake off the stock and cling to the punch or drawing die. This produces rough, scratched work, and is generally bad when used in this way. A foreman has trouble with the tools, and wonders why the punches will not stand up, why they heat so easily and draw the temper, why the work is so rough, burred and scratched, especially on drawn shell work—when it is directly traceable to the use of machine oil in a service it was never designed to fill.

One of the best lubricants for cutting and punching, and in many cases for drawing also, is a good grade of lard oil. This perhaps is a little more expensive than machine oil, but it is obvious that machine oil can never take its place in this field. Lard oil cools the punches and places them in a better condition to perform their function; and it is really an admirable press-room lubricant on all kinds of work, while on the other hand it is very poor for oiling purposes around machinery. As a drawing solution for light brass and copper shells it has no equal, and in many cases works as well on light steel shells. I have also used it with marked success in broaching and lapping operations.

For heavy drawing work there are a number of lubricants on the market, all of more or less value on certain classes of work. One of the cheapest as well as most effective drawing solutions is a soap, oil and water emulsion. This is composed of equal parts of hard soap, lard oil and warm water, the hard soap being dissolved in the warm water first and the lard oil stirred in after. This is one of the best drawing solutions available for light brass and copper shell work, its only disadvantage being on work that has to stand any length of time between operations, the alkali in the soap having a tendency to corrode the brass; but on work where each operation is carried along to completion, this mixture will be found very satisfactory.

For heavy steel shell work I have used a mixture of dry white lead and lard oil of about the thickness of heavy paint with remarkable success. The drawing solution that I would prescribe for heavy and light steel shell work alike is a mixture of lard oil and precipitated chalk. After a thorough mixing, this should stand over night to allow it to "jelly" or grow softer, as it were; in fact, the longer it stands the better it gets, and for use it can be mixed to the right thickness to secure the desired results. The principle involved in shell drawing is to furnish a lubricant heavy enough and of the right nature to produce a film that will enter between the sides of the shell and the dies, thus lessening wear on the die and flaking of the metal resulting in scratches on the sides of the shell. These scratches are a grave defect on shells that are redrawn two or more times, as they cause the shell to split or crack open on the redraw. When shells are annealed between operations, and the best results are desired, an acid pickle should be prepared to remove the scale. This is generally of the same composition as the "bright dip" or the "firing off" that is used in the plating room. The lubricant that is used should be kept clean and free from dirt, scale and sediment, even if straining is resorted to, as drawing solutions must be clean to do the best work. In very heavy boiler-plate punching, blanking and cutting I have used cylinder oil with success. This is a very heavy oil, almost a grease, and gives very good results.

Non-metal materials require a varied assortment of lubricants to gain the maximum efficiency. In blanking and piercing mica parts, gasoline or kerosene is used, preferably gasoline. The mica dust collects and clogs the stripper parts and piercing punches, and gasoline used freely washes away this dust and adds to the life and effectiveness of the tools. In the blanking of celluloid and other camphor gum compositions of a like nature, I have used nothing but clean water. Some of these compositions do not stick to the tools at all, while others are very troublesome. If the water is not effective, a very little lard oil on the punch once in a while will be of value. Leather, cloth and felt I have always blanked dry, and on felt I work on one thickness only, with the punch entered deep in the die, as this material will cause the tools to shear unless great care is taken. On rawhide and horn-fiber parts, I have used wood alcohol successfully. Wood alcohol also softens the rawhide for forming and cupping, dries very quickly, and does the material no harm whatever. Fibers, as a general rule, can be cut dry, but in some cases lubrication, or rather washing out of the dies with gasoline, is required occasionally. Gasoline is very effective in this instance and does the fiber no harm. Glass blanks can be pierced successfully by laying them in turpentine and then piercing on a quick-action press. A press having a speed of 1000 revolutions per minute or more is required. The Campbell Mfg. Co. of Chicago, Ill., has brought out a clutch that will operate a power press having a greater speed than 3000 revolutions per minute.

Wood of certain kinds can be successfully pierced and embossed by first steaming or boiling, the work being done on a slow-action press with a long dwell, such as is used for cardboard forming. Foils, light tin, paper and cardboard, tapes and cambrics I have always cut and blanked dry. Cork can be successfully broached and turned by wetting first in good clean gasoline, the turning tool being emery, or stone of a like nature. In all classes of power press work, suitable lubrication and preparation of the material is the cardinal point.

* * *

A simple demonstration of the difference between the frictional resistance of a bearing with an unbroken oil film and one in which the film is broken can be made with a glass bottle fitted with a ground glass stopper. Oil the stopper and press it lightly into the bottle; it can be turned very easily, but if more pressure is applied the oil is squeezed out and the opposing surfaces come into intimate contact, with the result that the stopper can be turned only by the exertion of considerable force.

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LETTERS ON PRACTICAL SUBJECTS

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PRECISION GEAR CENTER GAGE

The accurate measuring of gear centers is not easily accomplished without the aid of special tools, but the simple form of gage illustrated and described herewith enables this work

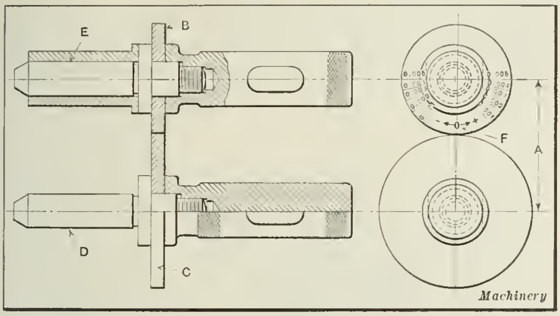


Fig. 1. Precision Gage for measuring Distance between Gear Centers

to be done quite rapidly. The method of procedure is as follows: Assume that center distance *A*, Fig. 1, is equal to one-half the sum of diameters of collars *B* and *C*. Arbor *D* of gage *C* fits into one hole, and the small diameter of gage *B* fits into the other hole at *E*. Referring now to Fig. 2, which shows angular spacing of different radii on gage *B* and the difference of these radii. we will assume that *F* represents the zero or datum point from which center distances are measured.

It will be evident that if we turn graduated collar *B* through an angle of 36 degrees, 51 minutes, in a clockwise direction, the center distance is + 0.001 inch; similarly, if the point of contact is located a similar distance on the other side of datum line *F*, we obtain — 0.001 inch. If the measurement of collar *B* is continued through an angle of 90 degrees, the center distance will be + 0.005 or — 0.005 inch, according to the direction in which the collar is moved; and for intermediate points the amount of eccentricity and whether it is plus or minus will be determined by the magnitude and direction of movement of the collar. The maximum eccentricity of 0.005 inch is far in excess of that actually found in practice, and to obtain a more accurate gage the maximum eccentricity may be reduced; for instance, making 0.003 inch the maximum, would mean that the graduations on dial *B* could be placed further apart so that the gage would read within 0.0005 inch of accurate.

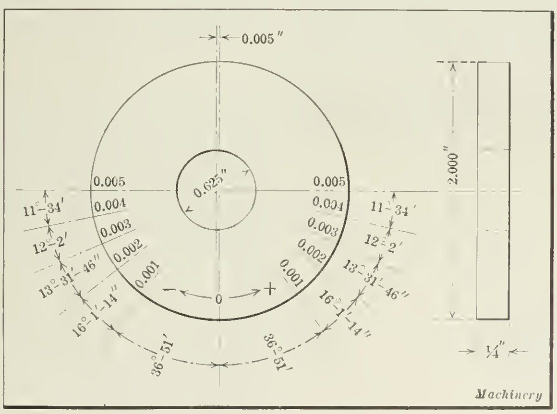


Fig. 2. Close View of Graduations on Collar B

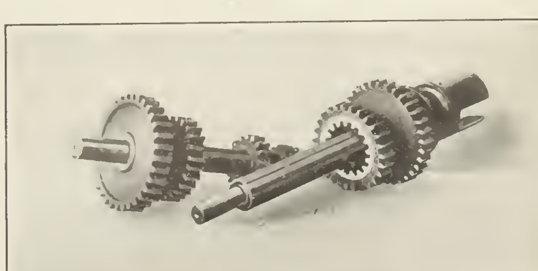
The graduated collar should be made a standard for other center distances by simply increasing or decreasing the diameter of the plain collar. For instance, suppose it is required to measure a center distance of 5 inches and you have a graduated collar 3 inches diameter; it would be necessary to use a plain collar 2 inches diameter. Similarly, if you desire to measure a center distance of 7 inches with this graduated collar, it would be necessary to use a plain collar 4 inches in diameter. By making a series of plain collars for use in connection with the more expensive graduated collars, a universal outfit could be obtained at moderate cost. It would appear that a firm specializing in the manufacture of small tools could get up a useful combination to meet the requirements of automobile factories and other firms that have a lot of work of this kind to do.

INSPECTOR

UNUSUAL GEAR REPAIR JOB

At the Wentworth Institute, a few years ago, we were given the job of repairing the sliding gear transmission of a car that was no longer manufactured. The teeth of one of the gears shown in the accompanying illustration had been stripped off, making the gear of no further use, and in order to put it in condition we employed the following method with satisfactory results. An arbor was squared on the milling machine centers to just fit the hole in the sliding gear; and the damaged gear was then mounted on this arbor and the teeth ground off on a plain grinding machine so that the diameter of the gear was reduced to a point about 1/4 inch below the bottom of the teeth. Then a ring made of 3 1/2 per cent nickel steel had twenty-eight 6-pitch teeth cut in it instead of twenty-six teeth, which had been the number in the original gear, this increase in diameter plus 1/4 inch previously mentioned giving a total thickness of 9/32 inch for the ring at the bottom of the teeth. This ring was then heat-treated and ground out to a diameter 0.0035 inch smaller than the gear on which it was to be pressed. In the accompanying illustration, the part of the original gear on which the ring was pressed is shown white; and a pressure of five tons was required to force it into place.

At the joint between the ring and the old gear, three holes were drilled to receive drill rod keys 3/16 inch in diameter, and particular care was taken to drill each keyway at the bottom of the center of a tooth in order to weaken the ring as little as possible. The steel was quite hard, but it was found possible to drill it with a drill having no rake, very slight clearance and run at slow speed, using a mixture of lard oil and turpentine as a lubricant. Even then, considerable patience was required to complete the job, but when the keys were driven into place a very satisfactory result was obtained. The mating gear was repaired in the same way, except that the number of teeth was decreased by 2 instead of increased as in the preceding case. After being in service for two years we took the gears out, cleaned them, and took the photograph that is reproduced here-



Satisfactory Method of repairing Obsolete Transmission Gears

with. The gears run nicely, and the faces of the teeth now have a good polish; so far as we can see, they are just as good as if they had been cut from solid blanks. Although this method of making the repair called for some careful work, it was much cheaper and quicker than making a new set of gears.

Boston, Mass. LEIGH J. RODGERS

TO DIVIDE A MIXED NUMBER BY 2

To divide a mixed number having an odd whole number by 2, subtract 1 from the odd number and divide by 2; then add the numerator and denominator of the fraction and use the sum for the numerator of the quotient, and multiply the denominator of the original fraction by 2 to obtain the denominator of the quotient. For example, divide 3 7/8 by 2; subtracting 1 from 3 and dividing by 2, gives 1; adding 7 and 8 equals 15; and multiplying 8 by 2 equals 16. The quotient is 1 15/16. Some readers of MACHINERY may appreciate this simple rule for dividing an odd mixed number by 2, as it can be done mentally by anyone at all proficient in figures.

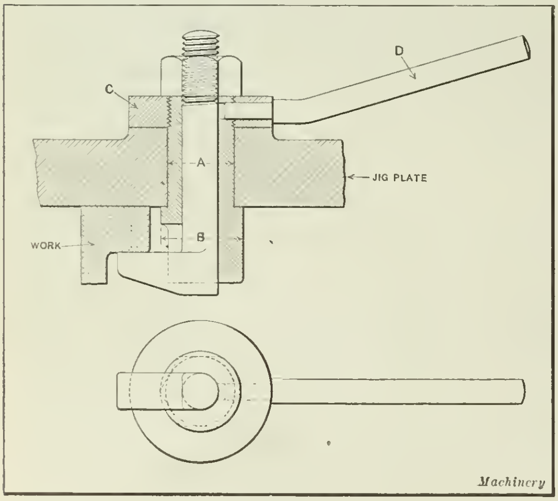
Cleveland, Ohio. A. STEINICKE

IMPROVEMENT IN HOOK BOLT DESIGN

Many engineers will not consider the use of a hook bolt if a bolt can be employed with some form of head, and yet the tool designer must at times resort to this type of clamping device in order to obtain the results desired. A hook bolt of the ordinary type fails, owing to the fact that it has no support in opposition to the point where it is clamped, and hence as the pressure is applied, it becomes more or less bent with use and therefore does not clamp the work tightly; furthermore, it binds more or less in the hole. The bolt shown in the accompanying illustration is designed to overcome the defects mentioned. The diameter of the body *A* may or may not be as large as the nut over the corners, as the collar *C* takes the load. The nature of the work determines the diameter at *B* and the necessary clearance.

It is always well to so design the bolt that it will come as close to the work as possible, always, however, bearing in mind that if used on rough castings an allowance for variation should be made; whereas, if used for finished castings the bolt may come very close to the finished edge of the work. The handle shown at *D* is used for turning the hook and for locating it in a fixed relation to the work. A nut and washer are equally satisfactory without the handle. Applications of this design may be made to various classes of work, and it can be adapted to many conditions where it would be difficult to use other methods of clamping.

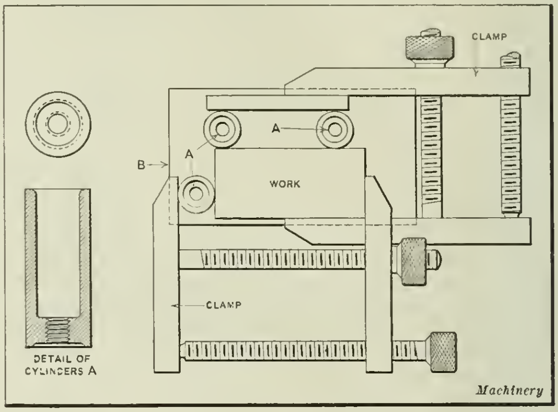
INSPECTOR



Improved Type of Hook Bolt

SQUARING UP WORK ON A SURFACE GRINDER

Grinding small pieces square on the surface grinder is often a difficult matter, as it is seldom one can find an absolutely square block or angle plate against which to clamp the piece to be ground, and, of course, a small error on work of this kind multiplies rapidly as the piece is turned from side to side. In order to have something that could be relied upon, and also that would be light and easily carried in a tool kit, the following arrangement was devised, as here illustrated. This consists of the three cylindrical pieces *A*, shown in detail at the left of the illustration, made of tool steel and hardened, ground and lapped perfectly parallel, having the ends square with the sides. One end was bored out for the sake of lightness, while the other was tapped out to receive a screw for fastening it to the plate *B*. This plate can be of any convenient size, and only requires to be ground parallel on its faces and the holes drilled and counterbored in it to receive the screw.



Method of squaring up Work on Surface Grinder

In use, the cylinders or buttons are first secured to the plate with screws, and then the work clamped against them as shown, in which position it is ready to be placed on the surface grinder and ground. The accuracy of the work depends upon the plate *B* being ground perfectly parallel, and also upon the accuracy with which the buttons are made. The latter, however, should not cause any great difficulty if care is taken in first grinding the cylinders parallel (this can be easily tested with a good micrometer), and then grinding the bottoms square with the sides at the same setting. To determine their truth, they should be tried out with a square after fastening to the plate, and if out of true a little, they may be carefully lapped on the ends until perfectly square.

Long Island City, N. Y. DONALD BAKER

"MADE-IN-AMERICA" DRAWING PENCILS

We often hear the remark, "The manufacturers of this country should go after some of the trade in Latin America and other countries formerly controlled by the different nations now at war." But how about the trade of the same manufacturing countries with us? Have we captured all the trade possible in articles commonly imported? I think not, and will cite one article indispensable to engineering provisions—the common, everyday drawing pencil.

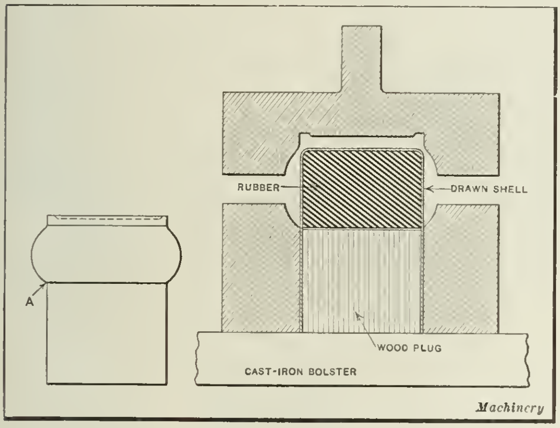
"Koh-I-Noor" is a pencil name familiar to engineers, architects and draftsmen from the day they enter the office or classroom; in fact, with many it has become a sort of fetish. They would not consider using any other make of pencil; they have always used that kind, so why change? This perhaps was all very well when this make of pencil could be readily obtained, but shortly after the beginning of the European war the supply of "Koh-I-Noor" pencils grew less and less, and the price advanced from 30 to 60 per cent.

For the past five months I have been using several kinds of domestic drawing pencils and have yet to notice any defects that would cause me to believe that the imported pencil is superior to the "Made-in-America" pencils. Perhaps some readers have found defects that I have not seen, but I do not doubt that if defects were found and the users had sufficient interest to make them known to the manufacturers, we would soon be able to obtain the very best grades in domestic drawing pencils. Users then would have the satisfaction of knowing that they are using a "Made-in-America" product.

South Orange, N. J. WILLIAM PHILIP

QUICK DIE JOB

Tools were nearly completed for the production of copper shells for percolator bodies similar to that shown at *A*; the shells had been blanked and drawn straight ready for the



Copper Shell for Percolator Body and Punch and Die for forming it

forming operation, which is usually accomplished by spinning. A special spinning chuck and roller are required for every variety of form spun, and in this instance, seemingly on account of the bulge in the form being deeper than ordinary, the spinning tools could not be made to perform the operation satisfactorily, but fractured the shells before the chuck and roller could be brought together close enough to start the form properly. Previous delays had made the delivery of samples of the goods over-due, and something had to be done quickly to help the job along.

The tool department foreman believed that the spinning tools would work satisfactorily if the form were previously started, and therefore had a punch, die and plug made from maple wood. At the first trial the shell did not expand, but collapsed and cracked open. To prevent this the mechanic on the job tried putting a piece of soft vulcanized rubber (cut from such a piece as is used under compound dies) into the shell before placing it on the wooden plug. The result of the next trial was even better than had been hoped for; the shells were formed so perfectly that spinning afterward was not really necessary. They were spun a little, however, to sharpen up the corner *A*.

To operate, it was necessary to withdraw the die (which was not fastened down) from under the punch, take out the finished shell, plug and rubber, reload with another straight shell and push the die back in place against two straps which acted as locating stops. Enough shells were formed for the samples required and cast-iron parts were ordered to replace the ones of wood. The time consumed from the starting of the wooden die until the first satisfactory shell was formed was three hours and thirty minutes.

Bayonne, N. J. WILLIAM A. HAWES

STRAIGHTENING HEAVY SHAFTS WITH COLD WATER

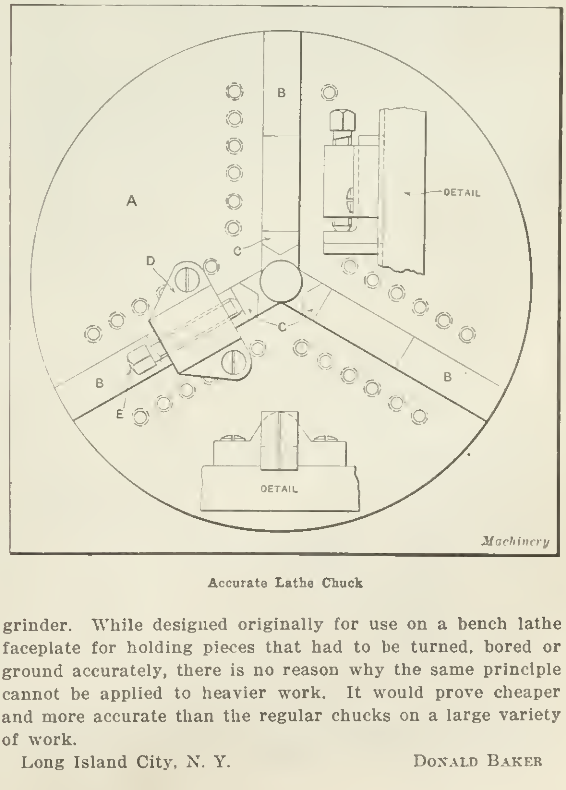
It is not generally known that it is possible to straighten heavy shafts with cold water. I had a connecting-rod 8 inches in diameter by 15 feet long on which a new end had been forged; and when I tried this rod on the lathe centers, it was found to be about 3/4 inch out of true. I had it heated to a red heat and straightened it quite true; but after the shaft had cooled down to a black heat it "went back" sufficiently to show an error of 1/4 inch. After experimenting for a little while I found that by pouring cold water on the "full" side of the bend while the hot shaft was rotating slowly, I was able to get a perfectly straight rod. The same method will be found useful in straightening heavy piping or for similar straightening jobs.

Toronto, Ont., Canada. THOMAS MASON

ACCURATE LATHE CHUCK

The jaws of the average lathe chuck seldom have a bearing for their full length on the piece of work which they are holding, and therefore cannot be depended upon to hold work perfectly square. They may work fairly well while new, if they have been perfectly fitted, but they soon wear, and the looseness between the jaws and the chuck body allows them to become bell-mouthed when tightened on a piece of work. The need of a chuck which could be easily kept true led to the design shown in the accompanying illustration, which shows a set of auxiliary jaws fitted to a bench lathe faceplate. *A* is the faceplate in which have been cut the shallow grooves *B* that the jaws *C* slide in. *D* is the strap which holds the jaws in place and carries the adjusting screw *E*. The strap is held to the faceplate by screws that enter tapped holes, as indicated, spaced to allow for shifting the strap to different positions as shown.

The illustration is clear enough to show the principle, but it is well to note that the chuck jaws and strap are hardened and ground on all wearing surfaces or points of contact, while the grooves in the faceplate are either scraped or ground on the surface grinder until they are perfectly parallel with the surface of the faceplate, as strap *D* must bind sufficiently on the jaws so that when the screws are drawn down tight the jaws will be a tight sliding fit. Special jaws for holding odd shaped or thin pieces can be easily made up, while any wear on the jaw faces can be remedied by regrinding on a surface



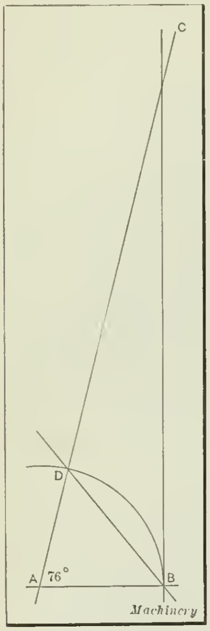
Accurate Lathe Chuck

grinder. While designed originally for use on a bench lathe faceplate for holding pieces that had to be turned, bored or ground accurately, there is no reason why the same principle cannot be applied to heavier work. It would prove cheaper and more accurate than the regular chucks on a large variety of work.

Long Island City, N. Y. DONALD BAKER

MEASURING ANGLES

In the July number of MACHINERY, F. B. Jacobs offers a method for measuring angles that he thinks is better than the one described by me in the May number. Mr. Jacobs overlooks several important points. The method I describe requires the use of a straightedge to produce one of the sides of the angle and a pair of dividers to describe an arc and space it. Mr. Jacobs' method requires a scale, two measurements, a geometrical construction, and a table of natural tangents. Moreover, for angles between, say, 75 and 105 degrees, it is practically impossible to obtain accurate results, since the point of intersection *C* cannot be located with any degree of exactness. (See illustration, which shows the construction for an angle of 76 degrees, the tangent of which is 4.01. Also see last sentence of the answer to the preceding question in the May number, which deals with the problem of dividing a right line into any number of equal parts.) Further, great care will have to be exercised to draw *BC* perpendicular to *AB*. If it is desired to use a table, the following method is to be preferred to that of Mr. Jacobs': with any convenient radius, say 5 inches, describe the arc *BD;* measure the chord *BD;* then, $\sin \frac{A}{2} = \frac{BD}{2AB} = \frac{BD}{10}$. Since an arc always intersects its radius at right angles, the points of intersection can be readily determined in all cases. For angles less than 45 degrees, Mr. Jacobs' method will give accurate results, though probably not as accurate as the method described by me. J. J.

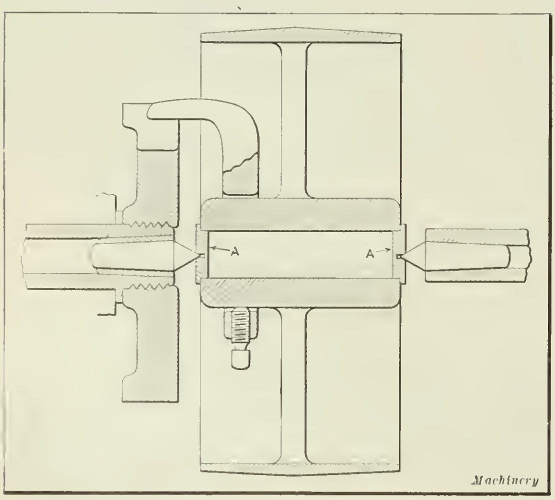


Measuring Angles

TURNING PULLEYS MOUNTED ON CENTER PLUGS

Pulleys and similar parts are usually turned on an arbor; but work of this kind can be handled on two center plugs which are a snug fit in the hole, as shown in the accompanying illustration; and very satisfactory results will be obtained in this way. The center plugs are provided with a small recess under the shoulder so that they may be pried out with a screwdriver.

Miami, Ariz. H. B. SAVAGE



Center Plugs used for turning Pulleys on Centers

COMBINED BLANKING, DRAWING, FORMING AND PIERCING DIE

The muffler cup shown in Fig. 1 is finished complete as shown in one operation by means of the combination blanking, drawing, forming and piercing die shown in Fig. 2, in a single-action press. The operation is as follows: When the blanking punch descends, it enters the blanking die, the blank being held firmly by the drawing ring against the bottom of the blanking punch in order to prevent wrinkles in the metal. The pins shown are used to transfer the pressure. As the downward movement continues, the blank is drawn between the bore of the blanking punch and the drawing punch. As it reaches the end of the stroke, the rim is formed between the recess in the blanking punch and the tapered shoulder on the drawing punch; holes are pierced by punches located in the punch-block, as clearly

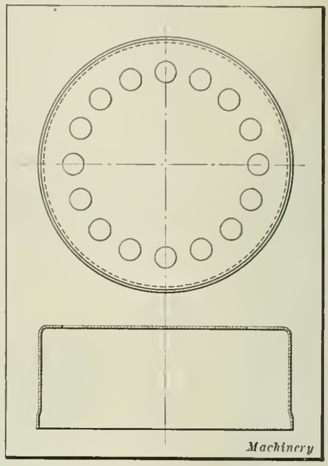


Fig. 1. Automobile Muffler Cup

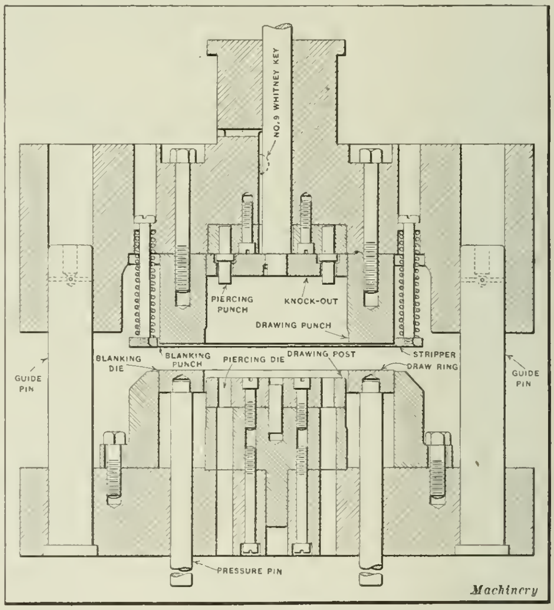


Fig. 2. Combined Blanking, Drawing, Forming and Piercing Die for Automobile Muffler Cups

indicated in the illustration. A spring stripper is used on this work and a knock-out is kept in line with the piercing punches by a Whitney key.

Norfolk Downs, Mass. W. L. JONES

GEARING FOR ROLL FEED

A roll feed is shown in the August number of MACHINERY on page 1053, which I think could be improved upon by eliminating the train of spur gears connecting the two sets of rolls. Instead of using the train of spur gears, I would have continued the horizontal shaft across to the second set of rolls, and connected them by another pair of bevel gears similar to the first pair.

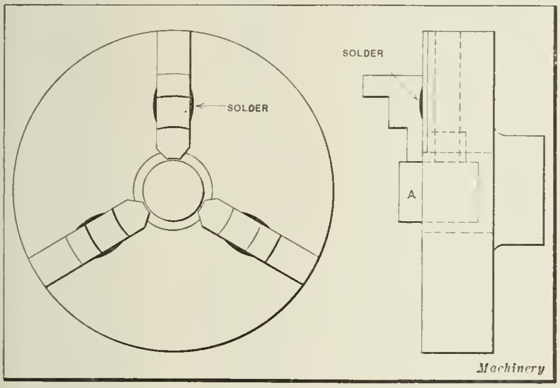
A better location for the horizontal shaft would be at the

back, provided the conditions would permit, and this would result in easier access to the dies. I. L. C.

An important principle in machine design is touched on by I. L. C. in the foregoing. In all cases, wherever possible, power for driving a series of rolls or other machine elements should be conveyed by shafts rather than by trains of spur gears. The reason is that with a train of spur gears frictional resistance is cumulative, and in long trains it may become so great that the mechanism as a whole is inoperative. Another objection to trains of spur gears in such situations is that lost motion is also cumulative and may become prohibitive if the train is long. With a longitudinal shaft, however, frictional resistances are proportional directly to the number of units driven, and lost motion is no more for ten than for one set of elements.—EDITOR.

GRINDING CHUCK JAWS

The article by R. Gordon Edjell in the August number of MACHINERY on truing up the jaws of scroll chucks reminded the writer of a very satisfactory method of grinding chuck jaws which is in use in the tool-room where he is employed. Having had considerable trouble in producing a good, true job by other means, it occurred to the writer that the desired result could be reached by gripping a cylindrical piece *A*, shown in the accompanying illustration, in the chuck with a fair pressure, lightly soldering each jaw to the face of the chuck, and then driving piece *A* carefully out of the jaws. This leaves all the steps open and free to be ground by a toolpost grinder on the carriage, the jaws being left in the position in which they grip the work, and produces accurate surfaces on the jaws. After grinding, the solder can be easily scraped from the surface of the chuck. If preferred, the jaws could be soldered to a small brass or steel angle instead of in the joint, which would facilitate removal of the solder.



Suggestion for grinding Chuck Jaws

Aurora, Ill. CORWIN LAMOREAUX

LAYING OUT DIAGONAL STRIP IN RECTANGLE

In the July number of MACHINERY, J. J. gives a solution to the problem of finding the length of the longest rectangle 3 inches wide that can be laid out in a rectangle 24 by 40 inches. This problem has been solved from time to time in various ways, but it is thought that the following trigonometrical solution will be found to be the shortest method. Using the notation given in the accompanying illustration, we have:

$AB = m \sin \phi$

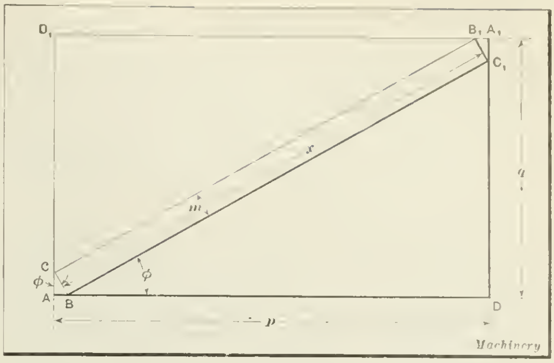
$BD = x \cos \phi$

and $AB + BD = p$

Then

$m \sin \phi + x \cos \phi = p$ (1)

$AC = m \cos \phi$, $CD_1 = DC_1 = x \sin \phi$, and $AC + CD_1 = q$.



Laying out Diagonal Strip in Rectangle

Then $x \sin \phi + m \cos \phi = q$ (2)

Solving Equations (1) and (2) for sin ϕ and cos ϕ, we get:

$$\sin \phi = \frac{pm - qx}{m^2 - x^2} \text{ and } \cos \phi = \frac{qm - px}{m^2 - x^2}$$

Squaring, adding, and making $\sin^2 \phi + \cos^2 \phi = 1$, we get:

$$\left[\frac{pm - qx}{m^2 - x^2}\right]^2 + \left[\frac{qm - px}{m^2 - x^2}\right]^2 = 1$$

Expanding, clearing of fractions and reducing, we obtain:

$$x^4 - (p^2 + q^2 - 2m^2)\, x^2 + 4pmqx - (p^2 + q^2 - m^2)\, m^2 = 0$$

With $p = 40$, $q = 24$, and $m = 3$, we get:

$$x^4 - 2194x^2 + 11520x - 19503 = 0$$

Solving this equation by Horner's method, we find $x = 44.07637$ inches, the length of the diagonal strip.

Cleveland, Ohio. WILLIAM W. JOHNSON

GRINDING NARROW PARALLEL STRIPS

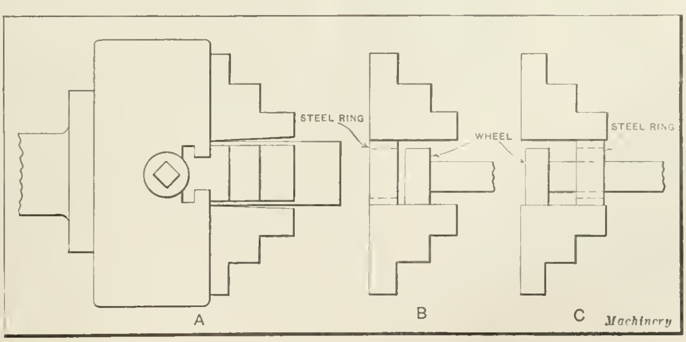
In the August number, "Server" writes in "Grinding Parallel Strips," "Why did not my foreman tell me if the present method represents common practice?" The reason the foreman did not tell "Server," in all probability, is simply that he did not know. I have found that most foremen and toolmakers know very little about surface grinding. They do not know what kind of wheel to use on their work; they generally use any wheel that is on the machine. The best wheel for a Brown & Sharpe surface grinder for general use is a Norton wheel, 46G, 7- by ½-inch face.

When grinding narrow parallel strips it is not necessary to solder them together as described in the August number. Put a parallel about ⅛ inch narrower than the strips in front of them on a magnetic chuck, and on each side if they will not stand up. Then you can grind as many as the chuck will hold.

When grinding jig bushings or punches, if it is necessary to grind on parallels, one of the parallels should be placed on the outer side of the chuck; this will hold a good deal better than when both are put in the center. A. GRINDER

TRUING JAWS OF SCROLL CHUCK

On page 1077 of the August number of MACHINERY, R. Gordon Edjell describes a method of truing the jaws of a scroll chuck, and I think a little further comment on the subject will be of interest to many readers. The retruing of scroll chucks is generally occasioned by the jaws becoming worn at the front; other portions of the chuck and jaws also become worn or strained, with the result that they grip a piece in the manner illustrated at *A*.



Suggested Improvement in Method of truing Chuck Jaws

One of the most im-

portant rules for an internal lapping job of this sort is to keep the lap moving in and out continually while lapping. The only manner in which this could be done, still preserving Mr. Edjell's principle, would be by means of the bar and bushing mentioned. The bushing should slide on the bar. It is a fact that unless a reciprocating motion is imparted to the lap, it will speedily become grooved; also, it will become worn more at those points where the most lapping is done. If the jaws of the chuck are as badly worn as some I have seen, grinding should be resorted to.

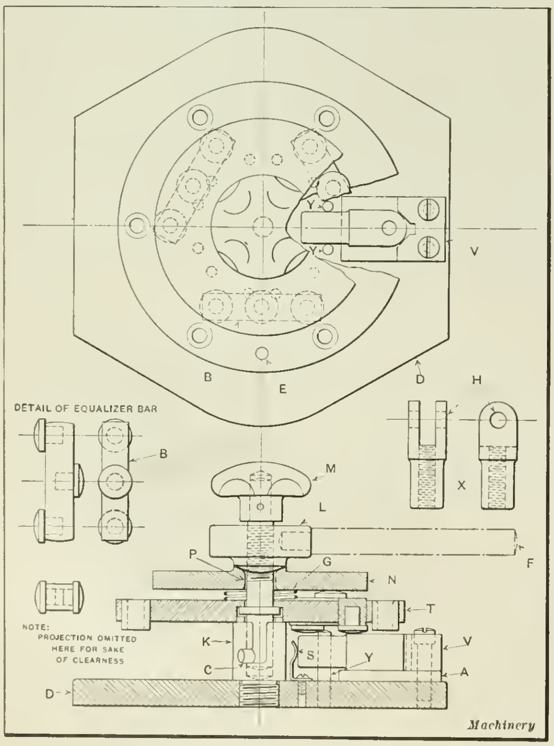
Mr. Edjell's objection to grinding is that the jaws will be slack during this process. This slackness may be removed as shown at *B* and *C*. A steel ring may first be placed as shown at *B*, while the exposed portion of the jaws is ground true. If the wheel is too large to admit passing through the hole in the ring, it may be removed from the spindle, the ring placed over the spindle, and the wheel, spindle, etc., moved into the chuck, the ring being gripped as shown at *C* and the untrued portion of the jaws finished.

Newark, N. J. GUSTAVE A. REMACLE

DRILL JIG FOR ADJUSTABLE YOKE END

In automobile nomenclature, the part shown at *X* in the illustration is known as an adjustable yoke end. Even the simplest motor car employs many such parts, and it will therefore be understood that jigs for drilling these yoke ends must be designed with a view to high production. The accompanying illustration shows a jig used for drilling the hole *H* in six yoke ends at the same time by means of a multiple-spindle drill head. Although complicated in detail, this jig functions very rapidly.

It is required that the hole *H* be practically concentric with the round end, so the piece is located in a V-block, between the two pins *Y*, shown in the upper view where the plate is broken away. The locating is accomplished by pushing the yoke end between the V-blocks *V* and the flat steel springs *S*. The bushing plate *T* and the entire clamping assembly is removed at this time to make the jig accessible. After the parts have been placed in position in the jig, the bushing plate and assembly are put back in place, and as the pin *C* enters the slot, it is pushed down to the bottom of the socket *K* and locked by turning the knob *M* clockwise. The bushing plate is brought to the right position by registering with the pin *E*, which location also brings the lower buttons of the equalizer bars *B* directly over the yoke ends. Turning the nut *L* clockwise by means of the removable handle *F* brings it against the spherical seat of the clamp plate *N* which, in turn, compresses the helical spring *G* and brings the equalizer bars against the work. The handle *F* is then removed and the work drilled. Reversing the process and rapping the base-plate *D* against the drill table releases the work. The function of the helical spring *G* is to keep the plate *N* against the nut *L* so that a small movement of the handle *F* will permit of unclamping the plate. A hardened steel plate *A* is provided for a seat on which the work rests. It should be noted that the slot in the yoke end is milled out in an operation following the drilling.

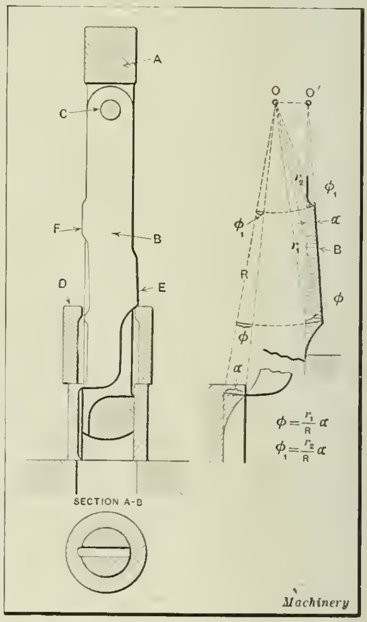


Drill Jig for Adjustable Yoke End

Bridgeport, Conn. W. BURR BENNETT

OIL-GROOVE CUTTING TOOL

If many bearings having the same inside diameter are to be grooved for oil with a straight groove as shown in the accompanying illustration, a tool must be designed especially for this purpose. This tool has a number of advantages over the type of tool which has a special feeding device for obtaining the correct depth of groove, the most important of these advantages being that no special machines or fixtures are necessary for the operation. The toolholder *A* is slotted out to receive the grooving tool *B*. This tool is pivoted on the pin *C* so that it can move freely. The work is so located on the fixture base that the bushing *D* is directly above it. The bar from which the tool is made is formed at *E* and *F* so that as it strikes the edge of the bushing it is carried into the work and out again as the tool travels downward. A light arbor press of the hand type can be used for the operation with excellent results. The diagram shown at the right-hand portion of the illustration shows the method of plotting the cam surfaces *E* and *F* to produce the desired result on the inside of the bushing. Lines drawn from the center *O'* to the angle α intercept ordinates for the cam at any position of the tool.

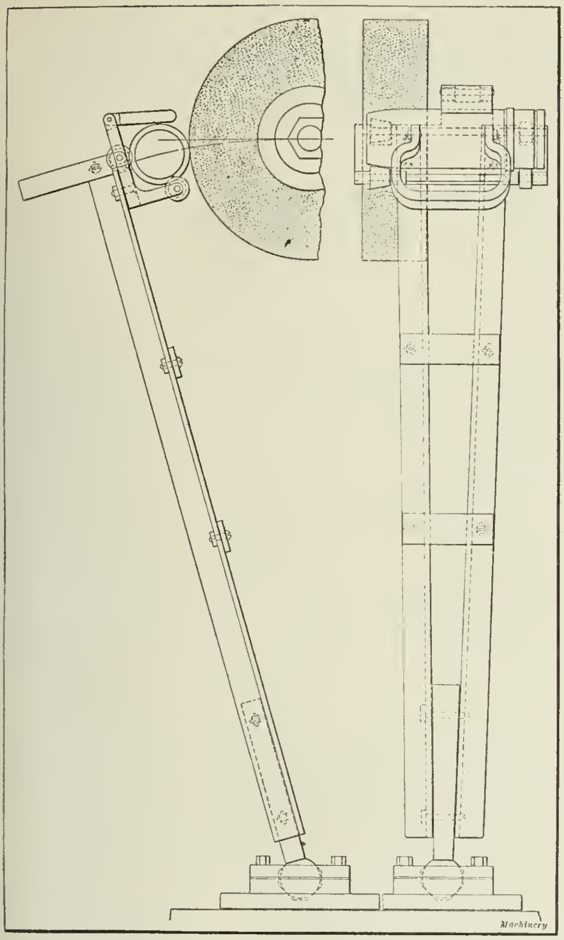


Oil-groove Cutting Tool

Avenel, N. J. ADALBERT O. ALEXAY

POLISHING FIXTURE FOR SHELL NOSES

In the manufacture of shrapnel shells there are two methods of finishing the nose of the shell after hardening. The specifications call for a polished nose, and one method is to grind these shells on centers, using a form wheel. The other consists in finishing this surface by polishing on a leather faced wheel that has been set up with fine emery. It will be appreciated that to hold the shell by hand steadily and turn it evenly while polishing is not an easy job. To facilitate this operation one of the large shell manufacturers has built the device shown in the accompanying illustration that takes



Support for Shells when polishing

care of this operation very well. Incidentally, this type of fixture can be employed to good advantage on cylindrical work of any diameter, whether shells or any other product.

The polishing head and wheel are no different from the usual type of polishing apparatus. The fixture consists of a pair of angle-iron strips that are mounted on a ball and socket base, attached to the floor under the machine. These angle-iron strips are strapped together, and just below the axis of the wheel is the shell holder. The shell holder or cradle consists simply of two sets of friction rolls on which the shell is laid. At the top is a hinged plate that is thrown over the shell and used as a brake. The operator grasps the handle and applies a slight pressure against the wheel. This causes the shell to turn slowly and polishes the surface, as the wheel surface travels much faster than the shell. For reaching the different parts of the curve, the entire fixture is rocked on its axis. The hinged brake above is for the purpose of retarding the rotation should a shell obtain too much momentum, and it is operated by hand pressure.

After polishing a few shells, the operator becomes dexterous in its manipulation, and production is far in excess of that obtained when working free-hand. C. L. L.

CLOCK TROUBLES

A watchmaker—a good one—bought a regulator of high grade and price, set it up with pride and joy, but found that the time it kept was hardly up to seventy-five-cent watch standard. Careful and prolonged study of its eccentricities revealed that its performance was in cycles. It did well for a certain length of time, and then for a shorter period it gained, again was righteous for a season, and so on. It seemed to the watchmaker, as a reasoning being, that this indicated trouble in the "great wheel" (the first in the train, which carries the drum for the cord), but careful inspection failed to find the "bug" either there or elsewhere in the movement. Finally, a friend was summoned who was supposed to be clock-wise; he looked where no one, not even the inspector at the maker's factory, had looked before, and found that the pulley on top of the weight was out of square with its arbor, so that at one point in its revolution it rubbed against its housing. That was all.

Another watchmaker set out to build a clock that should be an exact replica of a fine astronomical one which he had been employed to clean, all the dimensions, etc., of which he had noted for this purpose. A toolmaker friend bored all the holes in the plates with the utmost attainable accuracy, roughed out the staffs from drill rod and hardened them. Mr. Watchmaker ground them all over, jeweled every pivot hole in the plates, put in sapphire pallet stones, and, in short, did everything he knew to get a perfect job. I never have seen a finer piece of work. Yet when it was set in motion it proved unreliable, keeping nearly perfect time for four or five days, then showing a different rate for the rest of the week. To be sure, the owner might wind the clock twice a week, and thus get good results, but you and I know how unsatisfactory this would be to a man who had made what he intended for a masterpiece. After worrying over the problem for some weeks, he put it up to his toolmaker friend, knowing he had had a good deal to do with fine clocks. The advice he received seemed to him absurd, but he tried it, and found to his great surprise that the trouble was entirely cured. This "senseless" advice was to insert a plate of glass between the path of the weight and the plane of motion of the pendulum. After being convinced of the successful working of this device, the reason was explained to him.

In copying his model he had made one slight change, reducing the depth of the movement in order to make it fit a fine case that he owned. This brought the weight, at the lower end of its course, quite near the swing of the pendulum bob, and the weight, interfering with the air currents set in motion by the bob, had affected the rate of the pendulum. When I was first taught this point, many years ago, I was skeptical till experiment showed me its correctness. Later, by changing the insertion of the cord into the drum, so that the weight, at its low point, was farther from the bob by the drum's length, he was able to dispense with the glass. As indicating the excellence of workmanship in this case, I may mention the fact that the weight, though made large for the sake of appearance, was a hollow affair, weighing only a trifle over one-half pound.

In still another instance a costly clock of foreign manufacture had one rate for the first two or three days of the week and another for the later days. Through faulty design the drum was so small that the cord, when fully wound, made one complete layer on the drum and part of a second. A new drum, with the necessary alteration in the weight to compensate for the increased leverage, removed the trouble. I think this fault is never found in an American clock. In justice to American makers, I wish to say that the instance mentioned in the June number of MACHINERY is the first case I've ever known of a 'scape or other train wheel being out of center in a Yankee clock. Even in Europe, where they are subjected to scathing criticism, it is universally admitted that, with all their faults, American movements are faultless in truth of wheels and correctness of "depthing" (the center distances between wheels).

I know of a fine imported mantel clock, a beautiful piece of mechanism, jeweled, with "Brocot visible" escapement, gold-plated 'scape wheel of hardened steel, ruby pallet stones, etc., which cost in its marble case, over $100 at retail. This clock ran well for nearly a year, was then cleaned and ran six months. It was found that its escape wheel was 0.006 inch out of center. The hole was ground true, a bushing inserted, and all was well. Of course, 0.006 inch isn't much, and the movement ran, in spite of it, till it got a bit dirty.

New London, N. H. GUY H. GARDNER

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

RAKE OF SHEAR BLADES

D. E. T.—What is the inclination or rake of the upper blade in a power shear?

Answered by the Long & Alletatter Co., Hamilton, Ohio

A.—It is not feasible to make all shear blades with the same rake; but we generally give 3/4 inch to the foot for cross-cutting bars, and as near this as possible for splitting plates. But the variation in thickness of material and the length of sheet to be cut requires the blade to be set at different rakes in order to adapt the machine to the desired capacity. Sometimes we do not give more than 1/2 inch rake to the blade, and if it is, say, ten feet long, this requires a stroke of five inches. If the sheet is very wide and we cannot get the amount of rake to the blade owing to the length of knives, we are obliged to use a larger and heavier machine, because there is more work to be done at one stroke of the slide.

CASTING BRASS NUTS ON FEED-SCREWS

T. M.—We are using a large number of brass nuts for the cross-feed screws of our cutting-off lathes on shell work. The screws are 1 3/4 inch outside diameter, 4 inches in length and 4 threads per inch, square thread. Two nuts are used in each machine on right- and left-hand threads. We are cutting the nuts in a lathe, but they do not give satisfactory service. I worked for a company in England where all the brass nuts were cast on their own screws, and they made a good hard-service nut. Can you furnish information on the subject and tell what kind of coating should be put on the screws before casting the nuts? Should the screws be heated before pouring the metal around them? The hard skin secured by casting the nut on the screws makes a good wearing nut, and I am desirous of getting information on the process.

The inquiry is referred for answer to any reader having had experience with this class of work.

THE MATTER OF PERCENTAGES

L. A. B.—I noticed a statement in the August number to the effect that the output had been increased over 400 per cent. I was taught that 100 per cent of anything was the whole and it was impossible to have any more. I have run across the same statement in newspapers, magazines, technical books, etc., which has made me wonder if the basis of percentage had been changed. Will you please enlighten me on the subject?

A.—It is quite correct to state that the output had been increased 400 per cent provided it was five times the original output. If the output were quadrupled, the percentage of increase would be 300 per cent; if it were tripled, 200 per cent, and if it were doubled, 100 per cent. The error in statement of percentages to which you refer doubtless applied when they were matters of decrease. For instance, if the cost of doing a job were cut in half, it would not be correct to say that it was decreased 200 per cent. Obviously the cost could be cut only 100 per cent, and then the cost would be nothing. If the cost is cut in half, the decrease is 50 per cent; if it is cut to one-third, the decrease is 66 2/3 per cent, etc.

KILOVOLT-AMPERE

S. B.—What is the meaning of the term "kilovolt-ampere" as used in connection with various electrical machines? The writer always has known of electrical machines as rated in kilowatts, but has recently seen a number of catalogues in which the rating is in kilovolt-amperes.

Answered by E. A. Lof

A.—The term kilovolt-amperes (KVA), equal to 1000 volt-amperes, expresses the *apparent* power in a circuit, *i. e.*, the product of the effective values of the current and the voltage, IE, in a reactive circuit. The term kilowatt (KW), equal to 1000 watts, on the other hand, expresses the *true* power, $IE \times \cos \phi$, and is the reading obtained by a wattmeter applied to the circuit. The ratio of the watts to the volt-amperes is called the *power factor*. For example, assume an alternating-current generator supplying a load of 800 kilowatts, the power factor of which is 80 per cent. The true rating of such a generator, or the one on which the capacity of the prime mover should be based, would be 800 kilowatts, while the apparent rating of the generator would be $\frac{800}{0.80} = 1000$ kilovolt-amperes. To avoid any misunderstanding, the rating usually appears as follows: 1000 KVA (800 KW, 0.8 power factor). For direct-current generators, however, the rating is always given in kilowatts, inasmuch as such machines always operate on non-inductive load.

The rating of a synchronous machine is usually determined by its permissible temperature rise caused by the current. This rise increases with increasing load and with decreasing power factor. Thus, for a given kilovolt-ampere output, the total heat losses are larger for low than for high power factors, the difference being due to the heat generated by the increased field current which is required to overcome the armature reaction and maintain the given current and terminal voltage.

PEAUCELLIER'S COMPOUND COMPASS

T. L. M.—In the August number of MACHINERY, Frederic R. Honey describes several linkages for producing straight lines; have these ever been used in practice? Where can I obtain more information regarding these and other linkages?

A.—Both the first and second forms of linkage described by Mr. Honey have been used on the walking beams of pumping engines or for similar purposes; and either form could be used on a steam-engine indicator, provided the weight of the moving parts were sufficiently reduced. One of the most interesting applications is found in the compound compass—a very useful instrument for any drafting-room, and one that the writer has used with good results. Referring to the accompanying illustration, link *oD* is equal in length to distance *oA*. A graduated scale, to which is attached a vernier for accurate setting, is placed between *A* and *D*, the edge of the scale coinciding with the line *AE*. The end o of link *oD* can be moved along this scale to the right or left of point *o*, which is the zero mark on the scale. At joint *E*, there is an arrangement for holding a pen or pencil point; and when the end *o* is at the zero mark, the pencil at *E* will describe the straight line *FG*. When *o* is at any point to the right of the zero mark, as o′, the pencil will describe an arc of a circle, as *HEI*, tangent to *FG* at *E*; and when o is to the left of the zero mark, as o″, the pencil will describe an arc of a circle, as *JEK*, which is also tangent to *FG* at *E*. By means

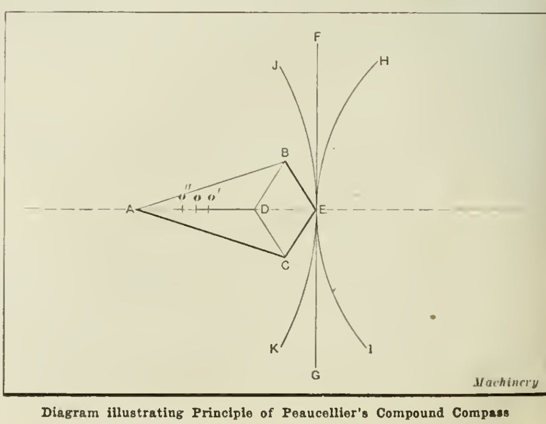


Diagram illustrating Principle of Peaucellier's Compound Compass

of a simple formula, the position of o′ or o″ may be calculated, whereby the resulting arc may be of any radius desired. The instrument is chiefly employed when arcs of large radii are to be drawn and a beam compass is inconvenient to use. A full description of this and other linkages is given in Weisbach's "Machinery of Transmission" (Wiley); it is also fully treated, together with many of its modifications, in "Linkages," by J. D. C. De Roos, in No. 47 of Van Nostrand's Science Series. The latter work is of great interest to those mathematically inclined, as it shows how the linkage may be modified to find the roots of numbers and equations, and to describe conic sections and other curves. J. J.

FIFTH ROOTS OF NUMBERS

A. H. M.—In the August number of MACHINERY, you give a small table to be used in connection with finding the fifth root of numbers. Please show me how the values in the third column are found; I think this would be useful to know when finding other roots by the same method.

A.—Referring to page 1085 and using the same values for the letters, $r =$ the root to be found; $m =$ the given number; $n =$ the index of the root; $x =$ an approximate value of the root. Then $r = \left(\frac{m}{x^n} + n - 1\right)\frac{x}{n}$. If the values in the third column be called the limiting values for the first approximate value of x, and be represented by L, then $L = \frac{(n-1)\,x^{n-1}(x+1)^{n-1}}{(x+1)^{n-1} - x^{n-1}}$.

For example, if $x = 2$ and $n = 5$, $n - 1 = 4$, and $x + 1 = 3$. Substituting in the formula for L, $L = \frac{4 \times 2^4 \times 3^4}{3^4 - 2^4} = 79.7$, the same value as in the table. For cube root, $n = 3$ and $n - 1 = 2$. For $x = 4$, say, $x + 1 = 5$, from which $L = \frac{2 \times 4^2 \times 5^2}{5^2 - 4^2} = 88.9$. The values of L for the cube root corresponding to $x = 1$, 2, 3 .....9, 10, are 2.67, 14.4, 41.1, 88.9, 164, 271, 418, 610, 853. It is not advisable to use more than three figures for L. J. J.

SIGN OF A BENDING MOMENT

A. J. E.—I notice that the sign of the bending moment for a simple beam is always positive, or +, and for a cantilever it is negative, or —; why is this, and what is meant by the negative sign?

A.—Fig. 1 represents a heavy beam of rectangular cross-section, supported at both ends as shown, thus representing to all intents and purposes a simple beam uniformly loaded. Let c be the center of gravity of the beam; then all the weight may be considered as concentrated at this point, and the effect produced by this weight is a bending of the beam as indicated in the illustration (greatly exaggerated). The dotted line (*ab* in *A* and *bd* in *B*) represents the neutral surface; and when the beam lies on a horizontal plane, this neutral surface is horizontal; the neutral surface always passes through the center of gravity of the cross-section. An examination of Fig. 1 shows that all longitudinal fibers of the beam above the neutral surface are in compression, due to bending, and all below the neutral surface are in tension, while those in the neutral surface are neither shortened nor lengthened—their lengths remain unchanged. Referring to Fig. 2, which represents a beam fixed at one end only, *i. e.*, a cantilever, an exactly opposite effect is produced; here the fibers above the neutral surface are in tension, and those below are in compression.

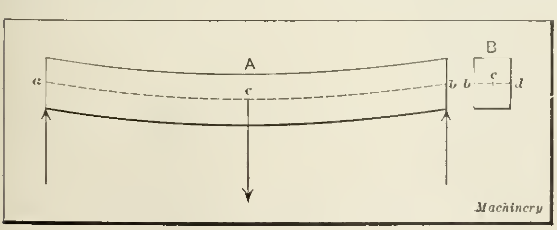


Fig. 1. Diagram showing Condition of Simple Beam subjected to Bending

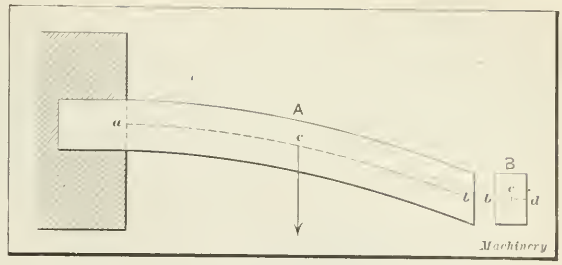


Fig. 2. Diagram showing Opposite Condition of Cantilever Beam subjected to Bending

Since the bending moments are measures of the effects just described, it is customary to call the bending moment of a simple beam positive, and of a cantilever, negative. The negative sign has no significance in so far as it affects calculations pertaining to the strength of beams; but it is useful and necessary in connection with investigations relating to restrained and continuous beams. It will also be noticed that the upper surface of the beam in Fig. 1 is concave, while in Fig. 2 it is convex; this is another reason for the opposite signs of the bending moments. J. J.

CUTTING A SEMI-STEEL GEAR ON A MILLING MACHINE

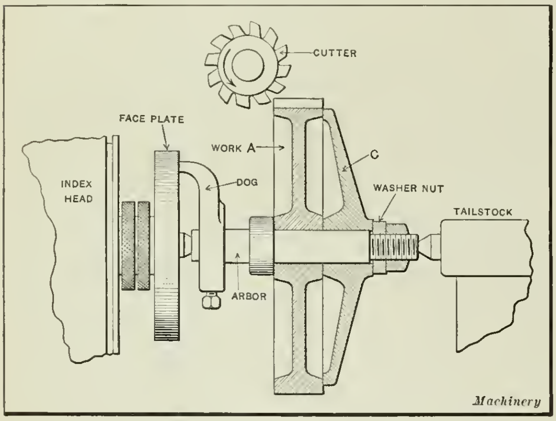
T. W.—Kindly give me an idea of what would be considered fair time to allow in cutting the teeth on a semi-steel spur gear of the following dimensions, giving the feeds and speeds which could be used on a No. 3 Cincinnati milling machine: gear sizes, 12.25 inches outside diameter, 2-inch face, 96 teeth, 8 pitch involute, whole depth of tooth, 0.270 inch, bore 1.25 inch.

A.—The material specified as semi-steel may vary greatly in hardness, so that it is difficult to give a definite feed and speed for this material without knowing its composition. Assuming, however, that the material is such that it can be cut at a speed of about 60 feet per minute for the roughing cut, with a normal amount of feed, the proposition would work out about as follows. The method used in setting up the gear itself is of considerable importance, as its diameter is such that unless it is properly supported a certain amount of chatter will be apparent and the speed must, therefore, be reduced, so that considerable loss of time will result. The accompanying illustration indicates a method which can be used for setting up a piece of work of this kind so that chatter will be avoided. The work *A* is held on an arbor which is supported on centers by the index head and suitably dogged, as indicated. A collar *C* can be used to support the portion of the gear which is being cut, so as to take the thrust of the cut and prevent chatter. The important point is to obtain a backing against which the cutter may work to its full capacity. In order to make a good commercial job, it would be necessary to take two cuts on each tooth, the first cut roughing out to within about 0.010 to 0.015 inch of the finished depth of tooth and the final cut bringing the work to the exact size.

The number of divisions or teeth to be cut being 96, it will be necessary to use differential indexing to obtain the proper division. The following settings would produce the desired result: index circle, 21; number of turns of crank, $\frac{9}{21}$; graduation on sector, 85; gear on worm, 28; gear on spindle, 32; idlers: No. 1 hole, 24; No. 2 hole, 44. The time necessary for setting up the machine would vary considerably and will not be taken into consideration in the estimate of time given herewith, for the reason that the number of gears to be machined is not known; hence, it would not be fair to consider the setting-up time in connection with this piece of work. The estimated time for the operation, assuming a cutting speed as mentioned and both roughing and finishing cuts on the teeth, is given herewith: diameter of rough stocking cutter, 2⅞ inches; cutting speed (rough), 60 feet per minute; revolutions of cutter per minute, 30; feed, 4 inches per minute; indexing gear and running back table for the cut on each tooth, 15 seconds.

In determining the amount of travel necessary for the cutter in cutting each tooth, it will be found that nearly 3 inches is needed to complete the cut, taking into consideration the approach of the cutter to the work when the latter is in the rough state. At a feed of 4 inches per minute and a distance to travel of 3 inches, 3/4 minute would be necessary to cut each tooth; the indexing and running back of the table after each tooth has been cut is estimated to be 15 seconds, which gives a total time necessary for cutting each tooth of exactly one minute. Hence, as there are 96 teeth to be cut, it will take 96 minutes to make the roughing cut on the gear.

For certain classes of work, a roughing cut might be all that is necessary, but in the majority of cases a finishing cut will be found advantageous. In finishing the work, the time consumed would be as follows: cutting speed, 80 feet per minute; revolutions of cutter per minute, 106; feed, 6 inches per minute; allowance for indexing and running back the table after each tooth is cut, 15 seconds. The actual length of time necessary to make the cut, therefore, is 1/2 minute, which, added to the 15 seconds allowed for indexing and running back the table, makes 3/4 minute for each tooth. Hence, $96 \times 3/4 = 72$ minutes. As the time for the first or roughing operation was found to be 96 minutes, and the second operation of finishing takes 72 minutes, the total time necessary for one



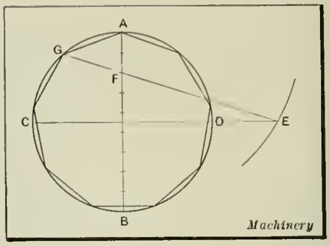
Set-up of Gear on Milling Machine

gear will be $96 + 72 = 168$ minutes, or 2 hours, 48 minutes, the total time necessary for cutting one gear of the size mentioned. It must be remembered that there is no setting-up time taken into consideration in this estimate, nor is there any allowance made for replacing the roughing cutter by the one used for finishing. The time given in the estimate, therefore, may be considered to be only the actual machining time with the incidental time necessary to perform the required movement of the table and index head. A man familiar with the machine and one well versed in this class of work might be able to make the necessary changes in the machine and set it up for the work in about an hour's time.

INSCRIBING POLYGONS IN CIRCLES

W. W. N.—Is there any rapid and accurate method for inscribing a regular polygon in a given circle? I want a general method, if possible.

A.—All general methods of inscribing a regular polygon in a circle are necessarily approximate, since, otherwise, it would be possible to square the circle, trisect an angle, and do other things that mathematicians have proved could not be done. The following construction is rapid, and is the best that is known to the writer; it is also sufficiently accurate to meet practically every need of the draftsman. Draw two diameters, AB and CD, at right angles to each other. Produce one of the diameters, as CD, and with one end of the other diameter, as A, as a center and a radius equal to the diameter, describe an arc cutting CD produced in E. Divide the diameter AB into as many equal parts as the polygon has sides, and through E and F (F is the second division point from A), draw EF cutting the circle at G. Then the chord GA is one side of the polygon, very nearly. For method of dividing AB, see the May number of MACHINERY, page 803. It is not necessary, of course, to draw in all the points of division, since only one, the point F, is needed. The figure shows how a regular polygon of nine sides may be inscribed. This construction is very accurate when the number of sides exceeds nine or ten; hence, if great accuracy is required, and the number of sides is less than nine or ten, it is better to inscribe a polygon of twice or three times the number of sides required. The desired polygon can then readily be drawn. J. J.



Inscribing a Regular Polygon in a Circle

TO FIND AREA OF ANY PLANE FIGURE

A. F. W.—Will you please give me a rule or method for finding the area of any plane figure, no matter what its shape?

A.—The two rules that are most frequently used for finding the area of a plane figure are the so-called trapezoidal rule and Simpson's rule; the latter is more accurate, but the former is a trifle easier of application. An actual example will make the process clear. Referring to the diagram, find the area included between the arcs ABC and AGC. First draw a line, either within or without the figure, but extending its entire length; in this case, the line AC will be the most convenient. Divide this line into any even number of equal parts, say ten, and through the points of division, draw perpendiculars to AC; these perpendiculars are called ordinates. The ordinates are lettered h_0, h_1, h_2 .... h_{10}, the end ordinates, h_0 and h_{10}, being equal to 0 in this case. Measure the ordinates very carefully; add those which have odd subscripts (as h_1, h_3, etc.) and multiply the sum by 4; add those which have even subscripts (as h_2, h_4, etc., but not including the end ordinates) and multiply the sum by 2; add the two products and the two end ordinates, multiply the sum by the distance between any two consecutive ordinates, and divide the product by 3; the result is the area by Simpson's rule. Expressed as a formula, the rule becomes

$$A = \frac{d}{3}\left[h_0 + h_{10} + 4(h_1 + h_3 + h_5 + h_7 + h_9) + 2(h_2 + h_4 + h_6 + h_8)\right]$$

in which d = the distance between any two consecutive ordinates $= AC \div 10$, in this case. As measured by the writer, the area is $A = 0.499 \div 3\ [0 + 0 + 4\ (0.83 + 1.73 + 2 + 1.73 + 0.83) + 2\ (1.37 + 1.93 + 1.93 + 1.37)] = 6.93$ square inches.

By the trapezoidal rule, measure the ordinates half way between the equal division points (as ab, cd, etc.), find their sum, and multiply it by d, the distance between two consecutive ordinates. As measured by the writer, $A = 0.499\ (0.45 + 1.12 + 1.56 + 1.84 + 1.98 + 1.98 + 1.84 + 1.56 + 1.12 + 0.45) = 6.94$ square inches. By calculation, $A = 6.93$ square inches. Had the figure been $ABCDHE$, AE and CD being parallel to $O'O$, and the radius $OH = 3.5$ inches, the area by Simpson's rule would be 9.79 square inches; by the trapezoidal rule, 9.84 square inches; and by calculation, 9.78 square inches. By the trapezoidal rule, AC may be divided into any number of equal parts, but Simpson's rule requires an even number. J. J.

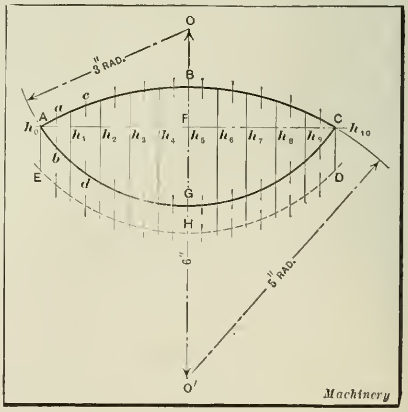


Diagram for finding Area of Any Plane Figure

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

BAKER HEAVY-DUTY DRILLING AND BORING MACHINE

This machine is noteworthy because of its exceptional size. The maximum distance from base to spindle is 48½ inches; distance from center of spindle to face of frame, 22 inches; total height of machine, with the spindle in its highest position, 13 feet, 3½ inches; over-all width, 60 inches; and net weight, 18,000 pounds. The drive is through a single pulley and back-gears to the speed-box, eight changes of speed being available, covering a range from 3.5 to 87 revolutions per minute. Twelve changes of feed are provided which cover a range from 0.005 to 0.032 inch per revolution of the spindle. An interesting feature of construction is the liberal use which has been made of ball bearings, twelve sets of bearings being used in each machine.

Constant effort made by progressive manufacturers to increase their rates of production has resulted in great progress in the design of machine tools intended for operation at high speed. To meet the demand for drilling and boring machines having sufficient power and productive capacity to work at high speed on cast steel and forgings, Baker Bros., Toledo, Ohio, have added to their line the heavy-duty high-speed drilling machine which forms the subject of this article. Reference to Figs. 1 and 2 will show that it is of the vertical type with a column of box section which carries the spindle, feed-box and speed-box; this column is bolted to a heavy base casting which extends out to the front, forming a table in which seven 1¼-inch T-slots are cut. A hole is also bored in the center of the table to form a support for boring-bars, in addition to which the base carries pockets for cutting fluid. No other table is required for handling those classes of work for which this machine is adapted.

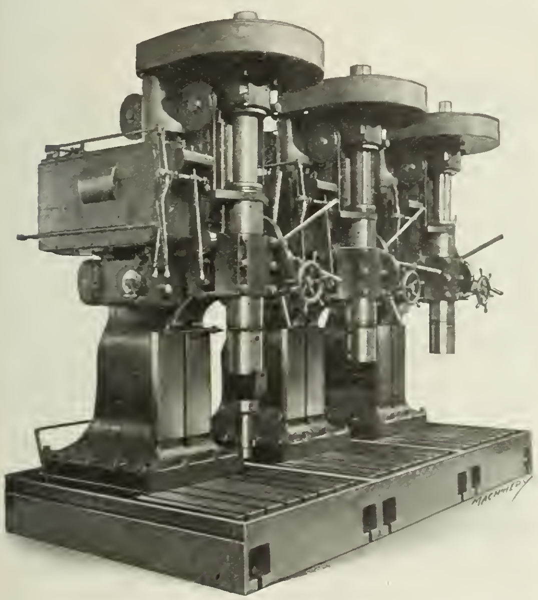


Fig. 1. Left-hand Side of Baker Drilling Machine, showing Speed- and Feed-boxes and Control Levers

Power is supplied by a 6-inch double belt which runs over tight and loose pulleys, 24 inches in diameter, that rotate at 400 revolutions per minute. The machine is started and stopped by shifting lever *A*, Fig. 3. From pulley shaft *D*, Fig. 4, power is transmitted through back-gears mounted on the frame to a speed-box shown in Fig. 3, which is mounted at the side.

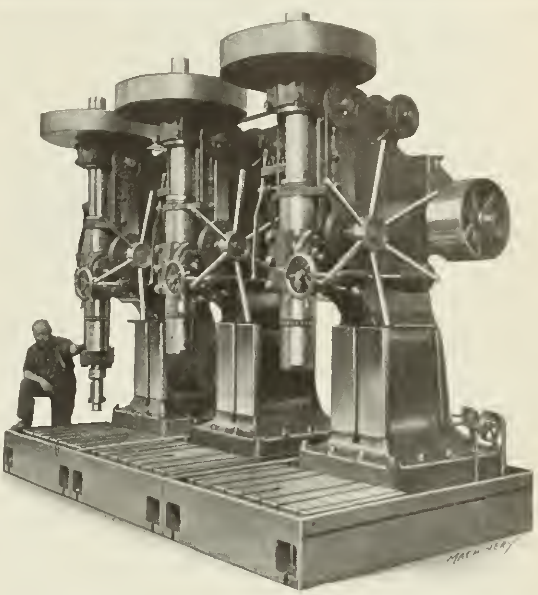


Fig. 2. Right-hand Side of Baker Drilling Machine, showing Hand Feed, Feed Trip and Rapid Traverse

The double back-gears provide two speed changes, and four changes are provided in the speed-box. Power is transmitted from the back-gears to the speed-box through 2-pitch bevel gears, and in this connection it may be mentioned that the back-gears *E* and *F* are 5/7-pitch stub-tooth steel gears which are hardened and ground. Lever *C*, Fig. 3, is used for shifting the back-gears, and lever *B* operates through an H-coutrol to give the four speed changes through sliding gears in the

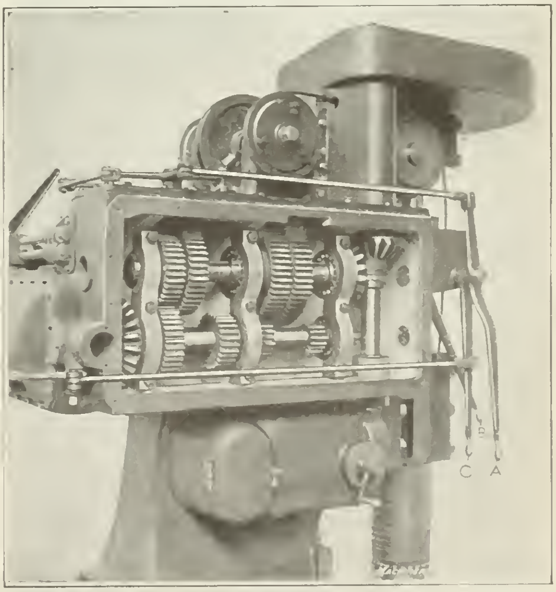


Fig. 3. Close View of Speed-box with Cover removed to show Gearing

speed-box. These are 4/5-pitch stub-tooth steel gears, which are hardened and ground, and supported on steel shafts similarly heat-treated. From the foregoing it will be evident that two levers provide eight changes of speed, which are 3.5, 5.5, 8.5, 13, 23, 36, 56 and 87 revolutions per minute. All shafts in the speed-box are mounted on S. K. F. ball bearings, of which twelve sets are used in each machine.

From the speed-box power is transmitted to the spindle through 2-pitch bevel gears and a driving shaft to spur gears mounted at the top of the machine. The spur pinion on this vertical shaft is a 2-pitch, 16-tooth gear of 5 inches face width

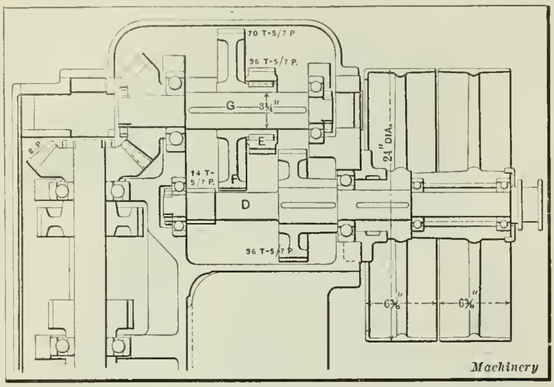


Fig. 4. Arrangement of Drive from Pulley Shaft through Back-gears

meshing with an 80-tooth main driving spindle gear. The teeth of this gear are cut in a steel shrouding bolted to a cast-iron hub by six ⅞-inch bolts. These gears are enclosed in an oil-proof housing and run in grease. The spindle is of forged open-hearth steel containing 0.60 per cent carbon; the maximum diameter is 10 inches and the minimum diameter, 7 inches. It is driven from the main driving gear through two 1¼-inch tool-steel feather keys located 180 degrees apart; and the end of the spindle is slotted 4 inches wide by 1 inch deep to provide for driving the tools. Owing to the extraordinary size of the spindle, standard tapers are not large enough, and so a special taper is employed. The hole is 9 inches deep by 4 inches in diameter at the bottom of the taper and tapers 0.625 inch per foot. The shank of the driving tool is held in place by a pin 1 inch in diameter, and at the end of the taper a drift hole 1½ inch in diameter is bored through the spindle instead of employing the customary slotted drift hole.

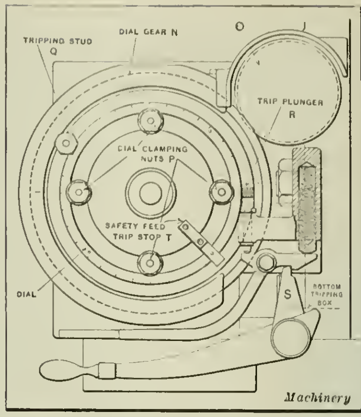


Fig. 6. Arrangement of Feed Trip Mechanism

The spindle thrust is taken by ball thrust bearings located at the top and bottom of the spindle quill. The balls are of a special alloy steel; in the bottom bearing they are 1¼ inch in diameter, while ¾-inch balls are used in the top bearing. The spindle quill is 10 inches in diameter, and it is made of cast steel and ground to size. Vertical feed is obtained through a rack and pinion, the rack teeth being milled from the solid quill, which has ¾-pitch stub teeth and provides a maximum vertical feed motion of 27 inches. Traverse of the spindle is effected by turning a six-handled capstan by hand.

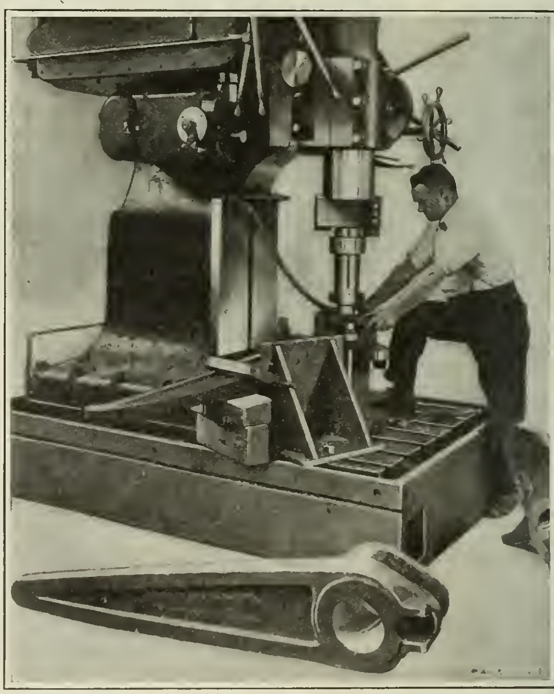


Fig. 7. Close View of Machine in Operation and Typical Example of Work

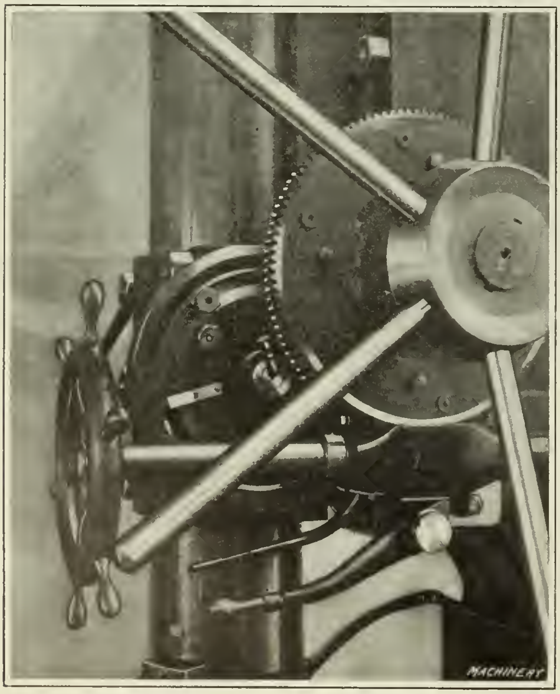


Fig. 5. Close View of Feed Trip Mechanism in Place on Machine

The quill is prevented from rotating with the spindle by two guide bars cast integral with the quill. In addition to preventing rotation, these guide bars carry the spindle counterbalance cables which support weights inside the frame of the machine. An idea of the size of the spindle will be obtained from the fact that the counterbalance weighs 1650 pounds. On smaller drilling machines built by Baker Bros. the quill carries the feed trip band, but on the present machine the feed band must necessarily be omitted because of clearances in design. An interesting tripping mechanism is employed for the automatic trip.

Power is transmitted from the vertical driving shaft and thence through a bevel gear and pinion to the feed-box. Four positions of a drive key with change-gears provide twelve changes of feed, which are 0.005, 0.006, 0.007, 0.008, 0.010, 0.012,

0.014, 0.016, 0.019, 0.023, 0.027 and 0.032 inch per revolution of the spindle. Any number of other feeds may be obtained by providing additional change-gears. From the feed-box a shaft is carried through the frame of the machine to connect with the feed worm and trip, and Fig. 6 shows the arrangement of this trip mechanism, to which reference has already been made. Dial gear *N* operates from feed pinion shaft *O* and is of sufficient size so that one revolution more than covers the 27 inches of vertical feed to the spindle. Within the dial gear—mounted and clamped in position by four bolts *P*—there is an adjustable dial plate graduated in divisions of 1 inch over a feed range of 0 to 27 inches. Trip stud *Q* may be set at any point on this dial plate, the trip stud being carried in a T-slot cut in the dial plate. As stud *Q* feeds around, it strikes the trip plunger *R*, which releases lever *S*, thus tripping the feed worm out of mesh with the worm-gear and releasing the feed. A safety stop *T* is provided which is set so that the feed is always tripped before the guide bars in the spindle quill strike the top of the lower spindle bearing. By loosening bolts *P* the dial plate can be set at any convenient point for the operator to set trip stud *Q*.

The principal dimensions of the machine are as follows: maximum distance from top of base or table to face of spindle, 48 inches; minimum distance from top of base or table to face of spindle, 21 inches; distance from center of spindle to face of frame, 22 inches; height of machine with spindle in highest position, 13 feet, 3½ inches; over-all width of single-spindle machine, 60 inches; and net weight of machine, 18,000 pounds.

CONTROL MECHANISM FOR ANDERSON DIE FORMER

In the October, 1915, number of MACHINERY a description was published of the die forming machine which had just been placed on the market by the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn. The general features of design were the same as those of the machine shown in the illustrations accompanying the present article, but recently an improved form of control mechanism has been developed, which enables greater accuracy to be obtained in finishing the sides of a die or similar piece of work than was possible with the original machine. The chief object of this device is to make it possible to machine straight surfaces in the die and have these surfaces at any desired angle to other surfaces in the die.

Referring to Fig. 1, which shows a plan view of the machine, it will be seen that there is a dovetail *A* along one side of the table, on which is carried a block *B*. Secured to this block is a guide *C* that slides over the table surface as the position of block *B* is changed by turning knurled nut *D*. Guide *C* is held at right angles to the edge of the table and is grooved to support rod *E*, the position of which may be changed by turning knurled nut *F*. Block *G* rides on the outside of

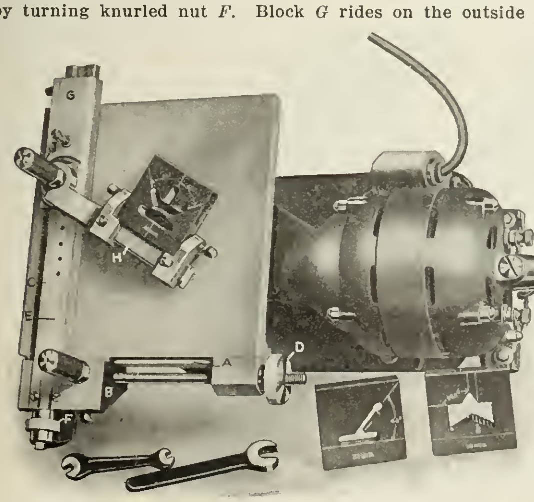


Fig. 1. Plan View of Anderson Die Former, showing Arrangement of Controlling Mechanism

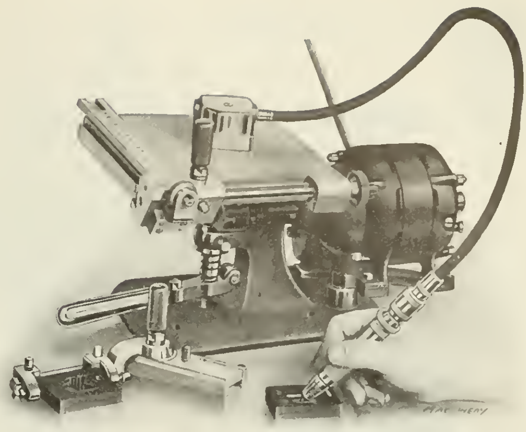


Fig. 2. Anderson Die Forming Machine with Flexible Shaft Connection to Tool

guide *C* and supports die-holding clamp *H* in the manner illustrated. Block *G* and die-holder *H* are secured to adjustable rod *E* by inserting pin *J* in one of the holes in this rod; and it will be noticed that set-screws provide for locking block *B* to dovetail slide *A*, and block *G* to slide *C*, respectively.

It will be evident that when a die-block has been set up in holder *H* and set-screws loosened so that blocks *B* and *G* are free to move on their respective guides, a suitable adjustment of screw *D* or *F* provides for feeding the die-block up to the cutter ready for taking a cut of the desired depth. After this preliminary setting has been made, the cut is taken by sliding block *B* on dovetail *A* or block *G* on guide *C*, as the case may be. After taking a cut in this way, the work is brought back to the starting point, after which the knurled screw is manipulated to feed the work to the cutter, ready for taking a second cut, and so on until the operation has been completed.

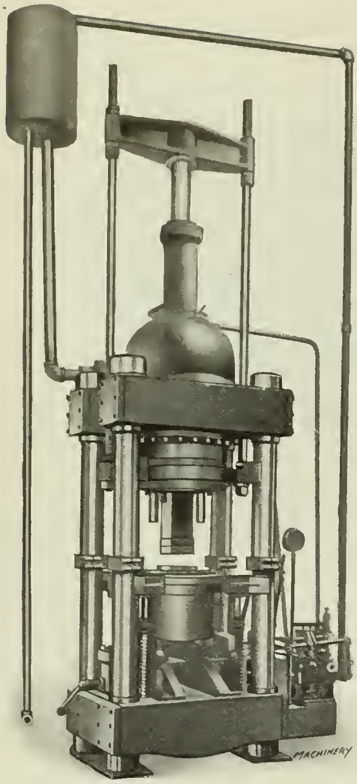
HYDRAULIC BRIQUETTING PRESS

The accompanying illustration shows a new hydraulic press recently brought out by the Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio. The press is used for briquetting metal borings, turnings, etc., so that they may be remelted without the loss of valuable constituents and without oxidizing; and it also puts the material in a convenient form for handling. This press is of the four-rod inverted cylinder type, and is built in three different sizes with pressure capacities of 1000, 750, and 300 tons, respectively. The illustration shows the 1000-ton press.

The briquet forming mechanism of these presses is capable of quickly forming a briquet of uniform density. This is accomplished by placing the material in a floating mold supported by four springs. When the pressure is applied from above, the friction of the material on the sides of the mold causes it to move down over a stationary plunger which projects into the mold from below. Pressure is thus applied on the bottom as well as on the top of the material, and a briquet of uniform density is obtained.

After being formed, the briquet is ejected from the mold by pressure of the main ram applied upon the briquet with the lower plunger removed, the latter being effected by a simple movement of a controlling lever. The briquet then falls through to the base of the press, whence it is removed by a conveyor. On the 1000- and 750-ton presses, hydraulic push cylinders lift the floating mold while the lower die is withdrawn or returned to place. A collar surrounding the lower die is held against the mold by a spring to close up all clearance between the mold and the lower die in the 300-ton press.

The press here illustrated is provided with a surge tank, the base of which is located higher than the main cylinder. By a simple movement of the valve lever, the plunger drops to the material in the mold and the main cylinder is filled



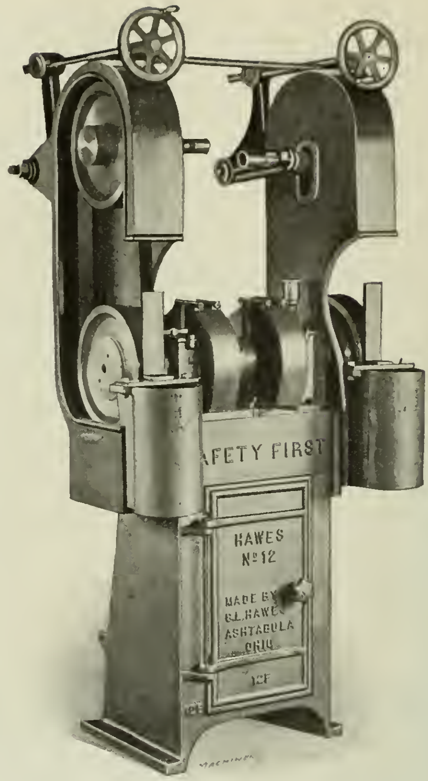
Hydraulic 1000-ton Briquetting Press for Metal Borings and Turnings

with fluid by suction caused by lowering the ram as well as by action of gravity on the fluid. Thus the first stroke of the pump initiates the pressure upon the material. After completing the pressing operation, the main ram is returned by means of the auxiliary ram located at the extreme top of the press, and, as will be readily seen, this action returns the fluid to the surge tank.

Every operation of these presses is controlled by conveniently located levers. The stationary plunger projecting into the mold from below is displaced and replaced by a lever near the operating valve. The presses are solidly built, steel being used throughout. The strain rods are made of heat-treated forged steel, and they have solid heads and collars. The main ram is guided in its travel by babbitted bearings working upon the strain rods and by a long bearing in the throat of the cylinder; the floating mold is also guided by babbitted bearings. The collars located on the center of the strain rods prevent the floating mold from ascending too high.

HAWES BELT POLISHING LATHE

The "Safety First" No. 12 vertical polishing machine which forms the subject of the following description is a recent product of C. L. Hawes, Ashtabula, Ohio. It will be seen that the base is designed along similar lines to that of the Hawes grinder and polisher; but two pulleys have been substituted in place of the grinding wheels, and overhead works furnished to support two upper pulleys for carrying two endless polishing belts. Provision is made for maintaining the required belt tension by means of two small handwheels that enable the upper pulleys to be raised to take up any slack that develops in the belts. These polishing belts may be from ½ to 2½ inches in width, and the pulleys may be run at speeds up to 4000 revolutions per minute. The illustration shows a belt-driven machine, but provision may be made for the application of electric motor drive, in which case a two-horsepower constant-speed motor is employed. The floor space occupied by the machine is 36 by 24 inches. The machine is 6 feet high and weighs approximately 1000 pounds.

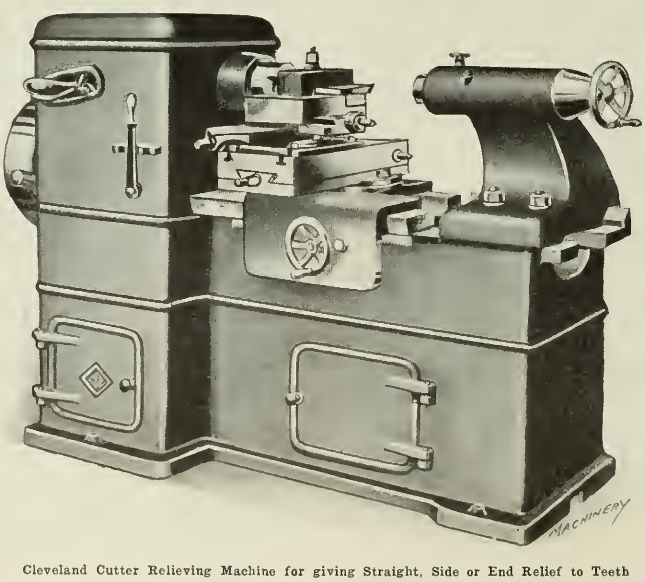


Hawes No. 12 "Safety First" Vertical Polishing Machine

CLEVELAND CUTTER RELIEVING MACHINE

The Cleveland Milling Machine Co., 18511 Euclid Ave., Cleveland, Ohio, is now building the cutter relieving machine illustrated and described herewith. This machine has been developed for the special purpose of relieving formed cutters up to 13½ inches in diameter with any number of teeth from one to twenty-eight, inclusive, and any even number of teeth from twenty-eight to forty-two, inclusive, giving straight, side or end relief on all cutters that come within the capacity of the machine. It will be noted from the illustration that box-type construction has been adopted for all large members, including the base, bed, headstock and tailstock, in which the metal is generously distributed in both the walls and webs to provide ample strength.

Power is provided by a 14-inch pulley which carries a 3-inch belt and runs at 460 revolutions per minute. From this pulley the drive is through a set of reverse gears to a tumbler pinion, from which five selective spindle speeds are obtained, the drive being transmitted through a



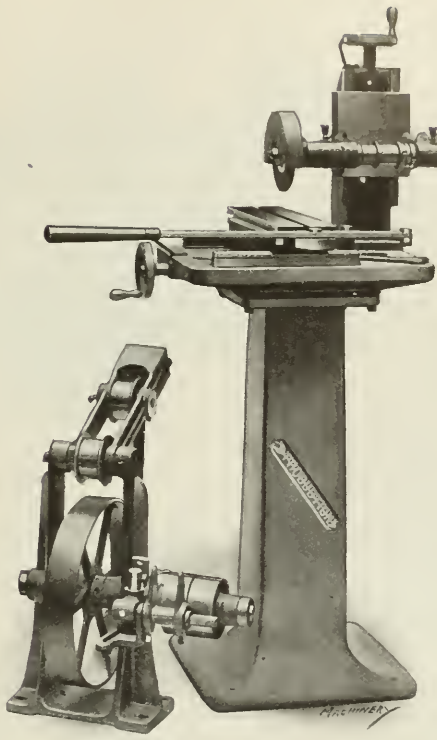
Cleveland Cutter Relieving Machine for giving Straight, Side or End Relief to Teeth

worm-wheel of large diameter, mounted directly upon the spindle. The machine can be started, stopped or reversed by manipulating a single hand-lever. The spindle is machined from a high-carbon steel forging and is 3½ inches in diameter at the largest point. It runs in solid tapered phosphor-bronze bearings, provided with means of compensating for wear. The taper hole in the spindle is No. 10 Brown & Sharpe, and the spindle is bored to accommodate a 1-inch draw bolt.

The tailstock sleeve is 2½ inches in diameter and is bored No. 10 B. & S. taper; it has a maximum adjustment of 7 inches by means of a handwheel. Alignment of the tailstock is maintained through one 90-degree V-way at the back of the bed, the flat bearing at the front being 2 inches wide by 15 inches in length. The tailstock may be locked in any desired position by two clamping bolts located in front of the tailstock. The rear carriage bearing is 3 inches wide and the front bearing 6 inches wide; the carriage is gibbed longitudinally to the front bearing and the apron is cast integral with the carriage. The carriage is provided with a maximum longitudinal adjustment of 13 inches, which is obtained by operating a handwheel. Each complete single turn of this wheel gives a longitudinal carriage movement of 1 inch.

A single throw cam giving relief from 0 to ¾ inch is carried by a cam slide swivel plate which is adjustable to any degree desired. Tapered gibs are provided for taking up wear on all slides. The forming tool may be quickly positioned in the proper relation to the cutter by means of a double adjustable toolpost graduated to 0.001 inch. Corrugated adjustable wedges on top of the toolpost provide for adjusting the amount of stock that is ground off the forming tool from ¾ to ¼ inch. This cutter relieving machine may be motor-driven, if desired, in which case a three-horsepower constant-speed motor is mounted on top of the headstock. The weight of the machine is approximately 7000 pounds.

"PRODUCTION" HAND SURFACE GRINDER



"Production" Hand Surface Grinder built by New Jersey Machinery Exchange

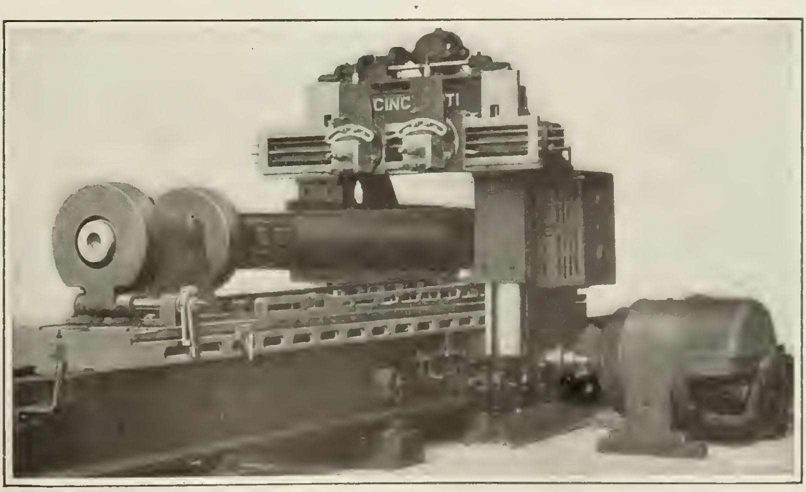
The "Production" hand surface grinder which forms the subject of the following description is a recent product of the New Jersey Machinery Exchange, 21 Mechanic St., Newark, N. J. In designing, an effort was made to make this machine as simple as possible and still adapt it for grinding and finishing flat surfaces on punches, dies and machine parts. By referring to the accompanying illustration, it will be seen that the spindle is carried by a vertical slide which has a maximum movement of 7 inches and is operated by a handwheel that has a dial graduated to 0.001 inch. The spindle is carried in taper bearings and is provided with means of compensating for all ordinary wear.

Longitudinal and transverse movements are provided for the table, the latter being operated by a handwheel fitted with a dial graduated to 0.001 inch, which is similar to the vertical feed. Longitudinal movement of the table is obtained by means of a hand-lever so proportioned that a quick and accurate movement is obtained for the work. The slides for both these movements have liberally proportioned bearing surfaces and are fitted with gibs to compensate for wear. The slides are so designed that it is impossible for grit to find its way into the bearings. This grinder is driven by a countershaft with a weighted idler pulley which maintains a constant belt tension. For average classes of work a countershaft speed of 400 revolutions per minute is recommended.

The principal dimensions of the "Production" hand surface grinder are as follows: size of table, 15 by 5 inches; maximum traverse of table, 8 inches; maximum cross-feed, 6 inches; maximum vertical adjustment of spindle slide, 7 inches; maximum distance between wheel and table, 6 inches; size of grinding wheel, 6 inches in diameter by ½ inch face width; width of driving belt, 1½ inch; diameter of countershaft tight and loose pulleys, 4½ inches; width of countershaft driving belt, 2 inches; speed of countershaft, 400 R. P. M.; and weight of machine, 435 pounds.

CINCINNATI GUN BARREL PLANER

The Russian 9.2-inch howitzers have a projecting guide extending along each side of the barrel, which allows the barrel to move back in the carriage to absorb recoil. The presence of these guides makes it impossible to turn the barrels on a lathe, and to provide for machining them the Cincinnati Planer Co., Cincinnati, Ohio, has built a number of special 48- by 48-inch by 18-foot planers, one of which is shown in the accompanying illustration. These planers are driven by a reversible motor drive coupled direct to the machine. The howitzer barrels are first turned on the outside wherever the projecting guides do not interfere, and one end is also turned to fit the chuck while a plug center is put in the opposite end to align the work properly. After this has been done the barrel is



Cincinnati Planer for machining 9.2-inch Russian Howitzer Barrels

mounted between centers on the planer table and completely finished between the projecting guides which are also planed while the gun barrel is set up on the planer.

It will be seen that the front center or headstock is provided with an expansion chuck which is part of the spindle, on which a large worm-wheel is mounted at the opposite end. The worm that engages this wheel is keyed on a shaft that has a ratchet lever mounted at its outer end; and this ratchet lever engages a tappet fastened at the side of the bed to provide for revolving the gun barrel for the next stroke after each cut has been completed. The cross-rail, which has a sliding fit on the housings, is provided with two brackets bolted under the rail and further held by a clamp on both the outside and inside. A roller is mounted on each of these brackets at the lower end, and projects over the side of the table to engage a cam, the contour of which corresponds exactly to that which is required on the gun barrel.

The operation of this machine differs but little from that of a standard planer except for the feed and taper attachment. The table is started on its cutting stroke in the regular way, and the cross-rail, instead of maintaining a fixed position, is guided by rollers contacting with the forming cams on the table to cause the cross-rail to rise and fall as the table passes under it, thereby giving the required taper form to the work. At the end of the return stroke the ratchet lever on the worm-shaft strikes the tappet at the side of the bed, causing the lever to rotate through an arc and give the worm-wheel the necessary movement to revolve the work through an angle corresponding to the required feed. It will be noted that this combination of two motions, *i. e.*, turning the gun on center at the end of each stroke and raising or lowering the cross-rail while the table is in motion, causes the tool to plane both a circular cross-section and a tapered longitudinal section for the gun barrel. When planing the straight rectangular recoil guides the cross-rail is raised a little so that the rollers are clear of the cams and bolted fast to the housings; the ratchet lever is also disengaged and the feed obtained through the regular feed gears at the end of the cross-rail.

HOLMES FILING MACHINE

The Holmes Mfg. Co., Shelton, Conn., is the manufacturer of the filing machine shown in the accompanying illustrations. A noteworthy feature of the design is that variable-speed drive is provided by a friction disk and wheel best shown in the rear view of the machine illustrated in Fig. 2. An Oldham coupling is employed to make connection between the driving motor and shaft on which the friction wheel is carried, as can be seen in the illustrations.

Another noteworthy point is that plain files can be used in the machine, making it unnecessary to obtain files with special shanks. General practice in the design of die filing machines has been followed by providing means of tilting the table to enable the necessary clearance to be filed in dies. In addition, special means have been furnished to enable the filing of punches to be performed in an expeditious manner. This is done by having the bar at the back of the machine, which supports the upper end of the file, sufficiently heavy so that a short file can be given plenty of support by simply holding it at the upper end. In this way a punch may be placed on the table and the file set so that it is able to file down close to a shoulder, as when filing the shank of a punch. This machine has four take-up bearings, and the stroke can be regulated from 0 to 1½ inch. The machine is portable, and can be carried to the work.

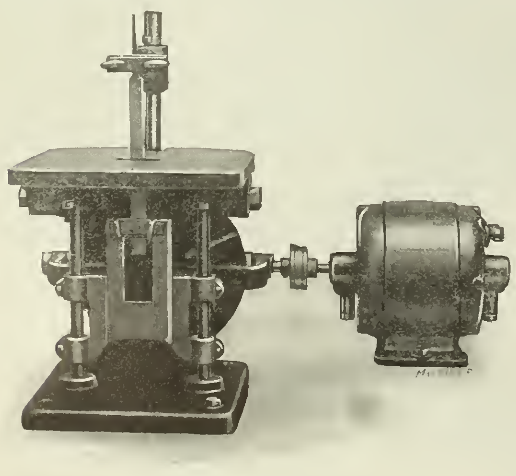


Fig. 1. Front View of Filing Machine built by Holmes Mfg. Co.

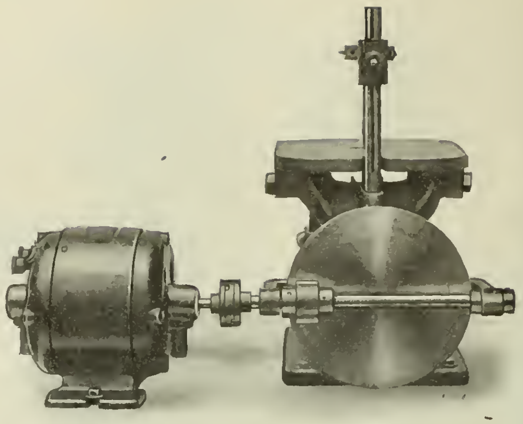


Fig. 2. Rear View of Holmes Filing Machine, showing Variable-speed Drive

FITCHBURG 8-INCH "LO-SWING" LATHE

The general features of design of this machine are similar to those of the well-known Fitchburg "Lo-swing" lathes, but the present machine is of much larger size, having a capacity for handling work up to 8 inches in diameter by 84 inches in length. Machines with longer beds can be built to meet special requirements. Connection between the feed-rod and carriage is made by an Oldham coupling which makes the carriage entirely independent of accuracy of alignment of the feed-rod. The drive is through a single 20-inch pulley which runs continuously, and no countershaft is required; the driving pulley is provided with a clutch operated by a shipper bar extending the full length of the machine. A pump is provided for supplying lubricant to all tools through supply pipes and thence through individual tubes to the cutting points of the tools. Under test in turning spindles from 50-point carbon steel, the machine removed 19.31 cubic inches of metal per minute.

The Fitchburg Machine Works, Fitchburg, Mass., have recently brought out a "Lo-swing" lathe of much larger capacity than previous types, and with different operating mechanism, although the machine has been designed after the "Lo-swing" principle, *i. e.*, that of turning different diameters and tapers with multiple tools operating simultaneously. The machine shown in Fig. 1 handles work up to 8 inches in diameter and will take shafts 84 inches in length or less, but machines with longer beds can be furnished to meet special requirements.

Bed and Carriage Construction

Fig. 2 illustrates the carriage mechanism and the bearings of the carriages upon the bed. It is one of the "Lo-swing" principles to place the carriages on the ways on front of the bed, and the tailstock and steadyrest on the back ways, thus permitting the carriages to pass both tailstock and steadyrest without interference. As may be seen in this illustration, the carriages are mounted on single heavy double-angle ways and each carriage is gibbed at the bottom to provide for taking up wear. An important feature of the carriage construction is the entire independence from alignment with the feed-rod that may be seen passing through the two carriages at the front of the

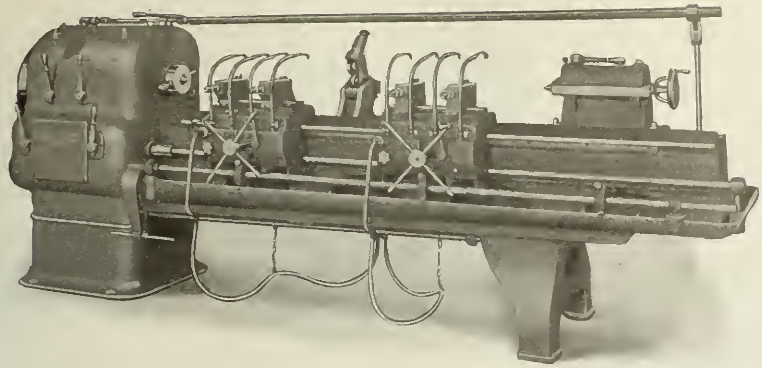


Fig. 1. Front View of Fitchburg 8-inch "Lo-swing" Lathe

machine in Fig. 1. Connection between the feed-rod and carriages is made through an Oldham coupling.

The feed driving gear is a double spur gear, and for forward movement of the carriage the right-hand section meshes directly with a sliding gear E on the worm-shaft F. For reverse movements of the carriage, the drive is through the left-hand section of gear D into the intermediate pinion G (best

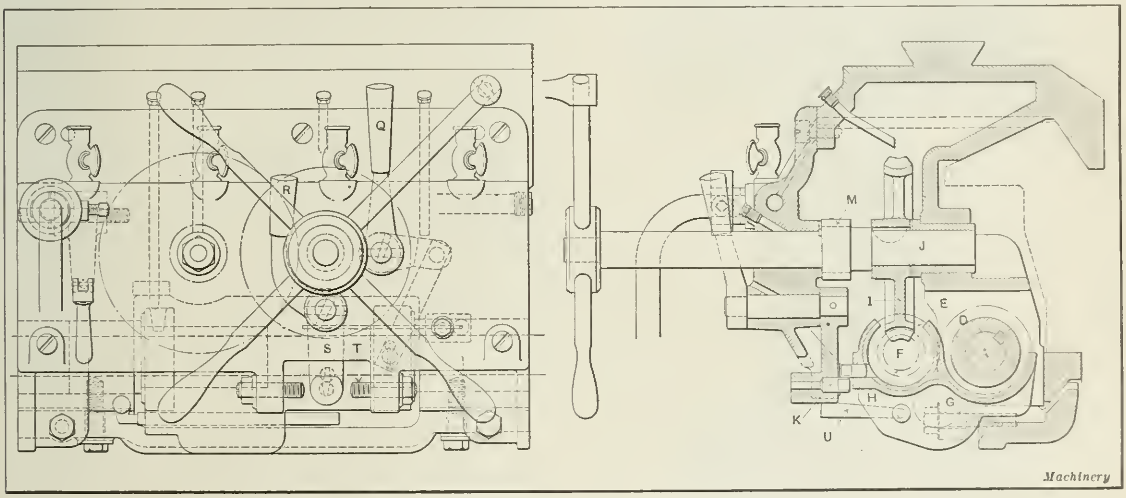


Fig. 2. Arrangement of Carriage Mechanism on Fitchburg 8-inch "Lo-swing" Lathe

shown in Fig. 2) and then into the worm-shaft pinion E. Worm-shaft F carries a single right-hand steel worm H that meshes with bronze worm-wheel I on the capstan shaft J. The familiar type of worm-box construction is used, permitting of engaging or disengaging the feed by dropping the worm from the worm-wheel, when stops on the stop-rod shaft trip the feed or when the feed is tripped by a hand-lever.

On the forward end of capstan shaft J is pinion M meshing with a large spur gear on the rack pinion shaft; and on the right-hand end of this rack shaft is a pinion that meshes with the rack on the under side of the bed of the machine, as may be seen in Fig. 1. The carriages are provided with locks to hold them stationary while necking in for shoulders on shafts. The carriage tool-holders are not shown in Fig. 2, but two are shown on each carriage in Fig. 1. These hold tools of ¾ by 1¼ inch and may be independently adjusted to or from the work and longitudinally on the carriage. This is one of the standard "Lo-swing" principles.

Lever Q is for throwing the worm-box and worm into mesh through the bellcrank and link shown; and the worm is thrown out of mesh by pressing lever R in either direction. In operation, when the carriage reaches the location of a feed trip dog, the worm-box is disengaged by the throwing over of lever S that allows the worm-box to drop. After it has dropped the carriage may be moved a small amount by hand until it comes up solidly against the positive stop-screw K which absolutely limits the carriage travel. Reversal of the carriage is secured by sliding lever U along in the direction desired to operate the carriage, and this lever may be operated without stopping the feed. Lubrication of the carriage mechanism is through oil tubes leading from the front of the carriage to all the principal bearings.

Tailstock and Steadyrest

As may be seen in Fig. 1, the tailstock is of extremely heavy design and it operates on the back ways of the machine, being entirely independent of the carriages which may pass it without interference. The tailstock spindle is 17½ inches long and is operated by a handwheel. The end of the tailstock is fitted with a No. 4 Morse taper center. The tailstock spindle may be clamped in any desired position with a hand-lever. The steadyrest, used in turning shafts of small diameter under heavy cuts, clamps on the back ways and is fitted with roller supports.

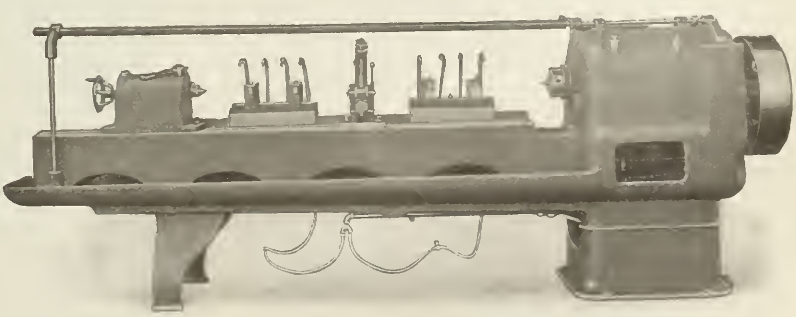


Fig. 3. Opposite Side of Fitchburg "Lo-swing" Lathe shown in Fig. 1

Driving Mechanism of Headstock

The drive is through a single 20-inch or 24-inch pulley, as desired, which runs continuously. No countershaft is required, as the pulley runs free on the driving shaft and is clutch-operated when it is desired to start the machine. A long shipper bar may be seen running the full length of the machine, and it is through this means that the clutch is operated. The clutch is toggle-operated and the drive is secured by clamping the loose driving pulley between flanges that are keyed to the driving shaft. This drive or pulley shaft is of large diameter and runs in bronze bearings. Six spindle speeds are available from the pulley shaft, three being obtained from the pinion on the pulley shaft and three from the clutch gear. When the drive is through the pinion, the clutch gear is disengaged; and when the drive is through the clutch gear, the latter is locked to a clutch plate keyed to the pulley shaft.

Referring to Fig. 1, the various levers for operating the feed and speed changes may be seen. The two upper levers are for the six spindle speeds. The left-hand lever operates a clutch on the spindle giving three speeds according to its location to the right, left or center. The right-hand lever operates the pulley shaft clutch gear, and this has two positions, right or left, thus compounding the speeds to give the six spindle speeds. Referring to Fig. 4, the various combinations of the clutch levers are shown at the left, and the resulting speeds that may be given to the spindle are shown. The spindle runs in adjustable bronze bearings with roller end thrust, and carries on the front end the "Lo-swing" balanced driver. The speed gears in the headstock all run in oil.

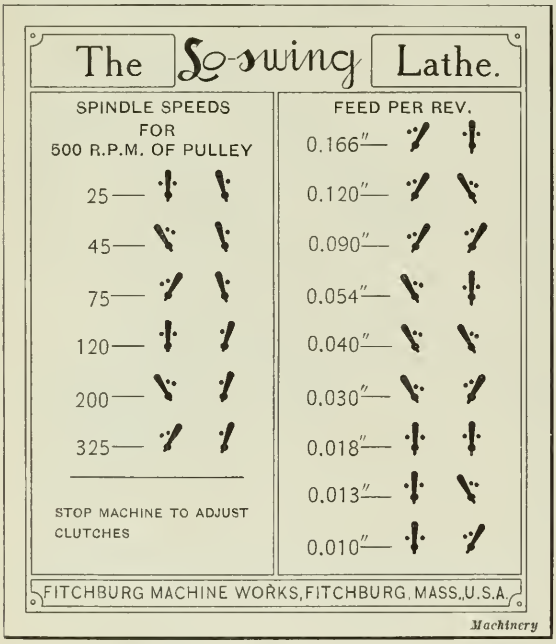


Fig. 4. Plate showing Lever Positions and Available Speed and Feed Changes

Feed Changing Mechanism

The feed is taken from a spur gear at the extreme left-hand end of the spindle, which operates through an idler gear and then through a gear on the upper feed shaft. This upper shaft has three feed gears of different diameters that may be meshed alternately with a three-step shoulder gear sliding on the lower feed shaft, thus giving three feeds to the lower feed shaft. The lower feed shaft has a three-step shoulder gear at the right-hand end, and this gear may be meshed with any one of three gears on the intermediate feed shaft, making a total of nine feed changes that may be given the intermediate shaft. This intermediate shaft is coupled directly to the main feed-rod at the front of the machine.

The nine variations of feed for the feed-rod are shown at the right-hand side of Fig. 4. This illustrates the position of the two levers for securing any rate of feed from 0.166 inch per revolution to 0.010 inch per revolution in geometrical progression. These two levers are the ones shown at the lower part of the headstock in Fig. 1.

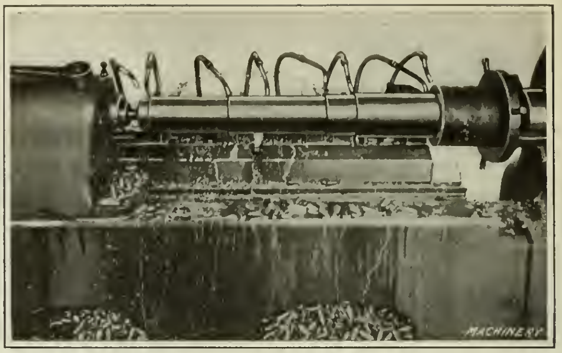


Fig. 5. Tooling used for turning Spindles on Fitchburg Lathe

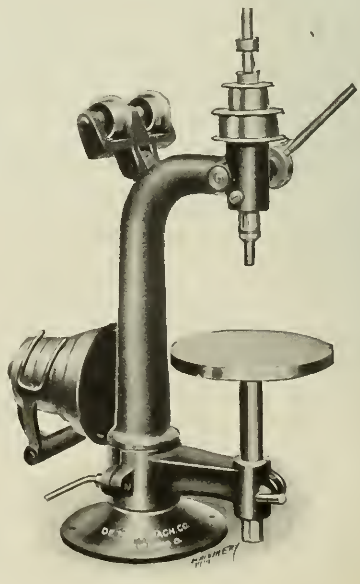
Lubrication

The pump for supplying the lubricant to the cutting points of the carriage tools is located in the base of the head and is operated by bevel gearing from the end of the pulley shaft. Thus lubrication is provided for the tools whenever the machine is in operation. Lubricant comes through the supply pipes to each carriage and thence through individual tubes to the cutting points of the tools.

An interesting set-up is the turning of a steel spindle for a lathe, shown in Fig. 5, that illustrates the character of the work that the machine can do. This shaft is 36½ inches long and is made of fifty-point carbon steel. At the first setting five tools are employed, the first of which takes a cut 1 inch deep, the second ⅛ inch deep, the third ⅛ inch deep, the fourth 3/16 inch deep, and the fifth 3/16 inch deep. When all five tools on this operation are at work, as shown in Fig. 5, a total depth of cut of 1⅝ inch is being taken, which means removing 3¼ inches stock from the diameter. As the outside stock diameter is 6¼ inches and the finished diameter is 3 inches at the small end, it is obvious that the diameter is being reduced by 3¼ inches when all five tools are cutting. The shaft is turned at 45 revolutions per minute, and the feed is 55 turns to the inch. 19.31 cubic inches of metal is removed per minute, finishing the shaft complete for grinding, except the head, at one operation in forty-two minutes.

DE MOOY BENCH DRILLING MACHINE

The De Mooy Machine Co., 1833 E. 55th St., Cleveland, Ohio, has recently placed on the market the 10-inch sensitive drilling machine illustrated and described herewith. This machine has a plain spindle bearing and is adapted for spindle speeds up to 1300 revolutions per minute. It will be seen in the illustration that the column and base are cast integral, the casting being of box section and composed of high-grade gray iron. The belt shifter is attached to the cone shaft bracket and may be shifted to conform to the angle at which the machine is driven. The table and pulley bearing sleeves are ground to in-



De Mooy Sensitive Bench Drilling Machine

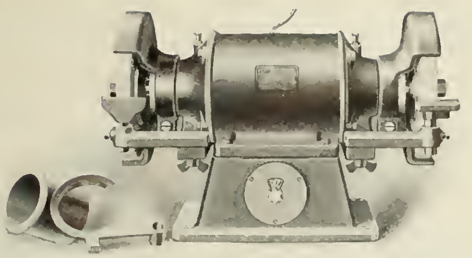


Fig. 1. Hisey-Wolf Bench Grinder built with One-half-horsepower and One-horsepower Motors

sure accurate fits. This machine has been designed with the view of making all parts as simple as possible.

These bench drilling machines are built in two sizes, known as Nos. 1 and 2, respectively. The principal dimensions of the No. 1 machine are as follows: maximum distance from spindle to table, 7½ inches; maximum vertical movement of spindle, 2¼ inches; maximum vertical movement of table, 6 inches; diameter of table, 8¼ inches; distance from center of spindle to frame, 5¼ inches; drilling capacity, for holes up to 5/16 inch in diameter; size of tight and loose pulleys, 4 inches in diameter by 1½ inch face width; speed of driving pulley, 550 revolutions per minute; height of machine, 24 inches; floor space occupied, 21 by 9 inches; and net weight of machine, 60 pounds. The principal dimensions of the No. 2 machine are: maximum distance from spindle to table, 12 inches; maximum vertical movement of spindle, 3½ inches; maximum vertical movement of table, 7 inches; diameter of table, 11½ inches; distance from center of spindle to frame, 7½ inches; drilling capacity, for holes up to ½ inch in diameter; size of tight and loose pulleys, 5 inches in diameter by 1⅝ inch face width; speed of driving pulley, 550 revolutions per minute; height of machine, 34 inches; floor space occupied, 26 by 13 inches; and net weight of machine, 110 pounds. The No. 1 machine has a taper spindle to fit a small drill chuck, while the No. 2 machine has a No. 1 Morse taper hole in the spindle.

HISEY-WOLF ELECTRIC GRINDERS

The accompanying illustrations show bench and floor grinders which constitute a recent addition to the line of machines built by the Hisey-Wolf Machine Co., Cincinnati, Ohio. It will be apparent from the illustrations that the machines shown in Figs. 1 and 3 are of essentially the same design with the exception of the fact that Fig. 1 shows a bench type machine while in Fig. 2 a similar head has been mounted on a column to make a floor type of machine. These grinders are built with ½-horsepower and 1-horsepower motors for either alternating or direct current. In the alternating-current type, ½-horsepower machines run at 3400 R.P.M., and the 1-horsepower machines at 1750 R.P.M. In the direct-current type, ½-horsepower machines are adapted for speeds of

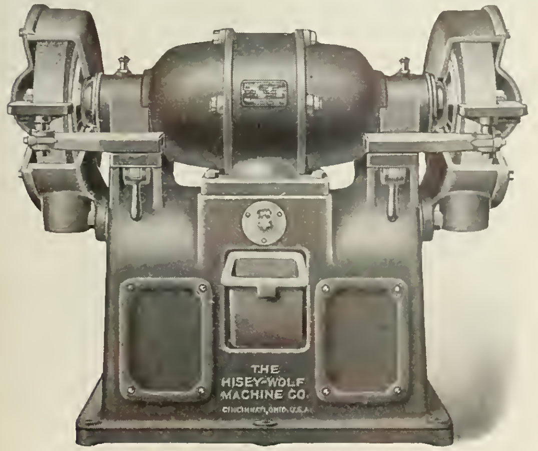


Fig. 2. Hisey-Wolf Five-horsepower Floor Type Grinder

3000 R.P.M., and the 1-horsepower machines 2100 R.P.M. With the exception of height and weight, the principal dimensions of both bench and floor type machines are the same. For the ½-horsepower machines these dimensions are as follows: size of grinding wheels, 8 inches diameter by ¾ inch face width; diameter of spindle at wheel mounting, ⅝ inch; and distance between wheel centers, 16 5/16 inches. For the 1-horsepower machine, the principal dimensions are: size of grinding wheels, 10 inches diameter by 1 inch face width; diameter of spindle at wheel mounting, ¾ inch; and distance between wheel centers, 21⅛ inches. The direct-current machines are furnished with 110- or 220-volt motors, and the alternating-current machines with 110-volt, 60-cycle, ten-phase or 220-volt, 60-cycle, one-, two-, or three-phase motors.

Fig. 2 shows a "Hisey" five-horsepower floor grinder which is provided with combination wheel guards as part of the standard equipment. These guards are of steel construction and the flanged outside cover adds greatly to the strength of the guard and prevents escape of dust. The grinder has an automatic starter operated by means of a quick-acting switch which permits the machine to be operated by an inexperienced workman, as throwing the current on or off is automatically controlled to insure protection of the motor. The starter and

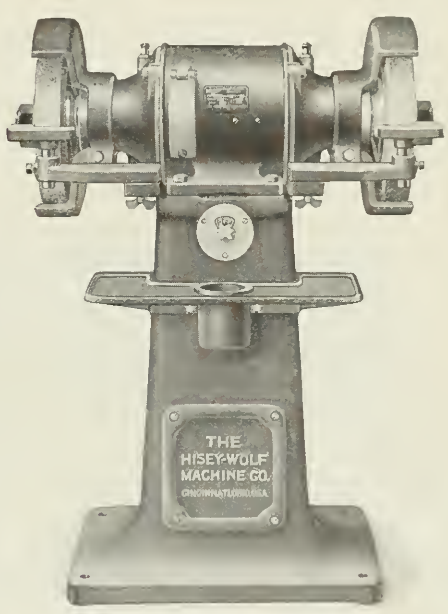


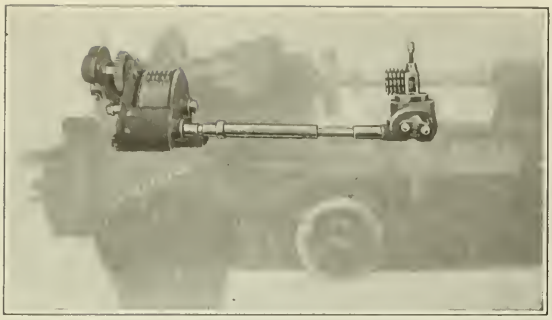
Fig. 3. Same Machine shown in Fig. 1 mounted on Column

control switch are mounted in the base, but each is a separate unit and easily accessible. If desired, automatic speed regulation can be provided for the direct-current grinder.

These grinders are provided in two types for connection with alternating- and direct-current circuits. The direct-current machine is furnished with motors for connection with 115- to 230-volt current, while the alternating-current grinder is made in four styles, all of which are provided for connection with 220-volt current, 60-cycle, two- or three-phase, or 25-cycle, two- or three-phase. The direct-current grinders run at 1100 R. P. M., the 60-cycle alternating-current grinders run at 1140 R. P. M., and the 25-cycle alternating-current machines at 1450 R. P. M. The principal dimensions of all machines are as follows: diameter of spindle at wheel mounting, 1½ inch; distance between wheel centers, 43 inches; size of base, 23 by 40 inches; height from bottom of base to center of spindle, 35 inches; and net weight, 1550 pounds.

CARROLL & JAMIESON RELIEVING ATTACHMENT

The Carroll & Jamieson Machine Tool Co., 257 Davis St., Batavia, Ohio, is now making a relieving attachment for use on the Carroll & Jamieson 14-inch lathes. This attachment,

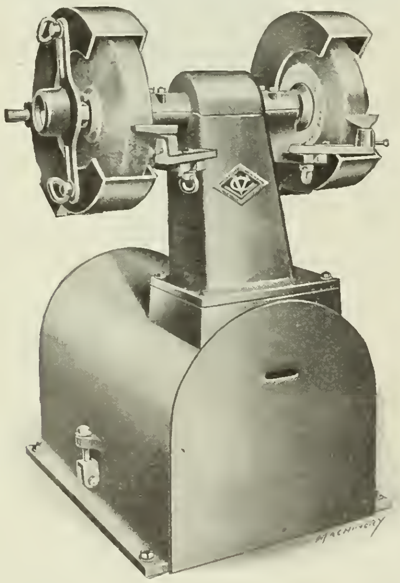


Carroll & Jamieson Relieving Attachment

which provides for indexing for 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14 and 16 teeth, may be used for relieving cutters, reamers and other tools with these numbers of teeth. The relieving attachment is mounted on top of the gear-box; it is secured in place by two screws and engages with a gear on the spindle. A special compound rest top and swivel is furnished with the attachment, which will fit any of the Carroll & Jamieson 14-inch lathes.

VALLEY CITY GRINDERS AND BUFFERS

In the motor-driven grinders and buffers which have recently been added to the line of machines built by the Valley City Machine Works, Grand Rapids, Mich., the most noticeable feature of design is that the motor is enclosed in the base. This gives all the advantages of the self-contained motor-driven machine with belt connection to the spindle, and the



Valley City Grinder with Driving Motor fully enclosed in Base

added advantage of thorough protection for the motor. The machines are built in two sizes, the larger of which is shown in the accompanying illustration, which is suitable for a grinder head carrying wheels up to 18 inches in diameter; and this machine is provided with a base having ample room to accommodate a five-horsepower motor. Bases are provided to carry different sizes of Valley City grinder heads according to the requirements of the work.

The motor is mounted on a pivoted base at right angles to the grinder spindle which is driven by a quarter-turn belt. Tension of this belt is regulated by means of an adjustment screw at the base of the machine. It is claimed that the motor-driven machine with belt connection to the spindle possesses an advantage over a machine with direct-connected motor drive in that all shocks are absorbed without danger of damaging the motor. In the present machine the manner in which the motor is encased also insures keeping it free from dirt and grease.

VALLEY CITY SEMI-UNIVERSAL MILLING ATTACHMENT

The Valley City Machine Works, Grand Rapids, Mich., is now building a semi-universal milling attachment for use in

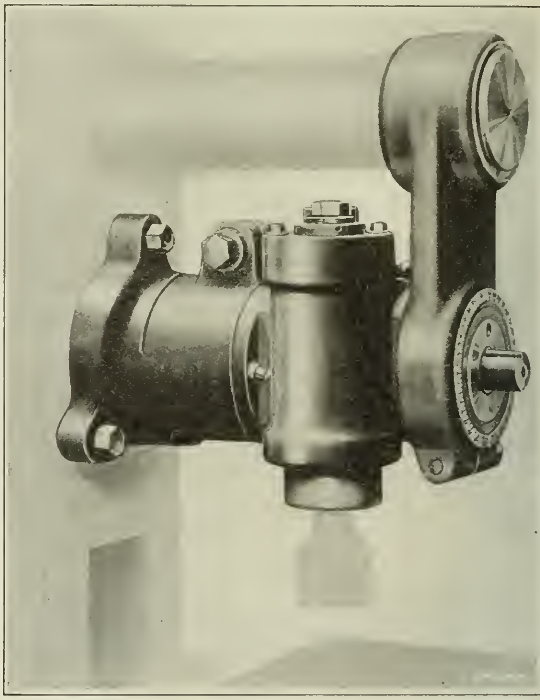


Fig. 1. Semi-universal Valley City Milling Attachment in Vertical Position

connection with the No. 1½ milling machines of its manufacture. This attachment enables the operator to get closer to angular cuts and still have a rigid support. Provision is made for swinging the attachment clear under the over-arm, and it may be reversed if necessary. The hole through the spindle is accessible when the spindle is in a vertical posi-

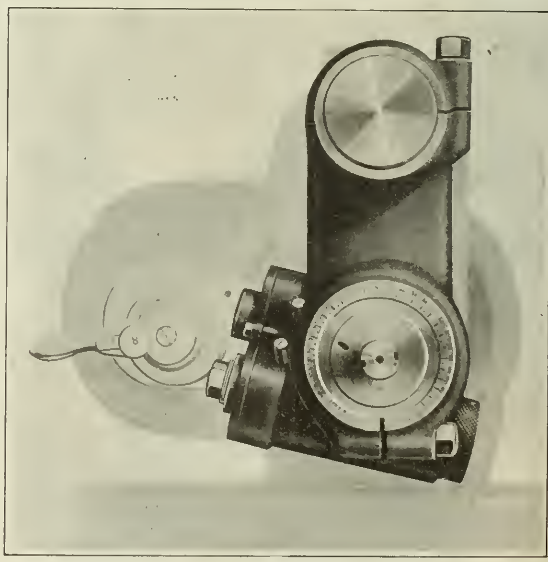


Fig. 2. Semi-universal Valley City Milling Attachment in Inclined Position

tion, as the spindle of the attachment is offset from the milling machine spindle. Power for driving the attachment is transmitted through a splined arbor, coarse-pitch miter gears, an intermediate ball bearing shaft and a pair of heavy steel spur gears. The spindle of the attachment rotates in the same direction as that of the milling machine and has a No. 10 taper. A clamp base is furnished with the attachment, which is bored to fit the spindle box and secured to the column with screws. This attachment may be applied to other makes of milling machines with slight modifications.

FOSTER GEARED-HEAD SCREW MACHINE

The Foster Machine Co., Elkhart, Ind., has recently developed an all-geared head for its No. 5 screw machine, which gives the advantage of instantly obtainable speed changes and high power, owing to the high belt speeds that can be

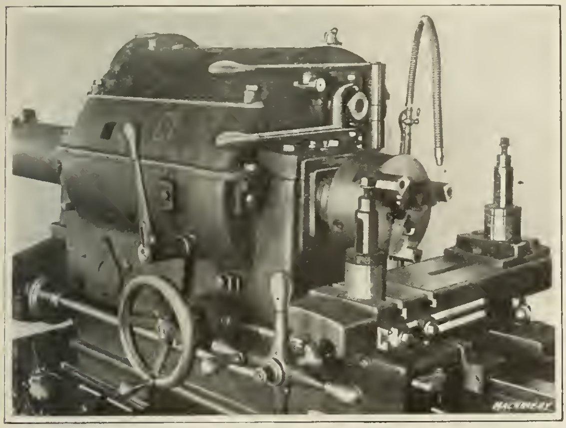


Fig. 1. All-geared Head for Foster No. 5 Screw Machine

employed. This geared head is a complete unit made to fit the standard Foster No. 5 screw machine; the cone pulley of the standard back-geared machine is replaced by a three-gear cluster mounted on a sleeve journaled to the spindle, and

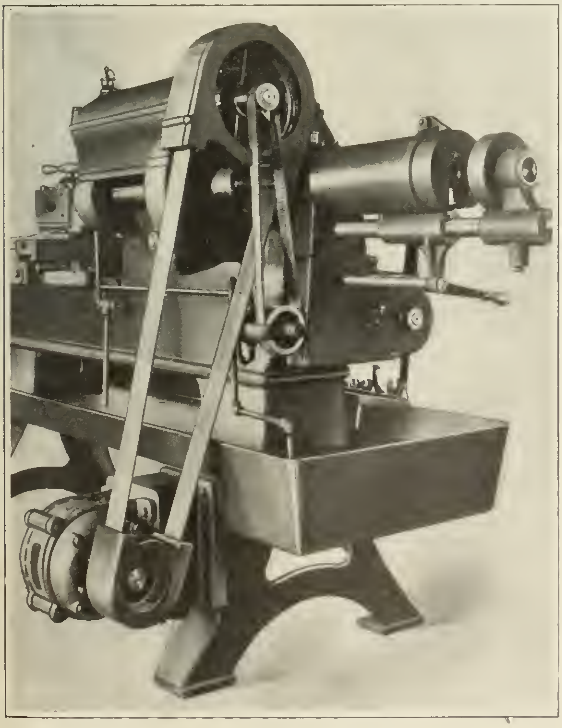


Fig. 2. Rear View of Geared-head Machine, showing Motor Drive

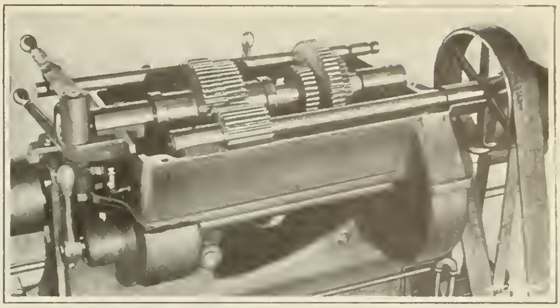


Fig. 3. Arrangement of Gearing in Head of Foster Screw Machine

this gear cluster is arranged to engage a triple sliding gear cluster mounted on a shaft located above the spindle. This shaft is journaled in bronze-bushed bearings carried by the main head casting, and the sliding gear cluster is operated by a rod and hand-lever.

On the same shaft with the gear cluster are two friction gears provided with a cone type of friction arranged to engage either gear. The purpose of this friction is to stop, start or reverse the machine, one of the gears being engaged by a reversing idler mounted beneath the main driving pinion, which is mounted on the pulley shaft that is also journaled in bronze-lined bearings held by the main head casting. All this gearing is illustrated in Fig. 3, which shows the cover removed from the head to show the construction. The reversing friction clutch is operated by the lower of two horizontal levers shown at the front of the head in Fig. 1. Attention is called to the three conveniently located speed-changing levers,

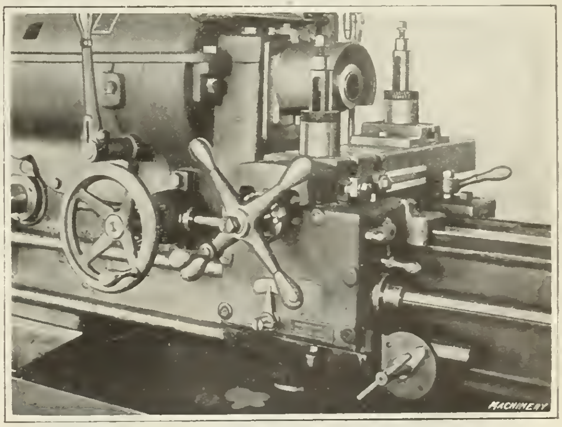


Fig. 4. Close View of Cross-slide on Foster Screw Machine

the vertical one of which—shown in Figs. 1 and 4—is for operating the friction clutch mounted on the spindle, the arrangement being the same as that used on the cone type of Foster screw machine.

A 2½-inch belt carried by a 10-inch pulley is employed for driving the geared-head machine; the pulley runs at 900 revolutions per minute, giving a belt speed of 2350 feet per minute, at which speed a single belt working under ordinary shop conditions has a capacity for delivering 6.2 horsepower. The reversing friction in the head is powerful enough to pull a still heavier load without damage, and the power rating just given is conservative, although greatly in excess of actual requirements of the machine, as a two-horsepower motor is employed for the general run of work. When work of an unusually heavy character is to be handled, it may be advisable to use a three-horsepower motor.

Fig. 2 shows a machine equipped with a two-horsepower General Electric motor mounted on the leg. The motor runs at 1800 revolutions per minute, and this high belt speed makes it possible to employ a high-speed motor of small size. The value of this feature will be appreciated by those experienced in the selection of motors for similar applications, as the cost

of the motor is relatively low and the amount of space occupied reduced to a minimum. Attention is called to the efficient method of guarding the belt at both the motor and machine pulleys. When so desired, the machine can be driven with equally satisfactory results through a plain tight and loose pulley countershaft.

Fig. 1 shows a machine equipped with a three-jaw geared scroll chuck which swings clear of the cut-off slide; and Fig. 4 shows the application of a collet type automatic chuck, the capacity of which on the Foster No. 5 screw machine is for work up to 1 13/16 inch in diameter. The scroll chuck is $7\frac{1}{2}$ inches in diameter and the swing over the cut-off slide is $8\frac{1}{4}$ inches. The cut-off slide and carriage are plainly shown in Fig. 4; hand longitudinal and power cross feed are provided with four changes of feed. Six changes of speed are available in the geared head, which are in geometrical progression and cover a range of from 34 to 466 revolutions per minute. These changes and the proper lever movements to obtain them are indicated on a speed chart mounted on the head of the machine, as shown in Fig. 1.

OTT PLAIN GRINDING MACHINE

The Ott Grinder Co., 32 N. Clinton St., Chicago, Ill., is now manufacturing the No. 8 plain grinding machine shown in the accompanying illustrations, which has a capacity for handling work up to 5 inches in diameter by 12 inches long. The machine is equipped with automatic feed and provided with a wheel 10 inches in diameter by $1\frac{1}{4}$ inch face width. It is especially adapted for the manufacture of duplicate straight cylindrical or tapered parts, the dimensions of which are required to come within close limits.

The wheel spindle is made of alloy steel, hardened, ground and lapped; the bearings are lined with bronze, provided with means of adjustment and furnished with ample facilities for lubrication by means of large self-feeding oilers. The automatic cross-feed can be set to feed at either or both ends of the table traverse and is automatically thrown out when the work is ground to size. The table drive is through worm and worm-wheel which insures a smooth uniform travel. Automatic travel is controlled by quickly adjustable dogs, and the table handwheel is disconnected during the time that power table travel is employed. The swivel table turns on a large central stud which is hardened and ground, and clamps are provided at both ends for securing the table in the desired position. The headstock is arranged for both dead and live center drive through a single pulley, and slides on V and flat ways. The tailstock also slides on V and flat ways, and both headstock and tailstock are fastened by a hook bolt.

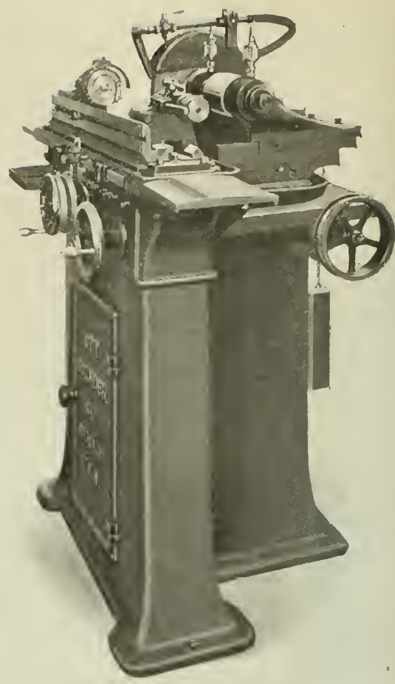


Fig. 2. End View of Ott No. 8 Plain Grinding Machine

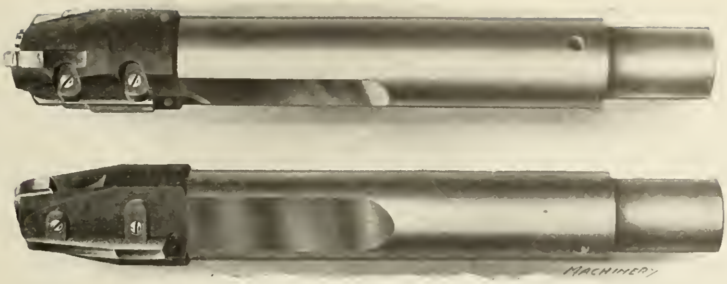
For use in the performance of wet grinding operations, ample facilities are provided for delivering a copious flow of water from a tank cast in the bed, which is provided with a settling pan that is easily removed for cleaning. The pump is of simple construction and requires no priming or packing. A universal back-rest for use on these machines has both vertical and horizontal movements, and is capable of delicate adjustment. Adjustable set collars are provided for maintaining the size of the work. Regular equipment furnished with the machine includes one 10- by $1\frac{1}{4}$-inch grinding wheel, one universal back-rest, one wheel truing device with a diamond, one center grinding attachment, one set of work dogs, overhead works, water guards, and the necessary wrenches for making all adjustments.

The principal dimensions of this machine are as follows: diameter of headstock and tailstock spindles, $1\frac{1}{2}$ inch; diameter of work-carrying centers, 11/16 inch, No. 2 Morse taper; number of work speeds, four; range of work speeds, 130 to 390 revolutions per minute; size of front grinding wheel spindle bearing, $1\frac{5}{8}$ inch diameter by $3\frac{3}{4}$ inches in length; size of rear grinding wheel spindle bearing, $1\frac{1}{2}$ inch in diameter by $3\frac{1}{2}$ inches in length; size of grinding wheel spindle pulley, 4 inches in diameter by $2\frac{1}{2}$ inches face width; capacity of grinding wheel guard, for wheels up to 10 inches in diameter by 2 inches face width; number of grinding wheel speeds, two; available grinding wheel speeds, 2250 and 3200 revolutions per minute; number of table traverse speeds, four; range of table traverse speeds, 34 to 120 inches per minute; minimum automatic cross-feed, 0.0002 inch; maximum automatic cross-feed, 0.004 inch; size of countershaft tight and loose pulleys, 10 inches in diameter by 4 inches face width; speed of countershaft tight and loose pulleys, 375 revolutions per minute; power required to drive the machine, 3 horsepower; floor space occupied, 31 by 68 inches; swivel table graduated to angle of 15 degrees; capacity for taper grinding, up to 3 inches per foot; and net weight of machine, 1500 pounds.

Fig. 1. Ott No. 8 Plain Grinding Machine

BLACK & DECKER SHELL BORING HEAD

The Black & Decker Mfg. Co., Baltimore, Md., has recently developed and placed on the market a boring head especially designed to meet the requirements of shops engaged in the manufacture of shells. These heads are of the inserted-blade type, and are customarily furnished in pairs, one of which is



Black & Decker Roughing and Finishing Shell Boring Heads

for the purpose of rough-boring the wall and bottom of a shell, while the other is employed for finishing the same surfaces. Each head has three blades, two of which are for working on the side wall, while the third is a nosing cutter for finishing the bottom. The side wall blades are set 180 degrees apart and the nosing blade is set half way between or at right angles to them. It will be seen from the accompanying illustration that the rear of the nosing blade overlaps the side blades, and in the case of the finishing head all blades are cylindrically ground in place to insure obtaining the proper contour, thus obviating leaving a shoulder in the shell at the junction of the bottom of the side wall.

These heads are economical in their use of high-speed steel, as the design has been worked out in such a way that the blades employed are of the minimum cross-section that is required for machining the work for which these tools are intended; and the blades can be lined out and reground a number of times before discarding the small weight of steel contained in the stubs. This eliminates the large source of waste incident to the use of solid-blade boring heads when working to the close limits required in munition work. Each blade is thoroughly backed up and supported by the metal of the head, and an effective wedge and screw system of clamping makes it unlikely that a blade will loosen or chatter while in service. Provision is also made for the unobstructed flow of chips back from the blades, and for the flooding of blades with lubricant under pressure, that is carried through a central lead. All heads, clamps and screws are casehardened, and the shanks are accurately ground to fit the turret.

WINFIELD ELECTRIC RIVETER

The Winfield Electric Welding Machine Co., Warren, Ohio, is now building a type R-4 semi-automatic electric riveter, which is illustrated and described herewith. This machine is said to be noiseless in operation, operate rapidly and produce perfect work. It has a capacity for handling rivets up to $\frac{3}{8}$ inch in diameter and is equipped with a $1\frac{1}{2}$-horsepower Crocker-Wheeler motor, a 10-K.W. transformer, and a 50-ampere Cutler-Hammer remote control solenoid switch. The drive is through noiseless rawhide gears, and a six-step self-contained regulator provides for controlling the amount of current used.

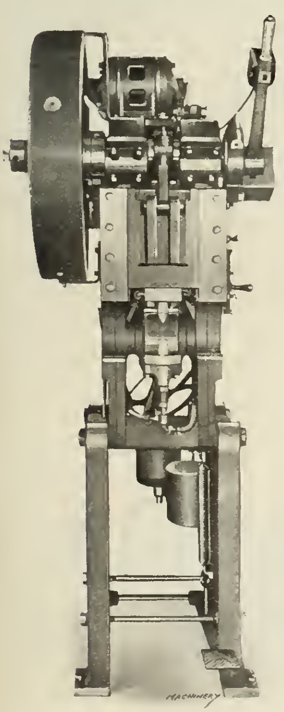


Fig. 1. Front View of Winfield Electric Riveter

In operating this machine, the work with the rivet in place ready to be headed is placed between riveting electrodes, with the rivet head resting in a depression in the lower electrode. The upper electrode is then brought into contact with the rivet by means of a hand-lever, and current is applied by operating a push-button located in the end of this lever. When the temperature of the rivet has been raised to the required degree, a foot-treadle is depressed, releasing the clutch and causing the slide to further depress the upper electrode, which results in upsetting and forming a head on the rivet. This machine is so designed that different gages of metal and variations in thickness of material are taken care of by a large rubber bumper; and the clutch is especially designed to make it impossible for the machine to operate more than once each time the foot-treadle is depressed. The floor space occupied by the riveter is 30 inches by 46 inches; the height of the machine is 90 inches; and it weighs approximately 1800 pounds.

MORRIS 22-INCH LATHE

The Morris Machine Tool Co., Cincinnati, Ohio, is now building a 22-inch engine lathe, the design of which is similar to that of the 16-inch lathe of this company's manufacture which was illustrated and described in the November, 1911, number of MACHINERY. The principal dimensions of the machine are as follows: swing over bed, $23\frac{1}{8}$ inches; swing over carriage, $15\frac{1}{2}$ inches; size of front spindle bearing, $3\frac{3}{4}$ inches in diameter by 6 inches in length; diameter of hole through spindle, 2 inches; diameter of cone pulley steps on double back-geared lathe, $11\frac{1}{2}$, $12\frac{3}{4}$ and 14 inches by $4\frac{1}{4}$ inches face width; and weight of machine, approximately 4500 pounds. These lathes are built with single or double back-gears and with quick- or semi-quick-change feed-box.

WARE ISOMETRIC PICK-UP TRIANGLE

R. B. Ware, 101 Northampton Ave., Springfield, Mass., is now manufacturing the isometric pick-up triangle illustrated and described herewith. At the center of the triangle there is a convenient pick-up handle, which consists of a knuckle joint which is raised sufficiently above the surface of the triangle to enable it to be easily grasped between the thumb and finger. This knuckle joint fits in a slot cut in the triangle and pops up on either side through pressure applied by a music wire spring. If the handle is raised on one side of the triangle and this side is then put down on the drawing paper, the pick-up handle will immediately be pressed into the hole, after which the spring forces it up at the opposite side. Similarly, the triangle can be placed between the leaves of a book; or it can be packed up without occupying any

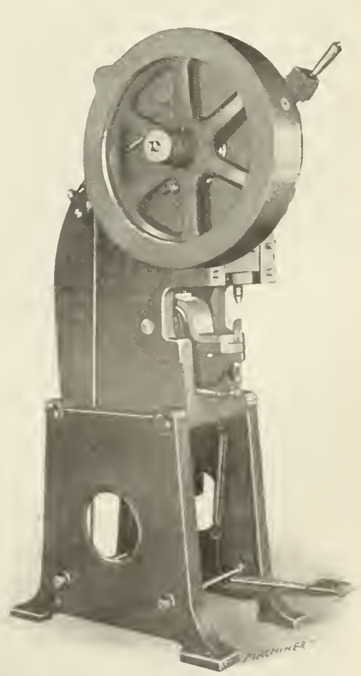
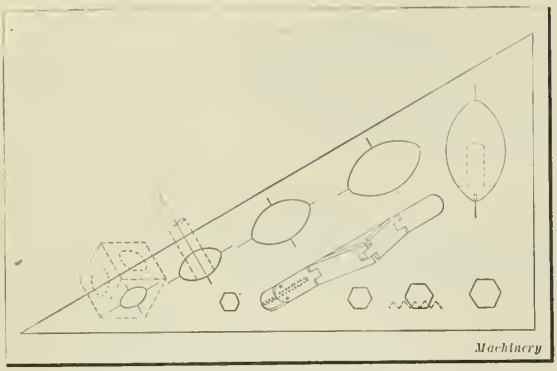


Fig. 2. Side View of Winfield Riveter shown in Fig. 1



Isometric Pick-up Triangle made by R. B. Ware

more space than an ordinary triangle, because in such a case the pick-up handle is held in the slot. This handle saves a lot of time in picking up the triangle.

By skillful manipulation this triangle can be used for cross-sectioning drawings, although it is not especially recommended for this work. For cross-sectioning, the hypotenuse of the triangle is placed against the T-square or other guide and pressure is applied on the two small brass retaining pins by one finger. After drawing a line, the knuckle joint is pushed down flat, while pressure is still applied on the retaining pins, thus causing the triangle to move into position for drawing the next line. The spaces obtained in this way will be about 1/16 inch apart on the long side of the triangle, and about 1/8 inch apart on the short side.

In addition to the pick-up device, it will be seen that the triangle is furnished with a number of elliptical shaped holes which are of isometric proportion and far more convenient to use than marking around the outside of templets. The long axes of these holes are parallel to the hypotenuse of the triangle, and lie in the correct angle for isometric drawing. All holes are beveled on both sides, so that the size drawn from them can be varied by tipping the pencil in or out; this beveling of the sides of the holes also avoids blotting if a ruling pen is used. The holes are convenient for rounding the ends of shafts, in which the short diameter is placed on the center line and the desired outline easily drawn. In addition, hexagonal shaped holes are provided for drawing in the head of bolts and the outline of nuts in plan view.

BROWN RECORDING THERMOMETER

A recording thermometer suitable for measuring temperatures up to 800 degrees F. or 425 degrees C. is one of the latest additions to the line of instruments manufactured by the Brown Instrument Co., Philadelphia, Pa. Its operation is governed by the expansion of gas with change of temperature, and in order to apply this principle a bulb of copper containing nitrogen gas under pressure is connected with a recording instrument by a small copper tube protected by flexible steel tubing. The recording instrument has a helical spring somewhat similar to that used in pressure gages, and the expansion of gas in the bulb exerts pressure which is conveyed by the connecting tube to this helix, causing an expansion according to the magnitude of pressure exerted. The helix is direct-connected to a recording arm which marks a record on the chart.

This type of instrument can be furnished with tubing as long as 100 feet if required, so that the recording gage can be placed at this distance from the point where temperature is to be measured, thus permitting application of the thermometer in numerous processes where it is desirable to keep a constant record of temperature on a chart. Some features of this thermometer are as follows: A Seth Thomas clock which revolves the chart is mounted directly on the front plate which supports the chart, thus assuring alignment of the clock and chart plate. Clips that hold the chart in position are mounted on the door so that when this door is swung aside the clips are swung away from the chart, permitting its easy replacement without interference. A device is furnished which automatically raises the chart pen from the chart when the door is opened and also automatically lowers it into position when this door is closed. A similar instrument is made in the indicating type where it is desired to indicate temperature on a dial instead of recording it on a chart. These thermometers are furnished with a number of different types of bulbs, with either threaded connection for insertion in mains and pipes, or with lead coating to withstand the action of certain chemicals and acids.

CLARK TRANSFER TRUCK

One of the latest additions to the line of elevating trucks manufactured by the George P. Clark Co., Windsor Locks, Conn., for use in transporting material around industrial plants, is the type WN truck which has a capacity for loads up to 2500 pounds. This truck is constructed entirely of metal, the frame, axles, rods and handle being made of steel, while the wheels are made of cast iron and provided with roller bearings. The handle is attached to a swivel designed in such a way that sharp corners can be easily turned. These trucks are made in ten different styles; six trucks have capacities for loads up to 1000 pounds and are made in various dimensions, making them suitable for use in connection with loading platforms, the maximum size of which covers a range from 32 by 32 to 42 by 32 inches in size. The four remaining styles of this type of truck have capacities for handling loads up to 2500 pounds in weight and are suitable for use in connection with loading platforms, the maximum size of which covers a range from 32 by 32 to 52 by 38 inches in size.

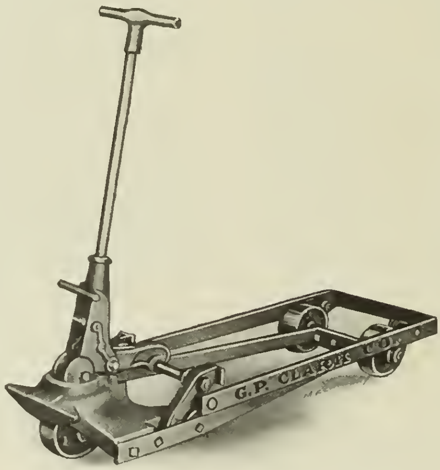


Fig. 1. Clark Industrial Truck with Platform lowered

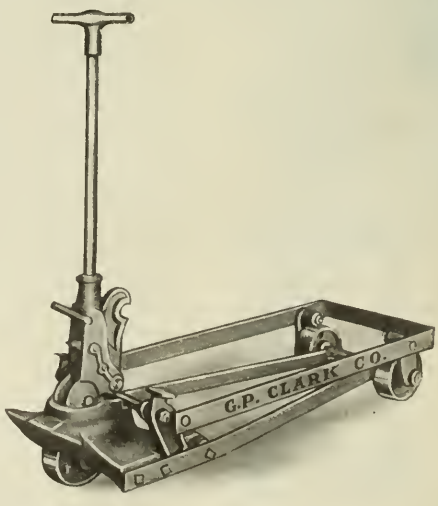
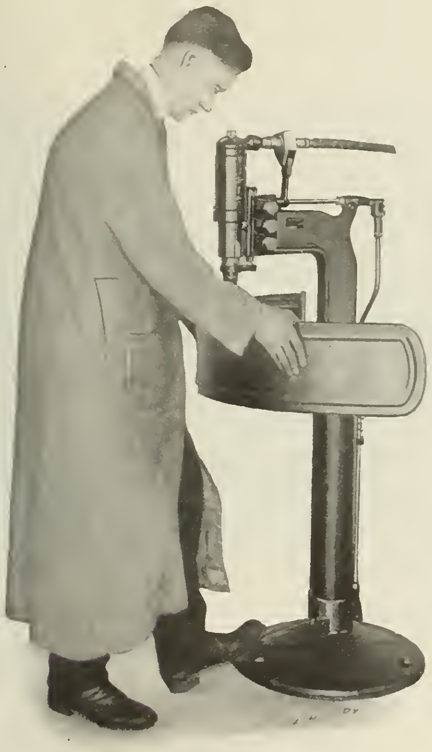


Fig. 2. Clark Industrial Truck with Platform elevated

BOYER PEDESTAL RIVETER

The Boyer pedestal riveter shown in the accompanying illustration is a recent product of the Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill., and is designed for use in riveting small parts that can be conveniently handled on a stationary machine. The design has been worked out in such a manner that the machine is operated by a foot-lever, leaving both of the operator's hands free to handle the work. The yoke consists of a crucible steel frame mounted in the end of a pipe column, all of which is supported on a cast-iron



Boyer Pedestal Riveter built by Chicago Pneumatic Tool Co.

base which has anchor bolt holes to provide for fastening it securely to the floor. The standard yoke has a gap of 8 inches and a reach of 11 inches, but special yokes may be furnished of any required dimension for handling larger work.

Where it is desirable to handle more than one size of rivet, a special dolly may be supplied, that will accommodate four different sizes of rivets. This dolly is so designed that it may be used in very close corners. The riveter head is a standard Boyer riveter 1 1/16 by 3, 1 1/16 by 4, or 1 1/16 by 5 inches, and is held in a clamp which permits of its being adjusted to compensate for wear on the dies or variation in length of rivets. The net weight of the machine equipped with a 1 1/16-by 3-inch riveter is approximately 173 pounds.

CORRECTION

An error appeared in the description of the Metalwood presses made by the Metalwood Mfg. Co. of Detroit, Mich., in the September number. The function of the knockout press shown in Fig. 2 is knocking or pushing the plug out of the bottom of British shells after the band has been set. The plugs are inserted to prevent the shells being distorted in the banding operation.

NEW MACHINERY AND TOOLS NOTES

Plug Wrench: Holden-Morgan Co., Ltd., Toronto, Ontario, Canada. A wrench especially designed for screwing in the base plugs of shells, although it could be used for other classes of work. The shell is held in a clamp and the plug is driven in by a mechanically operated wrench.

Jointer and Planer: Globe Inventing Co., 4877 N. Hermitage Ave., Chicago, Ill. A combination bench planer and jointer in which the thickness gage over the table can be set at any required height up to 4 inches, or it can be set to plane work on any angle up to 15 degrees. The table can be lifted and swung back for convenience when adjustment of the knives has to be made.

Rail Punching Machine: Covington Machine Co., Covington, Va. A machine developed for use in punching the bolt holes in the ends of two light rails at the same time. It is intended for use where the material handled does not weigh more than forty pounds per yard, this type of rail being used principally for industrial and mine railroads, and for the third rail of electrified lines.

Balancing Washer: Munning-Loeb Co., Matawan, N. J. A slotted washer intended for use in quickly bringing polishing wheels into balance. The washer is placed in such a way that the heavy end counterbalances the weight of the wheel which is off center, thus making it unnecessary to resort to the practice of tacking pieces of lead to the sides of wheels or driving in pieces of metal or nails.

Portable Electric Drill: Electro Magnetic Tool Co., Chicago, Ill. A machine in which the gears are made of steel, case-hardened and heat-treated to provide the required strength and durability. These gears run on bronze shafts immersed in grease in a separate gear case; and the thrust is carried by a ball thrust bearing. The motor is air cooled by a ventilating fan on the spindle, and the spindle and chuck are offset so that the tool will reach into close corners.

Weight Slide-rule: Hornyak & Kelly, 5526 Walton Ave., Philadelphia, Pa. This device was especially designed to meet the requirements of estimators in figuring the weights of machine shop materials. The dimension scales are graduated in inches and fractions thereof, and the weight scales in pounds and tenths of pounds. The weights of regular and irregular shaped pieces made of various metals and other commonly used materials are rapidly and accurately obtained by the aid of this instrument.

Planer Belt Shifter: Cincinnati Planer Co., Cincinnati, Ohio. This is an improved form of the planer belt shifting mechanism previously used by the Cincinnati Planer Co.; the shifting cam is entirely enclosed by a cover bolted to the overhanging arm, which eliminates trouble from belt scrapings, grit and dirt usually found on top of the planer shifting mechanism. The upper belt guide is provided with a sliding bearing on the over-arm bracket, which relieves the fulcrum stud from the downward pressure of the belt.

Roller Bearing: Delvante W. Crossland, 1608 Claus Spreckels Bldg., San Francisco, Cal. A roller bearing in which there is no sliding friction; the load bearing rollers are made of parallel solid hardened steel, so that the bearing can be heavily loaded without fear of failure. The bearing is provided with separating rollers that contact with the main rollers in such a way that no roller in the bearing can revolve without every other roller revolving. The separating rollers space the main rollers equally upon the journal, but do not contact with it.

Boring Tool: Clark Machinery Co., 1302 Ontario St., Cleveland, Ohio. The features of this tool are simplicity of construction and the ease with which it may be adjusted to the exact size and position required. Adjustment is made by worm and worm-wheel actuated by a wrench which makes it unnecessary to tighten the tool after adjustment and eliminates the necessity of loosening and tightening screws in making adjustment. The tool is made in five sizes, and all parts subject to wear are hardened to give them the required durability.

Sandblast Nozzle: W. F. Stodder, 218 S. Geddes St., Syracuse, N. Y. A sandblast nozzle operating on the injector principle and designed primarily for cleaning castings or other parts in a foundry or similar shop. This sandblast may also be used for removing scale from boiler tubes and boilers, and for removing rust and paint from structural steel, iron bridges, etc. In this nozzle the sand travels slowly through the hose, so that there is little wear; and an advantage claimed for the nozzle is that there is no sand tank which has to be filled.

Combination Disk Grinder and Saw Table: Globe Inventing Co., 4877 N. Hermitage Ave., Chicago, Ill. The arbor of this machine is so arranged that it is adapted for carrying either an abrasive wheel covered with abrasive cloth or paper, or a circular saw. Provision is made for mounting thin abrasive wheels on the arbor so that high-speed and hardened steel can be ground. The table tilts to any angle or can be raised or lowered at the back; it is provided with two adjustable angle rests that can be locked in any position by thumb-screws.

Munitions Parts Assembling Machines: Berggren & Pearson Machine Co., New York City. A battery of machines designed for assembling the bursting box for the contact detonator of 3-inch Russian shells. The battery consists of six machines so arranged that the two opposite machines assemble the same part of the work and are driven by the same belt. All the machines are mounted on a table 12 feet long by 30 inches wide, leaving ample room between the operators for loading and unloading the trucks which are rolled up to the assembling table.

Extensible Coupling for Mill Drives: Cutler-Hammer Clutch Co., Milwaukee, Wis. An extensible coupling for use in connection with herringbone gear drives on rolling mills, designed to eliminate trouble resulting from end thrusts or any constraint which does not leave the gears perfectly free to align themselves properly The use of this coupling between the driving motor and herringbone pinion provides for transmitting the necessary power, leaving the pinion free to align itself with the gear, and unaffected by any end thrust caused by lateral motion of the shaft.

Rail Breaking Machine: Covington Machine Co., Covington, Va. A machine for breaking rails, the weight of which does not exceed 100 pounds per yard of length. This machine is of the open-throat type and was designed as a substitute for the closed machine similar to a guillotine shearing machine. It breaks the rail with a single stroke of the plunger, and as the shock is somewhat severe, special attention was paid to the design of the main bearing for the eccentric shaft. A cast steel block is used to support the bearing which is relied upon to save the main frame from unnecessary wear.

Welding Outfit: Thermalene Co., Chicago Heights, Ill. A new method of torch welding in which oxygen and a gas known as "thermalene" are employed. This gas was discovered by Karl Frederich Linus Wolf of Zurich, Switzerland, and is handled in this country by the Thermalene Co. It is claimed that this gas possesses a low inflammability and that danger from its explosion is almost negligible. The Thermalene Co. manufactures a portable outfit consisting of thermalene generator and the other equipment, mounted on a truck so that it may be conveniently moved from one place in the shop to another.

Internal Thread Millers: Holden-Morgan Co., Ltd., Toronto, Ontario, Canada. An internal thread milling machine designed for threading the nose or base of shell bodies. The shell is held in a hollow spindle which is driven by means of a bronze worm-wheel. At the rear of the spindle there is a ring which operates the trip trigger, automatically disengaging the drive after the work has been completed by one revolution of the spindle. Two types of these machines are built, which are known as the heavy and light styles. The light style has a leg base construction, but in other respects the design of both machines is the same.

Engine Lathe: Oliver Machinery Co., Coldbrook and Clancy Sts., Grand Rapids, Mich. A heavy-duty 26-inch engine lathe on which the headstock is heavily ribbed and provided with a long bearing on the bed. The front spindle bearing is 6½ by 10 inches in size and the rear bearing 4½ by 7 inches. The headstock is of the single-pulley geared type and there are two changes of speed provided from the countershaft, giving a total range of twelve speeds from 8 to 300 revolutions per minute. There are thirty-two changes of feed ranging from 0.013 to 0.333 inch per revolution; and thirty-two changes of threads ranging from 1 to 24 threads per inch.

Surface Grinder and Sander: Globe Inventing Co., 4877 N. Hermitage Ave., Chicago, Ill. A bench machine designed for use in finishing up any size of surfaces and shapes on wood, metal and other material. Any required abrasive cloth can be quickly attached to the roller by loosening three screws, and two kinds of abrasive cloth can be put on the roller at the same time, each covering half of the roller. The guide can be quickly set to the required height over the abrasive, and it can be set at any angle up to 15 degrees. The table can also be lowered or raised at either side, and it can be lifted and swung up to the back while replacing worn out abrasive cloth.

Shell Plug and Socket Millers: Holden-Morgan Co., Ltd., Toronto, Ontario, Canada. One machine was designed primarily for the performance of operations on shell plugs, although it could be adapted for external threading on other classes of work. On this base-plug miller the piece is chucked by means of a device which may be adapted for handling different types of work, and the thread is completely milled at one revolution of the work-spindle. Opening and closing of the chuck are controlled by a handle conveniently placed at the side of the machine. The socket miller is adapted for milling outside threads on fuse sockets, nose pieces, and fuse bodies; and this machine is provided with a chucking device especially adapted for holding these parts.

Horizontal Tapping Machine: H. E. Harris Engineering Co., 1041-1055 Broad St., Bridgeport, Conn. A horizontal tapping machine on which the forward and reverse drives are accomplished by a friction cone consisting of leather contacting with cast iron. The leather forms a cushion to give an easy and sensitive though powerful grip under slight pressure. The forward friction is thrown into action by a slight pressure on the end of the tap applied by pushing up the hole in the work against it. When the work has been tapped to the required depth and the spindle in the tailstock comes into contact with a stop, the cone friction is automatically released by the action of the tap drawing into the work; and the rotation is then reversed to back out the tap by drawing the work away from the tap.

GEAR TESTING MACHINE

The machine here illustrated and described is the outgrowth or evolution of a previous machine, designed and built by Wilfred Lewis for the use of the American Society of Mechanical Engineers' committee on standards for involute gears. This was referred to in a paper presented at the American Society of Mechanical Engineers' joint meeting with the Institution of Mechanical Engineers at Birmingham in 1910, and a later design was presented again to the American Society of Mechanical Engineers in June, 1914.

Prof. Charles R. Richards, in charge of the Department of Mechanical Engineering of the University of Illinois, became interested in the problems which the latter machine was designed to solve, and ordered one for his mechanical laboratory. Before work was begun upon it, however, he noticed that no means had been provided to measure the power consumed, and, to make the machine more comprehensive in its scope, Wilfred Lewis agreed to add this feature, which had been one of the chief considerations in the first machine. The present machine has, therefore, been made to combine the means for controlling and measuring the pressure on gear teeth in action, with a later construction designed to measure the power consumed.

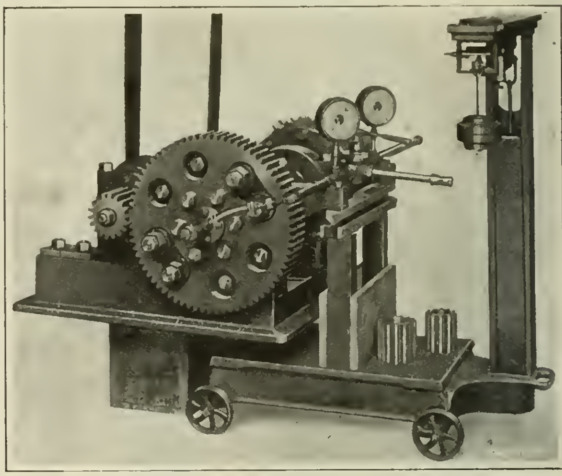


Fig. 1. Improved Gear Testing Machine built for University of Illinois

The former machine, which was described in the American Society of Mechanical Engineers' *Transactions* for 1914,* had a cast-iron frame or base, designed to rest upon a solid foundation. This construction has been taken bodily and mounted upon two horizontal axes, one of which coincides with the axis of the driving shaft while the other is a knife-edge resting upon portable platform scales, as shown in Figs. 1 and 2. A stand has been introduced to encircle the driving shaft and carry a foot down through an opening in the main frame of the machine. This foot rests upon a block of stone or concrete represented in the illustrations by a wooden box, and it will be understood that the shaft bearings are carried in this stand on ball bearings. On the other side of the machine, caps for the main bearings have been extended to carry the knife-edge as shown. The weight of the whole machine is therefore divided between these two supports at a certain distance apart, depending upon the size of the pinions used.

When driven in one direction, the load on the scales is increased, and when driven in the other direction it is decreased by the driving torque, as measured by the arm of the couple between supports. Fluid pressure is admitted to either side of the load-piston through a three-way cock, as shown, and the pressure resulting on the gear teeth is shown by the gages. It will be seen that this pressure can be readily reversed while the gears are running, and with a suitable countershaft or motor attached to the driving shaft

* This paper was published in the September, 1914, number of MACHINERY.

the direction of motion can also be reversed. With eighty pounds' fluid pressure in the load cylinder, the working load on the gear teeth becomes about 5000 pounds, and this is expected to break test gear teeth in cast iron, four per inch and 1 inch face or thereabouts at some speed to be determined.

The effects of various lubricants on the friction load can also be studied and the effects of wear at different speeds and loads. When breaking loads are approached, the test gear can readily be enclosed by a frame attached to a flange around the main casting so that broken teeth will not be thrown off to endanger the operator. No danger of a general smash-up is to be expected, however, because the remaining teeth will continue to mesh properly no matter how many may be broken. Of course the improvised foundation and the supporting stand on scales, as shown in the illustrations, will be replaced by substantial substitutes when the machine is placed in service.

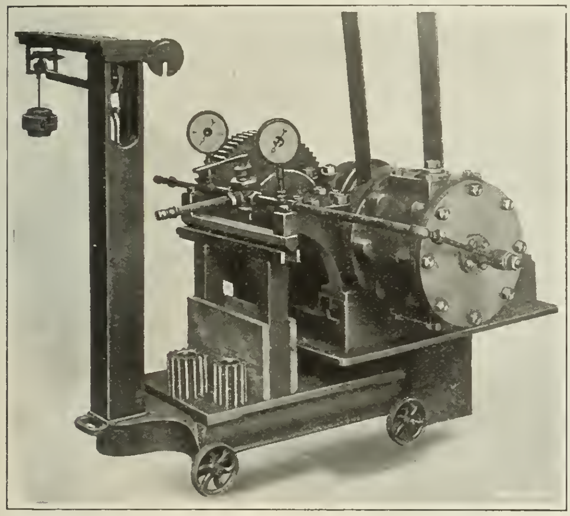


Fig. 2. Opposite Side of Gear Testing Machine shown in Fig. 1

* * *

MACHINING OPERATIONS ON RUSSIAN MILITARY RIFLE STOCK*

Several large plants in this country are at present engaged in the manufacture of the Russian military rifle stock; the equipment for this work varies to some extent in the different shops. One plant has an equipment which has been laid out along original lines with results that have been found highly satisfactory. The average time required with standard equipment to turn out the Russian military rifle stock is 1¼ man-hour, and in the plant referred to it is 9/10 man-hour per stock, with a total daily production based on 6500 stocks and operating on two shifts.

Many of the machines used for this work are novel in their application to the production of military rifle stocks. One of the interesting machines used is that for bandsawing the outline. The stock is held in a fixture which locates it from the top and front end, and when it is clamped, the stop at the front end automatically drops away. This fixture is held on a table which moves forward while the front end of the stock is cut off to length and the butt end milled to the required outline. The table is then returned to another stop and a special profiling cutter is brought into operation to profile the outline for the butt plate on the top and rear end. A lever is then operated, bringing into play a tool that hollow-mills the diameter at the front end and drills one hole in the butt to act as a driving point while turning. This machine is made by McKnight & Sons, Fitchburg, Mass., and produces fifty stocks per hour.

In rough- and finish-turning the fore end, a radical departure is made from the old practice of performing this operation in the stock turning lathe. In this case, the work is done in a fore-end stock turning machine built by Olney & Warrin, in which the stock is located by the ends and top, and the work is brought up to a set of cutters of the proper form and of a length sufficient to turn the entire fore end at one setting. The rough and finish cuts are taken at one setting by having the work make two revolutions, feeding in to the second stop for the second cut. The production is three stocks per minute.

In turning the butt end, use is made of a stock turning machine of the Blanchard type, but instead of using one tool with a number of cutters inserted in the periphery, two tools are used, each of which cuts one-half the length to be turned; these tools are a special form of saw which is very easily kept in shape, and is greatly superior to the old type of turning tool. The production is twelve stocks per hour.

For inletting, it is the practice to perform the various cuts separately, limiting the number of cutters in each operation and utilizing more machines so as to reduce the operation to the simplest form possible and obtain a greater output from each machine. The machines are much less complicated and cost considerably less than those equipped with six, eight or ten cutter-spindles.

In the Russian stock there is a mortised opening ⅜ inch by 2¼ inches, and the regular practice is to make this opening on an inletting machine. For this work a special machine has been bu lt by the New Britain Machine Co., similar to that used for m rtising wood level blocks, made by the Stanley Rule & Level Co. This machine has a table fixture on which the stock is placed, and it is provided with a feed mechanism that operates in a vertical plane. The head of the machine is arranged to carry a chain cutter; this cutter comprises a chain with links, the outer faces of which are formed with cutting edges and which is arranged to be driven by a sprocket and pass over a guide bar that gives it the proper tension and position. The production of this machine is four stocks per minute. D. T. H.

* For methods of manufacture and equipment used in the production of military rifles, see "The Military Rifle," published in the April, May and June numbers of MACHINERY.

* * *

FIFTH ANNUAL CONGRESS OF NATIONAL SAFETY COUNCIL

The fifth annual congress of the National Safety Council, an employers' organization formed for the purpose of establishing a clearing house of information on accident prevention, sanitation, health conservation, etc., will be held in Detroit, October 17, 18, 19 and 20. The importance of conserving the human element is voiced by a prominent manufacturer who recently said:

> I believe we are fast approaching the time when it will be no longer possible to make any such revolutionary economies in industry as were brought about by the invention of the steam engine, the application of electricity and the development of steel making. I believe the next great field of economy lies along the line of conserving the human equipment of our plants.

Chemical section, foundry section, iron and steel section, mining section, public utility section, steam railroad section and health service section meetings will be held, at which papers on various matters concerning the prevention of accidents, promotion of health and sanitation, etc., will be presented by experts in the various lines represented. It is expected that about 140 speakers will take part.

* * *

MONUMENT TO JOHN ERICSSON

On August 31 President Wilson signed a bill introduced in Congress for the erection of a monument to Capt. John Ericsson, the well-known engineer who designed the *Monitor*, which, during the Civil War, turned the naval power in favor of the North. The monument will be erected at Washington, D. C. A number of members of the American Society of Mechanical Engineers were active in securing the passage of the bill, because they considered the nation ought to erect a monument commemorating this great engineer. It is the first time that Congress has made an appropriation for the erection of a monument to any citizen who has not held high political office, and the first time that a monument has been erected to an engineer at public expense.

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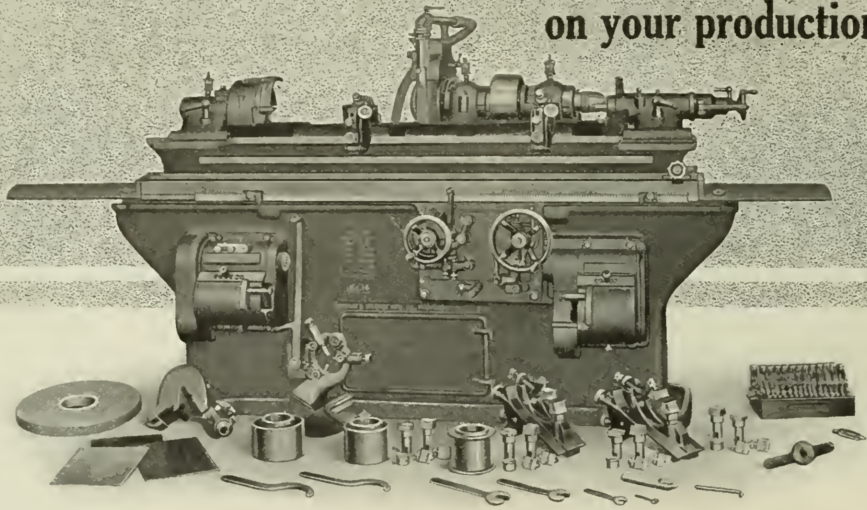

Built for Heavy Manufacturing Grinding

No. 12 Capacity to 8" diameter, 36" long.
No. 14 Capacity to 10" diameter, 48" long.
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Also two smaller sizes in plain machines and a full line of Universal, Tool, Cutter and Surface Grinders.

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You can get with these machines the steady production that is necessary to keep your grinding output balanced with the rest of your shop in these busy days.

Week after week, and month after month, they will produce consistently and at the fastest practical rates work that will come up to your most exacting standards for accuracy and finish.

There are good reasons for this ability. Here are a few:

Rugged support of working parts. The stability required in machines for heavy manufacturing is there. An examination of the bed, wheel stand, and other parts will reveal ample thickness of metal and strong bracing at points of greatest stress. But careful calculations have eliminated unnecessary weight that would tend to make the machines clumsy and slow to operate.

Bearings carefully aligned. Having bearings properly supported, correctly designed as to size, and then accurately aligned is responsible for the reliability of these machines in long continued service.

Just the right combination of speeds and feeds is always at your disposal—no excuse for using a combination that will not give the very fastest production consistent with the finish required.

You should know more about these and other features such as the Automatic Cross Feed, Universal Back Rests, etc. Write us for a descriptive circular of the machine best suited to your work. (See list of capacities above at left.)

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OFFICES: 20 Vesey St., New York, N. Y.; 654 The Bourse, Philadelphia, Pa.; 626-630 Washington Blvd., Chicago, Ill.; 305 Chamber of Commerce Bldg., Rochester, N. Y.; Room 419, University Block, Syracuse, N. Y.; Room 2538, Henry W. Oliver Bldg., Pittsburgh, Pa.
REPRESENTATIVES:. Carey Machinery & Supply Co., Baltimore, Md.; The E. A. Kinsey Co., Cincinnati, O., Indianapolis, Ind.; Pacific Tool & Supply Co., San Francisco, Cal.; Strong, Carlisle & Hammond Co., Cleveland, O., Detroit, Mich.; Colcord-Wright Machinery & Supply Co., St. Louis, Mo.; Perine Machinery Co., Seattle, Wash; Portland Machinery Co., Portland, Ore.

LAWS OF FOREIGN COUNTRIES RELATING TO BUSINESS*

UNFAIR COMPETITION AND TRUST LAWS OF VARIOUS COUNTRIES AND INTERNATIONAL AGREEMENTS AFFECTING THEM

In most countries, the laws governing the formation of monopolies and unfair competition are based on the laws of France. These laws are chiefly found in the general codes which were enacted shortly after the French Revolution. The principal provision of the penal code makes it possible to punish by imprisonment and fine anyone who shall effect the advance or decrease of price of any merchandise or public securities (above or below the prices that natural and free competition would have fixed) by the circulation of false reports, by offers of higher prices, or by agreement not to sell or to sell only at a certain price. Court decisions show that the circumstances of each case affect its standing. The court decided that it was illegal for all the important iodine manufacturers to combine: to divide the field that supplied the raw material; to fix the quantities to be purchased in each field and the prices to be paid therefor; or to sell their entire output through a syndicate that would fix the price and other conditions of sale. But when those producing about two-thirds of the phosphate of the Somme region combined to sell their products, fix the prices, etc., the court decided that the combination was legal because it did not include more than two-thirds of the production and there was competition from other parts of France and from Belgium.

The Belgian as well as the French criminal codes provide that:

> Every person, who with the purpose of compelling the increase or decrease of wages, or of interfering with the free operation of industry or of labor, shall have committed violence, proffered insults or threats, adjudged fines, prohibitions, interdictions, or any proscription whatever, either against those who labor or against those who employ labor, shall be punished with imprisonment, etc.

The combinations of employers and of laborers for the purpose of fixing the price and the conditions of labor are legal, though subject to restriction. In one instance a court said:

> Although employers and laborers have the right to combine in order to fix the price, the conditions of labor, etc., the use of this right is limited and the abuse of it is repressed by the laws which protect the laborer and his work. It is permitted to trade unionists to make by-laws which govern the members of the union and which authorize the expulsion of a member who disobeys them, but in advising third parties of this expulsion with the threat that they will be exposed to disagreeable consequences in case they take the excluded person into their service, the secretary of the union attacked the freedom of the latter; and he ought to compensate the damage caused by that illicit act.

When a Belgian association of dealers in druggists' supplies tried to "quarantine" a dealer for non-observance of the regulations of the association, although he was not a member and had no agreement with it, the court held that the defendant was not permitted to "resort to practices to induce all or a certain number of manufacturers to refuse to sell to the plaintiff or to sell only at a price that made it impossible to resell at a profit." While the court held that there was ground for an action of damages, it referred the case to an accountant to determine what damages may have been sustained by the plaintiff.

The civil code of Austria says that unpermitted companies have no rights either against their members or against others and that they are incapable of acquiring such rights. The code then defines these as follows: "Unpermitted companies are those which are forbidden by the political laws or which are clearly repugnant to security, public order, or good morals." The highest court in Hungary, however, declared the combination legal when several contractors agreed to regulate their participation in bidding on public contracts, including provisions as to prices and conditions and penalties for breach of that agreement. The court said:

> If those engaged in a branch of business combine to hinder the offer of cut prices which endanger the economical operation of the industry in order thereby to maintain a reasonable price for their work, an agreement pursuing such an end, and not fixed for too long a period (it was five years in this case), can be regarded as inconsistent neither with the interest of the participants nor with that of the public nor as repugnant to good morals. * * * A combination which seeks to avoid a crisis injurious both to the contractor and to the party employing him serves also the interest of the public.

The Italian civil code contains the following provision: "Whatever act of a person causes damage to another obliges him by the fault of whom it happens to compensate the damage." But the courts have held that it is legal for associations to regulate the prices, etc., and for producers to combine to prevent injurious competition and to maintain remunerative prices. A special law, also, provides that should a combination of shippers refuse to transport emigrants at rates approved by the government, their licenses shall be withdrawn. Italy has also established a compulsory cartel of the sulphur producers, as well as a commission for the promotion of the citrus products industry. Among other things, this commission advances money to the producers of citrus products and sells the products, a minimum selling price being fixed each year.

While the civil code of Russia provides that no contract shall be repugnant to the laws, to good morals, or to public order, the Russian government has encouraged the formation of several cartels. The decisions of the courts, however, are not legal precedents; they rather follow the administrative policy. The Russian government has insisted on the formation of a monopoly for the development of its sugar industry; Sweden, for its iron; Roumania, for its petroleum; Greece, for its currants; Brazil, for its coffee; and Mexico, for its sisal fiber.

Japan's commercial code is modeled after the German code; it states that:

> If a business association acts contrary to public order or good morals, the court may dissolve it on the application of the attorney-general, or by exercising its executive power.
>
> If a representative of a foreign business association establishing a branch office in Japan commits any act contrary to the public order or good morals during the management of the business of the association, the court may upon the application of the attorney-general or by its own executive power order the branch office closed.

In China, a person who "unduly depresses or raises prices to suit his own convenience entails a penalty of eighty blows and the undue profit arising therefrom is treated as theft."

Unfair Competition

Unfair competition, according to some French law books, is "an act committed in bad faith with a view of producing confusion between the products of manufacturers or of two merchants, or which without producing confusion causes discredit upon a rival establishment."

In European countries, it relates generally to unfair practices to injure a competitor; the effect on the consumer is not generally considered except as it concerns a competitor. The present tendency, though, seems to be to have a general provision in the civil code that is applicable to the ever varying forms of unfair practices, while several specific laws make the more easily defined or more obnoxious practices illegal and impose the penalties. These special laws are enacted especially where international treaties are concerned or where reciprocity provisions regarding the protection granted foreigners are incorporated in the statutes. Austria, Denmark, Greece, Spain, Portugal, and some of the Swiss cantons are modeled after the laws of Germany. This code provides a special law against specific kinds of unfair competition, which contains also a provision of general application. German jurists generally hold that unfair competition constitutes a violation of the rights which every individual has to his physical and intellectual property. Since 1910, many of the German cities have established boards of arbitration for settling contests on account of unfair competition. These boards are

* An abstract from the bulletin issued by the Department of Commerce, entitled "Trust Laws and Unfair Competition."

formed by mercantile associations and do away with much of the expensive and long litigation. They also offer speedy relief from the offense and avoid much distasteful publicity. These boards also have an enlightening influence on the business world regarding fair and lawful competition. They have been especially useful in cases where the decisions of the Imperial Court, in conformity with the letter of the law, were not broad enough and did not keep pace with the progress of current business methods and customs.

According to the French jurists, the relation between a business man and his customers constitutes a commercial property right, and whoever knowingly injures it commits an unlawful act and makes himself liable for damages. They hold that the cardinal principle of unfair competition is intent to injure, and they make a careful distinction between unfair and unlawful competition, based on the existence or nonexistence of wrongful intent. It is unlawful and not unfair competition where a person, in good faith, commits a legal wrong or injures another through negligence or carelessness. But both the French and the German codes agree that the deciding and controlling viewpoint for legislative suppression of unfair competition is not the protection of the public or consumers, but the protection of fellow tradesmen or competitors. In France, actions to enjoin unfair practices and to recover damages because of them are conducted before the tribunals of commerce. These tribunals, of which there are 214, are composed of merchants, and are chosen by the merchants of the district in which they reside. Appeals can be taken from them to the court of appeals.

British laws governing unfair competition, like the laws of the United States, are based largely on the common law. While decisions show that it is sometimes legal for a person to persuade another to break a contract, business competition or competition between union and non-union labor is not a justification for that action. For instance, when a labor union tried to force contractors to comply with its demands by refusing to work on supplies purchased from dealers who sold to them, thus causing them to break their contracts with these dealers, it was held that the dealers injured could recover damages from the members of the union. A similar decision was given by the House of Lords in the case of a union that induced some persons to break their contracts to buy from a man who refused to discharge some non-union men; in this case, the union also induced some of the employes to break their contracts with the man and leave his employ. It was held that some mine owners could recover damages from a union that caused the employes to refuse to work on certain days in violation of their contracts.

Under the Australian laws, unfair competition is presumed if the defendant is a member of a commercial trust; that is, any form of combination to restrict competition. The laws make every attempt to restrict competition or to procure a monopoly *prima facie* evidence of unfair competition. They also term as unfair any competition that will probably result in inadequate remuneration for Australian labor, thus making indirect injury to the employes of a competitor *prima facie* evidence of unfair competition. In order to prevent dumping, the Australian law states that competition is unfair:

> If the methods of importation are considered unfair, or if the importer has purchased the goods imported at prices below the cost of production, or if such goods are being sold at such prices that the importer will not receive a fair profit on the basis of their foreign market value or selling value, if sold in the country of production, allowance being made for freight charges to Australia and customs duties. But in determining whether the competition is unfair, regard must be had to whether the Australian industry is reasonably efficient and up-to-date.

International Agreements

Since the formation of the International Congress for the Protection of Industrial Property, in Paris, in 1878, most of the nations of the world have signed the following: "All the contracting countries agree to assure to the members of the union an effective protection against unfair competition." The Imperial Court of Germany has held that even though an American company had no branch office in Germany, the company was entitled to protection under the terms of this agreement. But it also held that where a British concern had been denied the exclusive use of a trade term in its own country, it did not have the exclusive right to the name in Germany.

In its eighth conference in Budapest, in January, 1914, the Middle European Economic Association formulated plans for making more uniform the laws relating to unfair competition in the various countries. It was also recommended that the several governments enact "uniform legislation for the suppression of such unfair practices as false advertisements regarding quantity and quality, misappropriation and misuse of distinguishing marks for the purpose of enticing customers, disparaging competitors, betrayal or other violation of trust, or spying out business and trade secrets." In the Sixth International Congress of Chambers of Commerce and Commercial and Industrial Associations, which was held in Paris in June of that year, it was recommended "that every nation should make an effort to stop corruption and corruptive practices that affect not only the countries where they are carried on, but also international commerce." It was also recommended that prohibited acts should be made punishable as a crime by the penal code of each country, but that civil prosecution should be allowed, so that the victims of bribery could procure compensation for injuries sustained. D. E. J.

PERSONALS

O. Ericsson, manager of the export department of Nielsen & Winther, Ltd., Copenhagen, Denmark, has come to America for the purpose of buying machinery and tools.

A. L. Buiwitt of Petrograd, Russia, has been given full charge of the New York office of the Russian Metal Trading Co. (Iznosskoff, Suckau & Co.), 149 Broadway, New York City.

Robert K. Greaves, formerly Boston manager for H. Boker & Co., Inc., has been made Western manager for the company, with offices and warerooms at 217-223 N. Desplaines St., Chicago, Ill.

Lester G. French, assistant secretary of the American Society of Mechanical Engineers and formerly editor of MACHINERY, who underwent a serious operation in July, has returned to his duties restored to health.

Albert V. Brouillette, for some time assistant to the chief efficiency engineer of the Remington Arms-Union Metallic Cartridge Co., Ilion, N. Y., is now connected with the New England Westinghouse Co., Springfield, Mass.

Arthur H. Halloran, a well-known electrical man, has been appointed Pacific Coast representative for the Society of Electrical Development. His headquarters will be in the Crossley Bldg., San Francisco, Cal. Mr. Halloran will represent the society in California, Arizona, Nevada, Utah, Idaho, Oregon and Washington.

Franklin G. Hubbard, chief engineer of the mechanical department of the Western Electric Co., Hawthorne, Ill., has resigned to become a stockholder and director of the H. E. Harris Engineering Co. of Bridgeport, Conn. Mr. Hubbard has been elected vice-president, and will have the factory under his supervision.

Swan F. Anderson has disposed of his interest in the Rockford Tool Co., Rockford, Ill., and with his brothers, H. E. Anderson and A. L. Anderson, has started the Anderson Mfg. Co. The Anderson brothers are expert mechanics, and they will make dies, tools, fixtures and special machinery to order. They have acquired a modern plant and are equipped for doing high-grade work.

OBITUARIES

William Bunting, president of the Bunting Brass & Bronze Co., Toledo, Ohio, and an authority on non-ferrous alloys, died August 26, aged sixty-six years. He was born in Belfast, Ireland. He served a seven years' apprenticeship to the brass molding trade in Belfast, and was made foreman two years after serving his apprenticeship. He came to America in 1880, taking a position in Chester, Pa.; from there he moved to Salem, Ohio, to take charge of the brass foundry of the Buckeye Engine Co. Later he moved to Mansfield, Ohio, where he was associated with the Ohio Brass Co. as general superintendent and director of the company. Mr. Bunting remained with the Ohio Brass Co. for sixteen years, during which time the company grew from a small concern to its present large size. He resigned in 1907 to start the Bunting Brass & Bronze Co. at Alliance, Ohio. In 1910 the business of the company outgrew the plant at Alliance and a new plant was erected in Toledo, Ohio—the present location of the company. For the past nine years Mr. Bunting has had his three sons associated with him

in business, namely, W. H. Bunting, superintendent; C. E. Bunting, secretary and treasurer; and J. N. Bunting, sales manager. The business will be continued by the three sons.

Mathias Pfatischer, consulting engineer of the Electro Dynamic Co., Bayonne, N. J., died in Roselle, N. J., September 10. Mr. Pfatischer was an electrical engineer and inventor. He invented the electric steering gear with which several Russian battleships and one or two United States cruisers are equipped and also the transatlantic liner *Finland*. He designed and engineered the entire electrical equipment of the *St. Louis* and *St. Paul*, which included several novel electrical features, such as the electric ship telegraph, propeller shaft electrical revolution indicators and electric rudder indicator. He was the originator of the plan of running wires in conduits aboard steamships, etc. He was instrumental in developing a single-phase alternating-current motor, about eighteen years ago, which has proved successful and is known today as the Wagner A. C. motor. In 1904 he invented the inter-pole variable-speed motor which revolutionized the design of direct-current motors, and in 1908 he was awarded the John Scott medal by the Franklin Institute for this invention. Mr. Pfatischer was a member of the American Institute of Electrical Engineers, Electric Power Club, the Technical Society of New York, Franklin Institute and the Elektrotechnische Verein Society of Berlin, Germany. He was with the Electro Dynamic Co. for twenty-seven years.

COMING EVENTS

October 11-21.—New York Electrical Exposition in the Grand Central Palace, New York City. Arthur Miller, director, Irving Place and 15th St., New York City.

October 17-20.—Fifth annual congress of the National Safety Council at Detroit, Mich. W. H. Cameron, secretary and treasurer, Continental and Commercial Bank Bldg., Chicago, Ill.

October 24-25.—Annual convention of National Machine Tool Builders' Association, Hotel Astor, New York City, headquarters. Charles E. Hildreth, general manager, Worcester, Mass.

October 24-27.—Postponed annual convention of the Traveling Engineers' Association, Chicago, Ill., Hotel Sherman, headquarters. W. O. Thompson, secretary, general offices N. Y. C. R. R., Cleveland, Ohio.

October 26.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

November 16-18.—Open conference of the Efficiency Society in New York City. Willis B. Richards, chairman, and M. L. Havey, secretary, 52 Broadway, New York City.

January 6-13.—National Automobile Show in Grand Central Palace, New York City.

SOCIETIES, SCHOOLS AND COLLEGES

Michigan College of Mines, Houghton, Mich. Year book for 1915-1916, with announcement of courses for 1916-1917.

Hebrew Technical Institute, Stuyvesant and 9th Sts., New York City. Catalogue for 1916, containing calendars for 1916 and 1917. Courses of instruction cover English, mathematics, applied science, mechanical drawing, woodworking, wood carving, metal working, engineering and forging, instrument making and electricity. There are also evening classes in toolmaking, instrument making, die making, pattern making, machine work, cabinet making and mechanical drawing.

The Swedish Engineering Convention in the United States, 1915.—Proceedings of the convention, containing a general review of the engineering and social activities, and the papers read at the Swedish Engineering Convention which was held in Chicago, September, 1915. The papers were: "Development of the Swedish Industries," by A. J. Korner; "By-products of the Steel Industry," by A. G. Witting; "Scientific Management and its Practical Application," by A. N. Engblom; "Natural Resources and the Industrial Possibilities of Sweden," by H. F. Sandelin; "Panama Canal, its Construction and Electrical Operation," by E. A. Lof. The proceedings also contain a list of the 290 members of the convention.

NEW BOOKS AND PAMPHLETS

Railroad Master Scales—Specifications and Tolerances. Preliminary Issue, May 20, 1916. Published by the Bureau of Standards, Washington, D. C., in mimeograph form for limited distribution.

Dyke's Automobile Gasoline and Gas Engine Encyclopedia. 824 pages, 6¾ by 9¾ inches. 2370 illustrations. Published by A. L. Dyke, Roe Bldg., St. Louis, Mo. Price, $3.

This book is of the fifth edition, revised and enlarged, containing 366 charts with dictionary and index. It treats of the construction, operation and repairing of motor cars and gasoline engines, and is in truth an encyclopedia of information for the motorist. It deals with the different types of drives, steering, springs, brakes, axles, clutches, change speed gears, engines, valve timing, firing order, carburetion, cooling, lubrication, ignition, magnetos, electric starters and generators, wiring, lighting, storage batteries, car operation, rules of road, insurance, tires and tire repairing, etc.

Practical Safety Methods and Devices. By George A. Cowee. 434 pages, 6 by 9 inches. 128 illustrations. Published by D. Van Nostrand Co., New York City. Price, $3 net.

Gradually the safety movement is coming to be regarded as an engineering matter in industrial organizations. Conceived with altruistic sentiment, it remained for engineers to design and build machinery free from dangerous, unguarded moving parts, to organize means and methods of handling materials, and arrange shops, mills, and factories with a view to promoting production with the minimum danger to life and limb. This work deals with the organization of safety committees, buildings and fire hazards, fire drills, organization of fire brigades, boilers, engines, elevators, electricity, power transmission, machine tools, grinding machinery, woodworking machinery, common machines, handling and storing material, construction work, railroading, mining and quarrying, explosives, etc. Rules for foremen and general rules are included. A chapter is given on sanitation, illumination, heating and ventilating, and another on welfare work, and still another on occupational diseases. The concluding chapter is devoted to first aid to the injured. The work is a very creditable production, well printed and illustrated. It should receive favorable attention of general managers, superintendents, foremen and others responsible for the safe management of shop, mill and factory workers.

Oxy-acetylene Welding. By S. W. Miller. 287 pages, 6 by 9 inches. 192 illustrations. Published by the Industrial Press, New York City. Price, $2.50.

Ten years ago the oxy-acetylene method of welding and cutting metals was hardly more than a laboratory process, but in the course of these few years it has become one of the most important of the methods in the metal-working industries. Much has been published relating to this process, but a great deal of that which has been placed on record in the past has been descriptive of odd jobs. It is, therefore, believed that the present volume, dealing in a more systematic manner with the principles and practice of the art of oxy-acetylene welding, will be of considerable value to those engaged in the metal trades. The information here presented on the subjects of oxy-acetylene welding and cutting has been mainly furnished by S. W. Miller, proprietor of the Rochester Welding Works, whose wide experience in the practical application of the process, and whose success in the work, vouch for the reliability of the information here placed on record. The experience of the author in the oxy-acetylene welding field has been unusually extensive, but having been mostly on repair work, he has written especially for those engaged in a similar line. A great deal of the work done with the oxy-acetylene welding torch is on repairs, and while there are also a great many applications of it in manufacturing work, such applications are more or less special in each case, and sometimes require a great deal of experimenting before success is attained. The general principles here presented, however, apply equally to repair and manufacturing work. This volume describes the equipment required for oxy-acetylene welding and cutting, deals in detail with methods used in welding cast iron, malleable iron, steel, copper, brass, bronze, and aluminum, and gives, in addition, special attention to the welding of sheet metal, tank welding, boiler repairs, etc., as well as to the subject of lead-burning, which is a special kind of autogenous welding.

Automatic Screw Machines. By Douglas T. Hamilton and Franklin D. Jones. 342 pages, 6 by 9 inches. 150 illustrations. Published by the Industrial Press, New York City. Price, $2.50.

This book deals with five distinct branches of automatic screw machine practice. It covers the design and construction of different well-known types of single- and multiple-spindle machines, the tool equipment used for various classes of work, the methods of adjusting or setting-up machines made by different manufacturers, the design of screw machine cams, and the application of machines of this type to both typical and unusual operations. The descriptions of machines are confined principally to the important fundamental features of the design, and deal especially with those mechanisms which control parts that must operate automatically and in accordance with the nature of the work being produced. The machines illustrated were selected as representative types, each embodying important developments in screw machine design. The various types of tools used for turning, boring, recessing, threading, knurling, etc., are described and the methods of applying these tools are illustrated by practical examples. Different attachments are also described, such as are commonly used for slotting screw-heads, milling, cross-drilling, and automatically feeding separate castings or forgings to the machine from a magazine. Information on the adjustment and setting-up of screw machines is given to supplement the general descriptions and show just what changes are necessary when a machine must be arranged for producing different parts. In dealing with the subject of cam design, the exact method of laying out a set of cams for a given operation has been described in detail, in order to clearly indicate the fundamental principles involved. This treatise is intended especially for the users of screw machines and the designers of tools and auxiliary equipment, and, in order to make it of greater practical value to the men responsible for the economical operation of these machines and the production of parts which conform to required standards of accuracy, many different classes of work and a large variety of standard and special tools have been described in detail.

NEW CATALOGUES AND CIRCULARS

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. Bulletin E-43 descriptive of the Duntley universal electric hammer drill.

Aberthaw Construction Co., Boston, Mass. Preliminary report of the Aberthaw investigation of the effects of vibration in structures.

Standard Tool Co., Cleveland, Ohio. Catalogue 22, containing revised price list of taps and dies, which supersedes the prices given in catalogue 20.

Searchlight Co., 415 Karpen Bldg., Chicago, Ill. Circular advertising Searchlight oxy-acetylene welding equipment and illustrating repairs made by this equipment.

Rhodes Mfg. Co., Hartford, Conn. Catalogue of Rhodes vertical and horizontal shapers built in two sizes, 3½-inch vertical and 7-inch horizontal, belt- and motor-driven.

Link-Belt Co., 39th St. and Stewart Ave., Chicago, Ill. Bulletin of "silent chain" drives illustrating chain drive covers for protecting chains and preventing accidents.

Ott Grinder Co., 32 N. Clinton St., Chicago, Ill. Circular giving specifications for the Ott No. 8 plain grinding machine with a capacity of 5 by 12 inches and wheel 10 by 1¼ inch in size.

De Mooy Machine Co., 1833 E. 55th St., Cleveland, Ohio. Circular of the De Mooy sensitive drilling machine made in two sizes, having maximum drilling capacities of 5/16 and 1/2 inch, respectively.

Manufacturers' Appraisal Co., Cleveland, Ohio. Booklet of scientific appraisals covering the appraisal of machine shops, automobile plants, factories, etc. Copies will be sent free upon request.

Montgomery & Co., 104 Fulton St., New York City. "Odds and Ends" No. 4, devoted to jewelers' tools chiefly, many of which are used by machinists, especially toolmakers doing the finer classes of work.

National Machinery Co., Tiffin, Ohio. National Forging Machine Talk No. 14 describes the making of clutch flange and drive shaft forgings for automobile service on National heavy-pattern forging machines.

Nelson-Blanck Mfg. Co., Detroit, Mich. Circular giving specifications for the Nelson two-spindle adjustable drill head, which is made in four sizes, with capacities for drilling ¼, 13/32, ⅝ and 2⅞-inch holes.

De La Vergne Machine Co., 1172 E. 138th St., New York City. Circular advertising the single-cylinder De La Vergne oil engine, type FH, and comparing its operation with that of primitive pumps in use in China today.

Searchlight Co., 415 Karpen Bldg., Chicago, Ill. Catalogue 12 giving specific information on the welding and cutting of metals by the oxy-acetylene process, and illustrating the Searchlight equipment for welding and cutting.

Henry & Wright Mfg. Co., Hartford, Conn. Catalogue of Henry & Wright drilling machines, with from one to eight spindles. These machines are made in two sizes of 8 and 12 inches, and will drive drills of ¾ and 1⅛ inch diameter.

New Jersey Machinery Exchange, 21 Mechanic St., Newark, N. J. Circular of the "Production" hand surface grinder. The machine, which has a platen 5 by 15 inches and a traverse of 8 inches, uses grinding wheels ½ inch by 6 inches.

Clarage Fan Co., Kalamazoo, Mich. Catalogue of Clarage multi-blade fans, containing capacity tables for the various sizes and styles, taken from actual performance tests, made with temperature of 70 degrees F. and barometric pressure of 29.92 inches.

Excelsior Needle Co., Torrington, Conn. Catalogue descriptive of the Dayton swaging machine, illustrating its construction and some of the work for which it is adapted. Dimensions and capacities of the various machines included in the line are given.

Stow Mfg. Co., Binghamton, N. Y. Bulletin 100, illustrating and describing Stow electric motors.

Bulletin 101 of electric tools, including portable drills, buffers and grinders, "Gee Whiz" machines, screwdrivers, etc. Bulletin 102 of flexible shafting, illustrating various applications.

Foxboro Co., Foxboro, Mass. Bulletins 95, 97, 98, 101, 102 and 103, treating of Foxboro indicating gages, counters and clocks; syphon and mercurial gages; recording gages; radial planimeter; mechanical and electrical time recorders; recording hygrometers or wet and dry bulb thermometers, respectively.

Brown & Sharpe Mfg. Co., Providence, R. I. Catalogue 27 of small tools, comprising micrometer calipers, steel rules, machinists' squares, combination squares, bevel protractors, straightedges, vernier calipers, screw pitch gages, surface gages, thickness gages, standard reference disks, limit gages, wire gages, indicators, spring calipers, milling cutters, etc.

Simonds Mfg. Co., Fitchburg, Mass. Booklet entitled "How to File a Hand Saw," containing information pertaining to the construction and operation of hand saws and the correct method of filing, as well as suggestions on the care of hand saws. Some of the Simonds hand saws are illustrated, for which dimensions and prices are given.

W. S. Rockwell Co., 50 Church St., New York City. Catalogue 31, treating of fuel oil appliances and the fundamental principles which govern the handling and burning of fuel oil. The catalogue illustrates installations of oil-fired furnaces, as well as the line of Rockwell oil and gas burners, fuel oil pumps, blowers, oil strainers, air pressure gages, etc.

New Jersey Foundry & Machine Co., 90 West St., New York City. Catalogue 88, describing the line of hand and electric cranes, monorails, trolleys, hoists, etc., made by this company. Tables containing prices are also included. The book illustrates a number of installations of cranes and other overhead carrying devices in various manufacturing plants.

Munning-Loeb Co., Matawan, N. J. Booklet of the "Safety" buff, polishing and grinding wheel balancing washer, which does away with the hazardous method of balancing by attaching pieces of lead, nails and screws to the light side of a wheel, and enables the operator to balance a wheel perfectly in a very short time. Copy of the booklet will be sent free upon request.

Lincoln Electric Co., Cleveland, Ohio. Catalogue of Lincoln induction motors for two- or three-phase alternating current. The bulletin describes in detail the rotor and stator construction, waterproof and dustproof insulation, and other features. Illustrations show a number of applications of these motors in chemical and paint factories, wood-working plants, bakeries, provision and packing plants, foundries, metal-working plants, etc.

Cincinnati Chamber of Commerce, Cincinnati, Ohio, has begun the publication of "O Cincinnatian" in Portuguese for distribution in Brazil, Portugal and the Portuguese possessions with a view of advertising Cincinnati and her industries. The first number is profusely illustrated with views of Cincinnati's buildings, streets, parks, bridges, etc. The new publication is in charge of A. S. Wilson, manager of the foreign trade department.

Detroit Tool Co., Detroit, Mich. Catalogue of semi-automatic drilling machines and pumps. These horizontal drilling machines are designed specifically for drilling small holes in small work. They are equipped with five spindles and are made in two sizes, the No. 1 machine being designed for very small high-speed work, and the No. 2 machine for a little larger work. Some of the work drilled on these machines is illustrated, and includes valves, small screws, keys, cotter-pins, etc. A table gives the diameter and depth of hole, material drilled, and pieces turned out per hour.

Buckeye Engine Co., Salem, Ohio. Catalogue of power presses formerly made by the Cleveland Machine & Mfg. Co. The catalogue gives dimensions for this line of presses as well as for the Cleveland shears, bending rolls, dies, etc. The Cleveland presses are built in many types and sizes, classified as follows: open-back inclinable presses, punch presses, straight-sided single crank presses, straight-sided double crank presses, gap frame single crank presses, gap frame double crank presses, horning presses, wiring presses, screw presses, knuckle joint presses, cam drawing presses, toggle drawing presses, and notching presses.

Fitchburg Automatic Machine Works, Fitchburg, Mass. New catalogue devoted to the "Radical" automatic multiple-spindle screw machine. The book contains illustrations of the pan, bed, tool-head, cylinder and cross-slide carriage, indexing mechanism, spindles, cams, gage stops, spindle gear-box, oil system and tools, together with the necessary descriptive matter of the salient features of construction. The make-up of the book represents a departure from the conventional form of catalogue. It is bound in imitation wood covers and printed on brown paper, with display type in green. The illustrations are printed separately and pasted on the pages.

Imperial Brass Mfg. Co., 1224 W. Harrison St., Chicago, Ill. "Imperial" welding and cutting handbook treating of oxy-acetylene and oxy-hydrogen welding and carbon burning. This handbook is distributed free to purchasers of Imperial equipment, and to all others the price is $1. The book describes the principles of welding and the operation of the "Imperial" welding outfit. The allowance for expansion and contraction in welding is taken up, as well as preheating agencies, regulation of the flame, preparing the work for welding by beveling or chamfering, and other essential data. The welding of different kinds of metal is treated and information is given on figuring costs. The "Imperial" oxy-acetylene equipment, including welding and cutting torches and oxy-acetylene regulators, is illustrated. The book should be of considerable value to all users of oxy-acetylene equipment.

Diamond Chain & Mfg. Co., 240 W. Georgia St., Indianapolis, Ind. Catalogue of roller chain and sprockets, which also comprises a treatise on chain driving. A new form of sprocket tooth known as the "Diamond tooth form" for roller chain sprockets has been developed by the company, and the advantages of this tooth are set forth in the new catalogue. It is claimed that this new tooth form results in quieter action and longer life for both chain and sprocket. The catalogue treats of the design of roller chains and sprockets, and gives formulas for the calculation of chain lengths, center distance for chain with no slack, pitch diameters, outside diameters, horsepower, chain velocity, sprocket speed, chain pull, maximum allowable pitch and maximum allowable revolutions per minute. A table of useful data for Diamond chain drives is also included. The problem of the selection of proper chain and sprockets for given conditions is worked out and discussed, illustrating the formulas in a clear manner. This book will be sent without charge to engineers, designers and officials.

Hendey Machine Co., Torrington, Conn. Catalogue of Hendey engine lathes, describing in detail the various parts, including the quick-change gear equipment, tie bar headstock, spindle and bearings, double-wall safety type apron, carriage reversing mechanism, automatic stop for carriage, etc. These lathes are submitted to careful tests before shipment, and illustrations show testing the alignment of the spindle, testing cross-slide alignment, testing tailstock spindle and testing the lead-screw. Specifications are given for lathes of 12-, 14-, 16-, 18-, 20- and 24-inch sizes. Geared-head lathes of the same sizes are also illustrated and specifications given. In order to meet the demands of foreign trade, the company provides all sizes of its lathes with metric pitch lead-screw and special gearing when ordered. The catalogue also illustrates various operations performed by means of the relieving attachment, among which are relieving spiral fluted hobs and taps, relieving form cutters, inside relieving, relieving sides of angular cutters, relieving counterbores, etc. Definite information for determining pitch of spiral, selecting gears, etc., for these operations is included. Tool-room equipment for use with Hendey lathes is illustrated, and the line of geared-head lathes equipped with electric motor drive is also shown. This catalogue is unusually comprehensive, well illustrated, and contains much valuable information for lathe users.

TRADE NOTES

Chicago Nut Co. has moved into its new building, located at 2513-2539 W. 20th St., Chicago, Ill., to which address all mail should be sent.

Brown & Sharpe Mfg. Co., Providence, R. I., has opened an office in Pittsburg, Pa., in the Henry W. Oliver building. J. F. Lyon is in charge.

Greenfield Tap & Die Corporation, Greenfield, Mass., manufacturer of screw cutting tools and machinery, gages and reamers, has discontinued its store in Detroit, Mich.

Elgin Tool Works, Elgin, Ill., makers of the Elgin precision bench lathe and special machinery, will erect a large addition to their plant at once, which will double the present capacity.

Munning-Loeb Co., Matawan, N. J., manufacturer of electro-plating and buffing apparatus and supplies, has removed its New York office from 417 Canal St. to the Taylor Bldg., 39 Cortlandt St. The office is in charge of G. C. Backus.

Sleeper & Hartley, Inc., Worcester, Mass., states that the heavy spring coiler which was illustrated and described in the July number of MACHINERY was shipped to France, and was sold through Edgar Bloxham, 12 Rue Du Delta, Paris.

Rockford Iron Works, Rockford, Ill., makers of punch presses, have completed a large addition to their machine shop, which more than doubles the present capacity. It is hoped that this additional facility will enable the company to catch up with its orders.

New Britain Machine Co., New Britain, Conn., gave an outing to its employes at Cosey Beach, Conn., September 19. In addition to paying all expenses of the excursion, including transportation, dinner, music, prizes, etc., the company allowed the men their regular day's pay. An attractive program was printed covering all events and giving the names of competitors, etc.

Rub-On Mfg. Co., Inc., 87-97 Brayton St., Buffalo, N. Y., has changed its name to the Ellis-Smith Mfg. Co., Inc. The management and sales policy will be changed in no way. The change of name was made because the original name no longer applies to the products now manufactured by the company, which are automobile turntable jacks, towing trucks and valve reseating tools.

Crocker-Wheeler Co., Ampere, N. J., announces that its San Francisco district office has been removed from the Crossley building, 619 Mission St., to the ground floor of 87 New Montgomery St. A large assortment of motors, generators and transformers will be carried in stock for the convenience of buyers of electrical equipment on the Pacific coast. W. K. Brown is district manager.

Steel Improvement Co., Cleveland, Ohio, has purchased the plant of the Forest City Forge Co. The two companies will be reorganized under the name of the Steel Improvement & Forge Co., and the manufacture of automobile forgings will be added to the heat-treating business. The officers are W. E. Byrns, president; George H. Chandler, vice-president; W. C. Whyte, secretary; and R. R. Abbott, engineer.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has recently received an order from the Pennsylvania Railroad Co. for a 20,000-K.W., 11,000-volt, 25-cycle, turbine unit, complete with a 24,000-square foot surface condenser and auxiliaries. This turbine is for installation in the railroad company's Long Island City power house which supplies power for the operation of the Pennsylvania terminal and the Long Island railroad.

J. N. Lapointe Co., New London, Conn., gave an outing to its employes August 26, in which over 200 of the workmen and also other guests participated. Early in the day, a large American flag was presented to the president, J. N. Lapointe, by the employes, the presentation being made by J. L. Wheeler. Mr. Lapointe promised the employes that at the completion of the four-story addition now being built on Pequot Ave., the flag would decorate the new building on appropriate occasions.

Imperial Brass Mfg. Co., 1224 W. Harrison St., Chicago, Ill., manufacturer of oxy-acetylene apparatus, reducing valves and brass specialties, has begun the construction of an addition that will increase the floor space 75,000 square feet, making the total floor space of the plant 150,000 square feet. The new building, like the old, will be of heavy mill construction, and will be located on the site adjoining the present plant, corner Harrison St. and Racine Ave., near the "Loop" district.

Sutherland Tool Co., 723 Ann Arbor St., Flint, Mich., is the new name of the Flint Tool Salvage & Machine Co. The company specializes in recutting milling cutters without annealing them. The change of name was made because of the confusion arising from the similarity of name to that of another concern engaged in the same work. The Sutherland Tool Co. has removed its cutting department, which has been run in connection with the machine shop, to a new shop recently completed.

Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill., is building a steel and brick addition to its drop-forging department 50 by 70 feet and a reinforced concrete fireproof building 60 by 130 feet, four stories, to be used for finished stock warehouse, shipping department and offices. These buildings, with the new machinery and equipment to be installed, will largely increase the company's facilities for taking care of its rapidly increasing business. The constantly growing demand for Armstrong tool-holders has made the increase of facilities imperative.

Brennan Engineering Co., 36 W. Randolph St., Chicago, Ill., has been incorporated under the name of Brennan Wahl Co., as mechanical, structural and chemical consulting engineers, and will act as manufacturers' sales and purchasing agents for machinery and allied products. The president is Daniel A. Brennan, patent attorney and designer of labor-saving machinery. Henry R. Wahl, the secretary-treasurer, was formerly construction engineer with the St. Joseph Lead Co., and Andrew G. Schneider, the vice-president, was formerly manager of the Sherardizing Co., of Chicago.

Gronkvist Drill Chuck Co., 20 Morris St., Jersey City, N. J., has moved to the fifth floor of the Locomobile building, 22 W. 61st St., New York City. In the new quarters the concern will have more space to meet the requirements of its growing business in the manufacture of gages. The company has recently been incorporated for $100,000, and is now known as the Swedish Gage Co., Inc. The officers of the company remain the same, and there will be no change in the product or policies. The new name was adopted as being more suitable to the business than the old.

H. E. Harris Engineering Co., Bridgeport, Conn., announces that Franklin G. Hubbard, chief engineer of the mechanical department of the Western Electric Co., Hawthorne, Ill., has become a stockholder and director and has been elected vice-president. Harry E. Harris will devote his entire time to engineering work and the commercial end of the business. In addition to the engineering business connected with the company's special machine tool and gage work, it makes taps, dies, thread gages, ring and plug gages, the Harris precision tapping machine, automatic grinders and notching machines.

CLASSIFIED AND WANT ADVERTISEMENTS

Will be found on page 329 of this issue and will be run in the same relative position in future.

Mechanical Die-Sinking

by

Edward K Hammond[1]

An article in the September, 1915, number described the uses of the duplicating type of die-sinking machine in the production of drop-forging dies. This is the type of die-sinking machine generally employed for making dies used for mechanical products. The reducing type of die-sinking machine has been identified largely with the production of dies used in the manufacture of artistic and ornamental work, such as silverware, coins, medals, etc. The duplicating machine has many important uses in making silverware dies in addition to the purposes for which it was originally designed, and in the same way it has been found that the reducing machine may be used for making dies employed in the manufacture of other products than those with fine ornamental details in their design. Typical examples are found in the manufacture of cutlery, builders' hardware and die-pressed products.

THERE are many lines of manufacture in which the drop-hammer or power press is used to produce a series of parts of the same design but of a variety of sizes. Instances of this kind are found in the cutlery, hardware and other trades; and the manufacture of such series of products naturally calls for the making of dies for each individual part. Formerly, it was necessary for all these dies to be made by hand, and the expense involved was an important item in the cost of production.

For many years the reducing type of die-sinking machine built by the Keller Mechanical Engraving Co., 70 Washington St., Brooklyn, N. Y., was used exclusively for more or less ornamental work—in making embossing dies for silverware, dies used in the manufacture of builders' hardware, and similar products. Recently it has been found that the same principle of die cutting can be used to advantage in making series of dies for the manufacture of these complete lines of work of the same design but of different sizes.

This machine works from a model of larger size than that of the die to be produced, and any desired ratio may be obtained between the size of the model and the work. When this die-sinking machine is employed, it is merely necessary to make a single large model, which may be used for producing a series of different sizes of dies; after the model has been completed, the personal equation is eliminated, the work being reduced to a simple manufacturing process without any of the technical details of die-sinking, such as laying out the work, constant measuring, etc. The machines work more rapidly than the most skillful die-sinker, and a high degree of accuracy may be obtained. All manufacturers who require considerable numbers of dies experience difficulty in securing the necessary number of die-sinkers to handle their work. It takes a mechanic of the highest order to make a really good die-sinker, and men possessing the required ability are more than likely to find an opportunity for better paid employment in other fields of activity; hence, the demand for die-sinkers is normally in excess of the supply.

[1] Associate Editor of MACHINERY.

Making Patterns for Drop-forging Dies and Other Plain Dies

The first step in producing dies for use in the manufacture of a given product is to make a model which can be used on the die-sinking machine for making the various dies that are required. Figs. 2 and 3 show examples of work for which it is necessary to make a series of dies of the same design but of different sizes in order to provide for the manufacture of a complete line of work, and these illustrations show very clearly the requirements which must be met in making models. In the case of the work shown in Fig. 2, the preliminary model would be made of wood, from each half of which a plaster cast would be made; and a metal cast made from this mold would be used as a model on the machine. The object of making the intermediate plaster cast is to bring the metal model made from this mold back into the same condition as the wooden model, *i. e.*, in relief or intaglio, as the case may be. In certain cases, however, the model can be made directly from metal. This is work which can be handled by any pattern-maker. In the case of door plates, as shown in Fig. 3, similar methods are employed; but for work of similar character, it is often advantageous to make the model from sheet metal laminations. These are cut out so that the profile of each piece follows the outline of the work at that level, and when the different laminations are assembled, they form a model which can be used on the machine without the necessity of making a casting. After the model has been completed, the personal equation is practically eliminated from the process of die-sinking, as the use of the machine reduces it to a simple manufacturing operation.

Cutting Lettering and Numbering Punches

An important application of this method of die cutting is in the making of steel lettering and numbering punches. For this

work the model is customarily arranged as shown in Fig. 4, *i. e.*, it consists of the letters of the alphabet or figures arranged in a circle; and the steel blanks for the punches are also carried in a fixture designed to hold them in a circle so that the complete set may be cut at once. A finished set of punches of this kind is also shown in Fig. 4. In this work the possibility of making punches of various sizes from the same model is of particular importance because a whole series of sizes of punches can be made from one model, thus effecting a considerable saving in the cost of production. Models for work of this kind may be made in various ways, but one of the simplest methods is to secure a set of printer's type faces of the desired style and group these in a circle as shown in Fig. 9, so that the required plaster and bronze casts may be made from them.

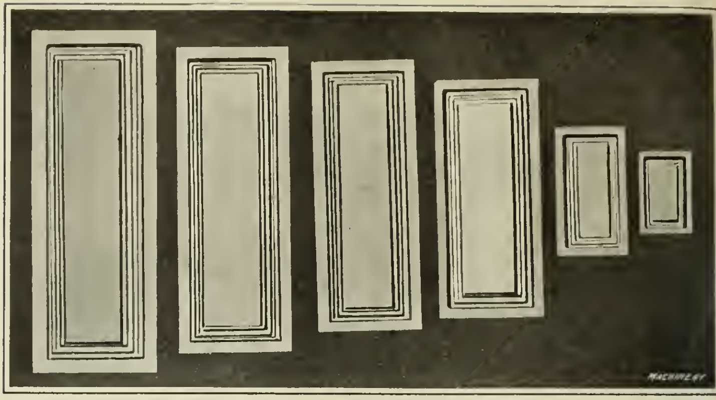

Fig. 3. Series of Door Plates made in Dies cut on Reducing Machine by the Use of a Single Model

In addition to making lettering and numbering punches, the reducing machine may also be used to advantage in making dies required for the production of a great variety of name and number plates used on machinery and for many other purposes. An example of this kind is shown in the illustration Fig. 9.

Making Punches and Dies for Sheet Metal Products

At the left in Fig. 6 is shown a highly decorated part which is stamped with machine cut dies instead of being engraved by hand, which was the original method of procedure. The design is embossed from a sheet metal blank, and attention is called to the fact that both the male and female dies are cut on the machine from models produced from a single wax model. The possibility of making both halves of a die in this way is of particular importance in making dies for many classes of sheet metal work, as it does away with the necessity of raising a force from the die.

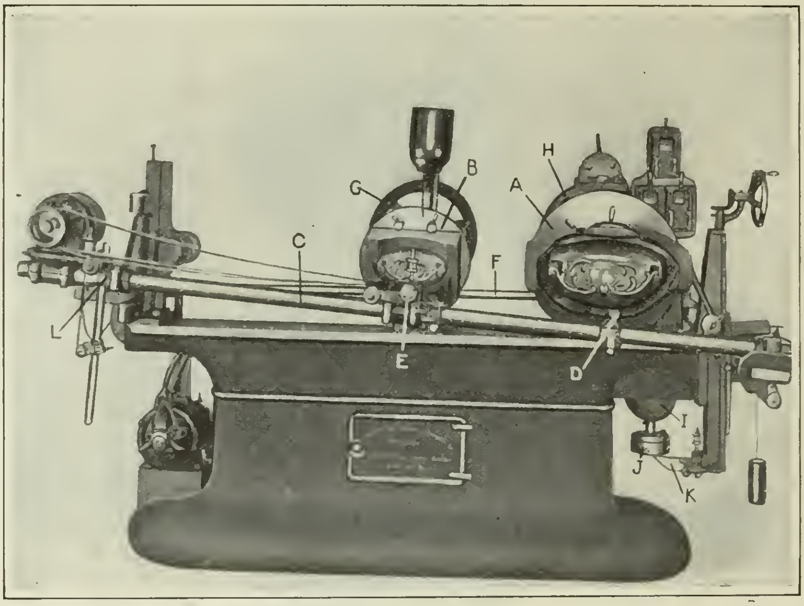

Fig. 1. Keller Reducing Type of Die-sinking Machine

Advantages of Having Model Larger Than Work

In all classes of die cutting done on the reducing machine several advantages are secured through having the model of larger size than the die which it is required to cut. Important among these is the fact that extreme accuracy is easily obtained, because any discrepancy in the model is minimized in making the reduction; also in making a model of relatively large size, it is often possible to work to better advantage than in producing a model of the same size as the work. This applies to both plain mechanical work and ornamental work.

The tracer point is made larger than the cutting tool in the same proportion that the model is larger than the work, and in cases where the pattern is extremely deep or narrow the tracer runs over a large model more easily than it would if the model were made the same size as the work. A case in point is seen in the model that was used in making dies employed in the manufacture of horseshoe calks, a plaster cast of such a die being shown at the right in Fig. 6. It will be evident from the illustration that this die is of considerable depth as compared with the distance across the opening, and it will also be noticed that the sides of the die are relatively steep. By having the model several times larger than the work and using a rotating tracer point and a five-degree cutting tool, very satisfactory results were obtained.

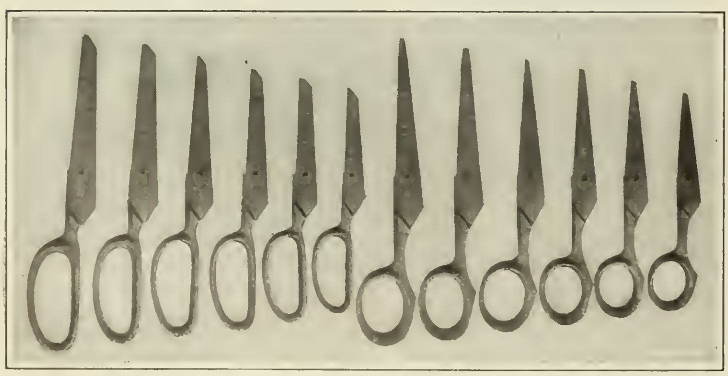

Fig. 2. Scissor Forgings made in Dies cut on Reducing Machine from Two Models

Keller Reducing Machine

A front view of the reducing machine is shown in Fig. 1, and by referring to this illustration in connection with the following description, the operation of the machine will be readily understood. Two revolving

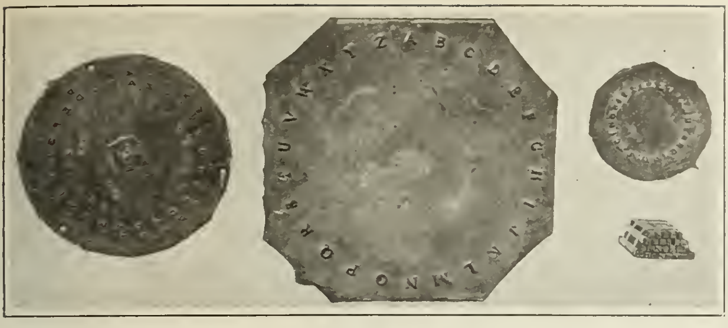

Fig. 4. Models used in making Lettering Punches and a Finished Set of Punches

faceplates A and B are provided on the machine, and the enlarged model is secured to faceplate A while the block in which the die is to be cut is carried by faceplate B. Bar C carries a tracer point at D, which moves over the face of the model, and a rotary cutting tool at E, which cuts the die. This bar C is carried by a double-pivoted support at its left-hand end, which allows the bar to swing in and out as the tracer point moves over the contour of the revolving model, and also permits the bar to swing in a vertical plane as the tracer point and tool are fed down from the center of the model toward the periphery. It will, of course, be evident that the cutting tool moves in or out from the work as the tracer point passes over low or high spots on the model, and that this action, in conjunction with the rotation of the work and feeding of the tool from the center to the periphery, results in the reproduction of the model in the die-block. To make the in and out movement of bar C, caused by the contact between the tracer point and work, as easy as possible, the right-hand end of bar C is supported by a roller. The relative size of the work and the model is determined by the ratio of the distances of the cutting tool and the tracer point from the pivot about which the bar C swings. Faceplate A occupies a fixed position in relation to bar C, while faceplate B may be adjusted to provide for obtaining the required size for the work. At the back of the machine there is a scale divided into 1000 spaces, and the center about which faceplate A rotates is located at a distance of 1000 units of length from the pivotal support of bar C. Then by setting faceplate B at the required distance from the pivotal support, the work may be produced in a given proportion to the size of the model. By reversing the positions of the work and model, *i. e.*, placing the model on faceplate B and the work on faceplate A, an enlargement can be made instead of a reduction. This practice is sometimes followed when it is desired to make model enlargements in plaster or wax.

Fig. 5. Model-making Department of Keller Mechanical Engraving Co.

Operation of Die-sinking Machine

In order to present a comprehensive description of the way in which the machine operates, it will first be necessary to enter into a somewhat more detailed description of its mechanical features than that previously given. It will be seen that two motors are employed. The motor which drives the rotary cutting tool (and rotates the tracer point in cases where the use of a rotating tracer point is required to run over a model where there are abrupt changes in contour) is mounted on a bracket clamped to the end of bar C. This mounting of the motor is necessary in order that swinging of the bar may not result in variations of the belt tension, which would seriously impair the free movement of the bar C and the driving efficiency of the belt. The second motor is mounted at the left-hand end of the machine, and is used to drive the faceplates A and B, and to actuate the feed mechanism which moves the tracer point and cutting tool from the center out toward the periphery of the pattern and work, respectively. The two faceplates are driven by worms on the horizontal shaft F, which mesh with the worm-wheels shown at G and H.

To provide for feeding the tool out from the center to the periphery of the work, horizontal shaft F transmits power to a vertical shaft which runs down through the gear-case I. This case contains an arrangement of back-gears which may be engaged for slow feed motions, or the drive may be carried direct for operating on work where a fast feed can be employed. Below the gear-case, there is a disk J which carries two adjustable crankpins to which the links K are connected. The crankpins may be adjusted on disk J with relation to the center of rotation so that any desired throw is obtained. Links K make connection with a vertical feed-screw which lowers the bracket that supports the right-hand end of bar C. Links K have an oscillatory motion, so that on the forward stroke one of the links rotates the screw, while the other link rotates the screw during the return stroke. By setting the crankpins on disk J at the required

Fig. 6. Sheet Metal Product where Male and Female Die were made from Same Wax Model; and Work where Depth of Die made Enlargement of Model an Advantage

distance from the center, a suitable rate of feed may be obtained for the work being handled.

In cases where the design to be cut is round or square, it is feasible to have the tracer point follow a continuous spiral in passing over the work. In other cases the work may be of oblong or irregular outline, so that the tool would only be cutting during part of each revolution, and to have the faceplate revolve continuously on such work would result in the loss of much time. To avoid this, stops are provided at the back of faceplate *B*, which trip a switch governing the reversing motor at the left-hand end of the machine, which drives the faceplates and feed mechanism. This causes the direction of rotation to reverse after the tracer point has passed over the model, so that it immediately starts back in the opposite direction, with the result that there is no loss of time. The tracer point and tool are fed out from the center of the model and work at a uniform rate, but it will be evident that the cutting speed would increase considerably as the tool moved out from the center toward the periphery of the work if the speed of rotation were maintained uniform. To prevent this, a variable-speed mechanism is provided which automatically reduces the speed as the cutter moves out from the center, so that a uniform cutting speed is maintained.

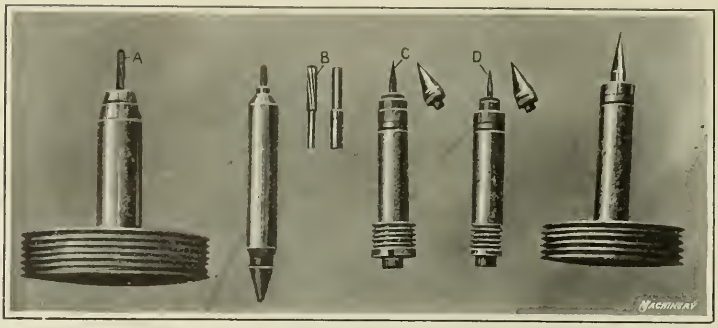

Fig. 7. Roughing, Intermediate and Finishing Cutters and Tracer Points

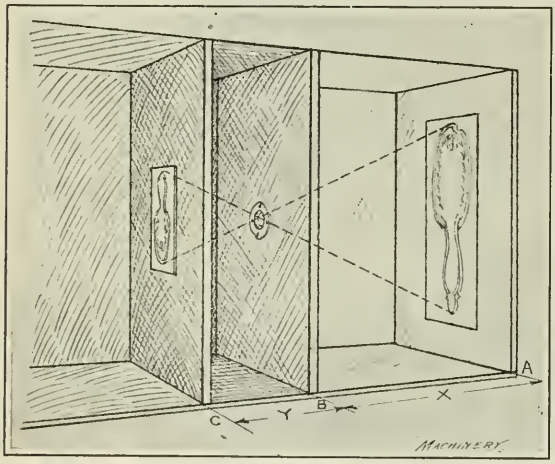

Fig. 8. Camera-obscura used in reducing Drawings to Required Size

Cutting Tools and Tracer Points

When the model and die-block have been set up on the machine, and the position of faceplate *B* has been adjusted to produce work of the required size, the machine is ready for operation. It is usually necessary to take roughing, intermediate and finishing cuts in order to complete the work. The roughing out or "hogging" cut is generally taken with an ordinary end-mill, while the intermediate and finishing cuts are taken by special cutters, examples of which are shown in Fig. 7. In each case the form of the tracer point is the same as that of the tool used in connection with it, but it varies in size in the same proportion as the model and the work. After the finishing cut has been taken, all that is required is to go over the die by hand to clean up any rough spots and remove all tool marks. The dies produced are extremely accurate, and not only avoid loss of time due to the failure of drop-forgings to fit in fixtures used for subsequent operations, but also reduce machining time by cutting down the amount of metal to be removed to a minimum.

Repairing Worn Dies and Replacing Broken Ones

In addition to the advantages secured through using machine made dies, to which reference has already been made, mechanical die-sinking is the means of enabling dies to be repaired very rapidly. In case a die has become too deep, it is set up on the machine and a cut is taken over the top face to remove an amount of metal slightly in excess of the error in depth of the die. Then a finishing cut is taken, using the regular model to guide the cutting tool. Dies made of good steel can be annealed and refinished in this way two or three times.

Fig. 9. Examples of Lettering done in Dies made on Machine

Mechanical Production of Dies

In making embossing dies used in the manufacture of silverware and other products where there is a great deal of fine decorative work in the design, it would be impracticable in many cases to make a model of the same size as the work. For dies of this kind, the reducing machine is extremely useful, because the model can be made large enough to enable all details of the design to be of sufficient size so that they can be accurately produced; and then this model can be used, with a proper setting of the machine, to enable the desired degree of reduction to be obtained. The machine is very accurate, and if a powerful magnifying glass is used to look at small work of intricate design, which has been produced from a large model, it will be found that each detail shows up with almost absolute precision. It was for handling work of this nature that the reducing machine was originally developed, and its application in making dies for use in the manufacture of silverware, etc., is well known in that trade. But there are many readers of MACHINERY who have never had an opportunity of visiting plants engaged in such lines of manufacture, and they will doubtless be interested in the following description of the way embossing dies are produced.

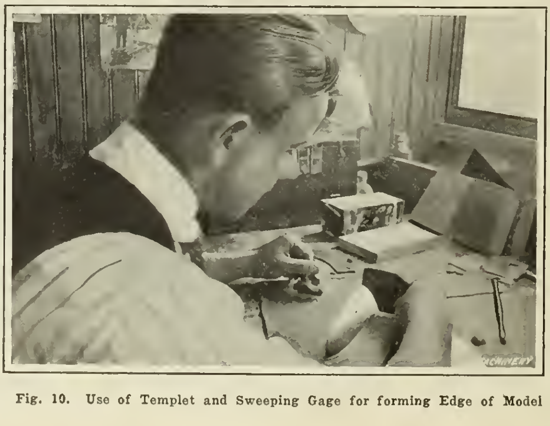

Fig. 10. Use of Templet and Sweeping Gage for forming Edge of Model

Making the Drawing for the Model from which Dies are Produced

In making a model for an embossing die which is to be produced on the Keller reducing machine, it will be obvious that the first step is to make a drawing. Where there is any appreciable amount of intricate detail on the work, it is advantageous to make this drawing of considerable size, and, in fact, this is desirable in most cases. After the preliminary drawing has been completed, it will be required to make a drawing of the actual size of the model, and for doing this part of the work an ingenious application of the camera-obscura principle has been made in the Keller factory. This arrangement is shown diagrammatically in Fig. 8. Its essential features consist of a model board *A* upon which the original drawing is tacked up; a fixed screen *B* in which a lens is mounted; and a ground-glass screen *C* upon which the image of the drawing is projected. The entire outfit is housed in a room with light-proof walls, and the walls of the room at the front of screen *B* are painted white, this part of the room being illuminated by a flaming-arc light. Behind screen *B*, the walls of the room are painted dead black to cut off reflected light as far as possible. Ground-glass screen *C* is mounted on a truck on which the operator sits, and the position of this truck in relation to screen *B* may be adjusted by turning a handwheel. Model board *A* is also mounted on wheels, and the distance *X* from this board to screen *B* can also be adjusted by means of a cord which runs over a set of pulleys and extends back within reach of the operator.

Fig. 11. Impressions from Spoon-handle Dies used in making Souvenir Spoons for Distribution in Moving Picture Theaters

In order to get any definite relation between the size of the original drawing and the size of the image which is projected on the ground-glass screen *C*, it is merely necessary to adjust distances *X* and *Y* so that the ratio of *X* to *Y* is equal to the ratio between the size of the drawing and the required size of the image. For instance, suppose it is desired to obtain an image 6 inches high from a drawing which is 24 inches high. The setting will be in the following proportion:

$$\frac{X}{Y} = \frac{24}{6} = \frac{4}{1}$$

Hence model board *A* will be located at a distance of 4 feet from screen *B*, and ground-glass screen *C* will be at a distance of 1 foot from screen *B*. As a matter of fact, this calculation is not made, because the operator adjusts the model board *A* and screen *C* until the desired size of image is obtained, which he determines with a ruler. To make the working drawing, it is then only necessary to secure a sheet of tracing paper in place on the ground-glass screen *C* and make a tracing of the required size, which is used in laying out the model.

Fig. 12. Finishing Dies by Hand to remove Tool Marks

The Keller Mechanical Engraving Co., does an extensive business in making various types of dies, and the arrangement for making the drawings described in the preceding paragraph is ideal for any shop which has a large amount of work to do. Such an outfit occupies considerable space, however, and is naturally somewhat costly to make. As a result, many shops will find it more desirable to use some simple method of reducing the scale of drawings, which will give perfectly satisfactory results, although more time may be required for doing the work. The familiar pantograph device used in drafting-rooms will be found to be satisfactory.

Making the Preliminary Wax Model

After the working drawing has been finished, the next step in the production of the model consists of reproducing the design in wax. The method of procedure will necessarily be governed by the character of the work, but numerous labor-saving devices and short-cuts have been developed to reduce the amount of time required to a minimum. For instance, it sometimes happens that models are to be made for a series of dies, all of which are of the same outline; and it may also happen that the edges of all of these models are to be of a given form. A rapid method of handling such work is to make a sheet-metal templet of the shape of the base of the model and a "sweeping gage" for forming the edge, which is moved around the base of the templet as shown in Fig. 10. The wax, from which the preliminary model is made, is placed upon the templet and worked up into approximately the desired shape, after which the sweeping gage is run around the periphery of the templet, cutting away enough of the wax to bring the edge of the model to the required form.

After this has been done, the modeler can proceed to work from his drawing to finish the model. For the benefit of those who are not familiar with the work of modeling, it may be said that the work is done by hand with a

variety of small spatulas and engraving tools; it consists essentially of hand-carving, and very exact results may be obtained. For instance, the Keller factory has recently been working on a set of dies to be used in making souvenir spoons to be distributed among the patrons of moving picture theaters. These spoons have the likenesses of different "movie" actors engraved on their handles, impressions of these dies being shown in Fig. 11. Photographs of the actors were sent to the factory and the modelers worked direct from these photographs, producing models which were, in every sense, as true to life as the photographs. It will be obvious that the wax model is too soft for use on the machine, and in order to make a model which will stand up under actual working conditions, a plaster-of-paris cast is produced from the wax model; this plaster cast is then used to make a bronze cast, which is the model that is actually used on the reducing machine. In casting the bronze model, great care must be taken to avoid all defects which are likely to appear in castings; but where the necessary precautions are observed, the bronze cast is ready for use on the machine without requiring any appreciable amount of mechanical or hand treatment.


Fig. 13. Store-room equipped with Vertical Racks on which are stored Plaster Casts from All Dies made in Shop

The description of the method of making models would be incomplete without referring to the way in which models of the same design but of different proportions are made up from the same wax model. This is frequently done in the case of symmetrical designs and saves the expense of making a new model in wax. For the purpose of discussion, suppose that it is required to make a part similar to any of the symmetrical designs shown in Fig. 3, but that a different ratio of width to length is required. The size of the model is immaterial, as the required reduction can be obtained by making the proper setting of the machine, but the proportions must be correct. In such cases, the expedient has been adopted of cutting the plaster cast through the center and removing the necessary amount of material so that the required ratio between the width and length is obtained. The halves of the plaster cast are then stuck together again and this cast is used in making a bronze model for use on the machine. While this seems like a makeshift method, it gives very satisfactory results and saves all the labor incident to the production of a new wax model.

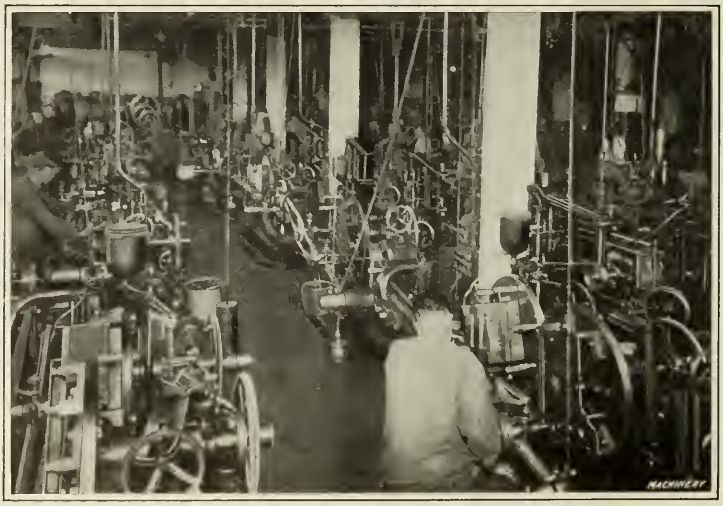
Fig. 14. Reducing Machines in Operation at Plant of Keller Mechanical Engraving Co.

In making dies for decorative work, a certain amount of latitude is allowed in setting the machine to obtain the desired effect. For instance, in making a set of embossing dies, it may appear that too much relief is being obtained to give the desired appearance to the work. In such a case, adjusting the longitudinal position of face-plate *B*, Fig. 1, on the machine bed would result in changing the relief, but this would also make a corresponding change in all other dimensions of the work, which would be out of the question. To overcome this difficulty, an adjustment has been provided which permits of changing the position of the center of oscillation about which bar *C* swings in a horizontal plane without moving the center of vertical oscillation. This enables a greater or lesser amount of relief to be obtained on the work without making it necessary to change the other dimensions.

Conclusion

In MACHINERY for September, 1915, an article entitled "Mechanical Production of Drop-forging Dies" explained the use of the Keller automatic profiling machine used for this purpose. Readers of this article will recall that the machine referred to is used for producing work from a model of the same size as the work. The advantages of the reducing machine in making a series of different sizes of dies from a single model and in handling work where there is a great deal of fine detail in the design have been explained in the present article; but there are relatively few classes of work handled on the automatic profiling machine which cannot be done with almost the same facility on the reducing machine. For this reason, manufacturers who desire to use their machines for a variety of work, but who do not have enough work to keep one or more machines of each type busy, will find that the reducing machine is best suited to their requirements.

* * *

EXPLOSIONS

An explosion is almost certain to be very serious. Like nearly every accident, explosions are the result of not thinking or knowing what will happen. Here are some things that cause explosions in shop work: (1) Pouring hot metal on a wet spot. When hot metal strikes any liquid a violent explosion takes place. (2) Sparks flying from a welding machine into a small can of gasoline. Always keep gasoline well away from sparks or fire of any kind. (3) Turning gas on in a furnace too long before lighting. Be absolutely sure you know how to light a furnace before attempting to do so.

MAKING A SANITARY TRAP

BY ERNEST A. WALTERS[1]

The making of a sanitary trap tube is one of the many difficult operations encountered in tube working, and must therefore be developed with care, judgment and patience until the proper tools have been found for making a particular piece of work. Referring to Fig. 1, *B*, *C* and *D* show the sequence of operations on the tube *A*, which is made from 16 gage seamless brass tubing. The first work on the piece is cutting it to length in an ordinary tube cutter and then bending in two separate operations, after which the piece is finished by putting it through an opening-up die and driving balls made from high-speed steel through the tube with a hardened tool steel plunger. The first five balls used to open the tube at the radius which has collapsed during the previous bending operation vary from ½ to 1⅛ inch in diameter.

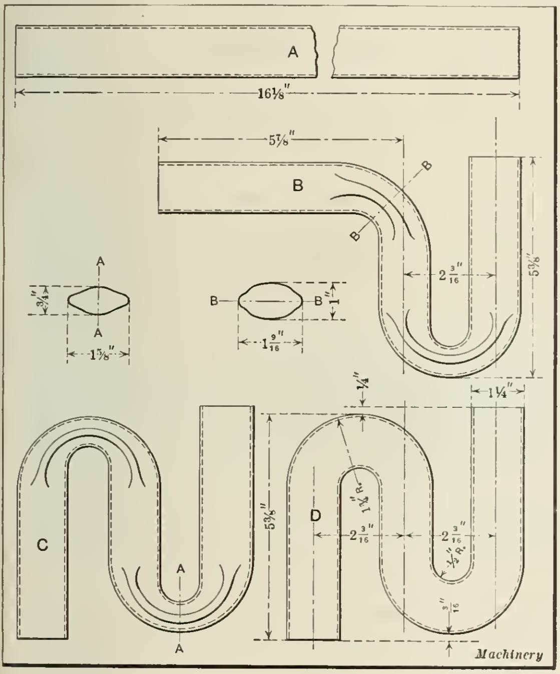

Fig. 1. Various Steps in bending Pipe for Sanitary Trap

First Bending Operation

Fig. 2 shows the bending die used in the first operation, which is that of bending the tube to the form shown at *B* in Fig. 1. *A* is the punch shoe and *B* the die shoe, both of which are made of cast iron. Proper alignment is insured by the guide pins *C* piloted in the guide pin bushings *D*. The punch *E* is dovetailed in the shoe *A* and is held in place by fillister-head screws *F*. The die *G* is made in sections, seated in the shoe *B*, and secured by the screws *H* and pins *I*. The pressure pad *J* receives the proper tension from the springs *K* on the rods *L*, which is transferred to the plate *M* that moves up and down on the guide pins *N* and supports the pressure pad. Care must be exercised to put the proper tension on the pad *J* in order to prevent the tube from collapsing at the bending point. The hole *O* is for fastening the punch shank in the press ram. The tube is shown in place at *X* ready for the bending operation.

Second Bending Operation

Fig. 3 shows the method of bending the tubing for the second operation in which it is shaped to the form shown at *C* in Fig. 1. The punch shoe *A* is made of cast steel and the die shoe *B* of cast iron. The die and punch are aligned by guide pins *C* in bushings *D*. Punch *E* is made from hardened tool steel and is secured by the screws *F*. The bending die is made in sections of hardened tool steel which are held in position

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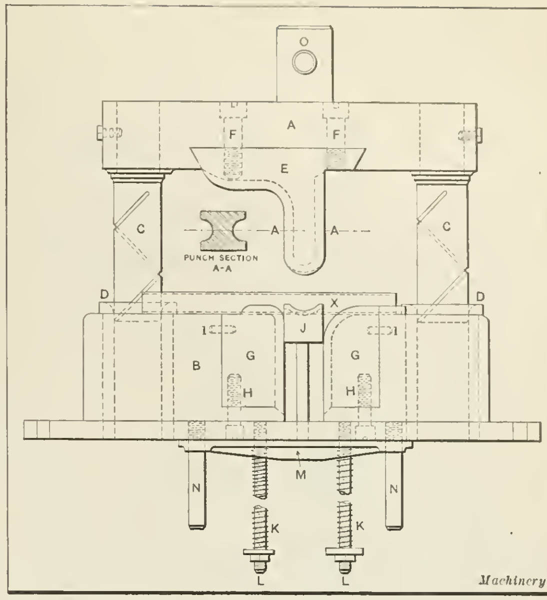

Fig. 2. First Bending Punch and Die

by screws *G* and pins *H*. Pressure pad *I* is supported by pins *J* which rest on the plate *K* and are given proper tension by the rubber buffer *L* held in place by the bolt *M* and adjusted by the nut *Q*. *P* shows the tube in place, ready for the bending operation.

Third Bending and Opening Operation

The third operation on the piece is shown in Fig. 4, in which the tube is formed as shown at *D* in Fig. 1. In this case *A* is the tool steel hardened punch, and *B* the cast-iron die shoe. The die *X* is made from tool steel and hardened. The die sections are opened and closed by means of the cam lever *C*, assisted by the spring *D* in the die and the pin *F*. The chute *E* carries the discharged balls *G* into a separator placed at the end of the tube so that they automatically arrange themselves in position for the operator to handle when opening the next piece. The upper view shows the tube in position with the balls *G* being driven through the first radius by the ram operating the plunger *A*.

It is obvious that the tube *D* in Fig. 1 must be opened grad-

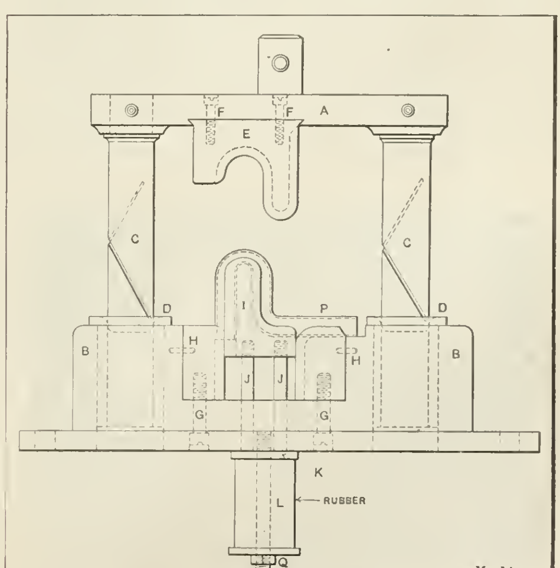

Fig. 3. Second Bending Punch and Die

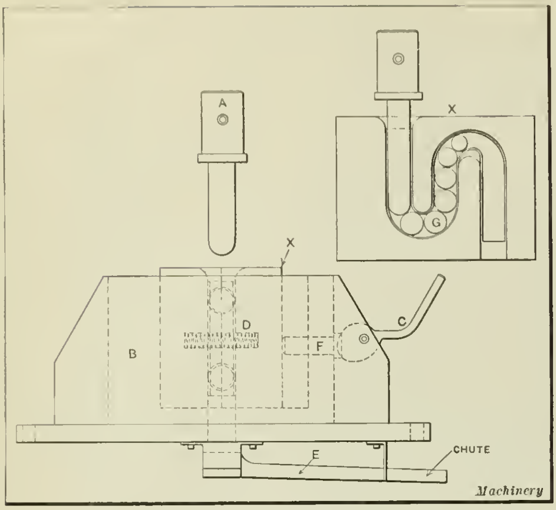

Fig. 4. Method of opening up Pipe after bending

ually, and therefore the balls used in this operation are made in step sizes. Before forcing the balls through the tube, the tube is dipped in a solution of water, oil and soap, thoroughly mixed, after which it is placed in the die as shown in Fig. 4. This die is closed by means of the cam lever *C*, and the first five balls, arranged in the order shown, are quickly dropped into the tube, the plunger forcing them into the position shown in the upper view. It will be seen that the punch advances the balls past the first radius in the tube, so that it gradually commences to open; as the plunger is withdrawn on the return stroke of the ram, five more balls 1/32 inch smaller than the inside of the tube are deposited in the tube, and the punch descends, driving the first five balls through the second radius, which is thus gradually opened. This process is repeated with four more balls 1/32 inch smaller than the tube, which drive the large sized balls completely through the tube and bring it up to size. The completed tube can then be removed and another inserted in its place.

* * *

CASTING BRASS AROUND STEEL TUBING

To cast a perfect brass casting around a piece of steel tubing without injury to the tubing and in a manner which insures a tight connection between the two is the unusual operation described in the following. This casting, an enlarged view of which is shown in Fig. 2, is a control lever fitting on the handle-bar of a motorcycle. After being machined as shown, it forms a foundation on which to attach the several control levers of the motorcycle. The cast-iron mold shown in Fig. 1 is made in two parts, one of which is stationary, and the other movable to permit of the removal of the casting when cooled. The movable half of the mold is operated by a long hand-lever which, in turn, is attached to other levers forming a toggle link action. Some ingenuity was used in making the mold. Originally a model of the casting was made of plaster and attached to a piece of tubing. Around the model was cast the mold in cast iron. They were then smoothed up on the inside.

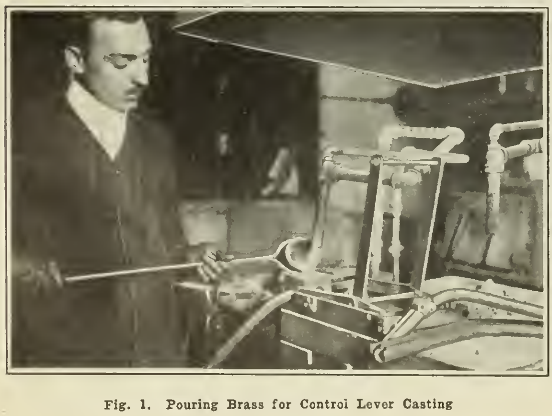

Fig. 1. Pouring Brass for Control Lever Casting

In operation, the movable mold is drawn back by the hand-lever, one of the handle-bar tubings is placed in the mold, and the mold is closed. Following this, the mold is heated to a red heat by the inverted torch shown. The handle-bar tube is also heated to a red heat. Two small crucibles of the type shown are constantly kept in a furnace with just enough molten brass in each crucible for the casting. Two men are generally employed on the operation, and after it is once started, one of the crucibles is heating while the other is being poured. The molten brass is poured through a small hole at the top of the mold.

Cooling takes place almost immediately. The part of the handle-bar tubing which comes directly under the brass casting is previously roughed with a file so that a surface will be afforded for clinging. The machining operations on the castings consist of drilling, counterboring and tapping.

It was in 1912 that this fixture was first made and tried out at the Schickle Motor Co., Stamford, Conn., and it has

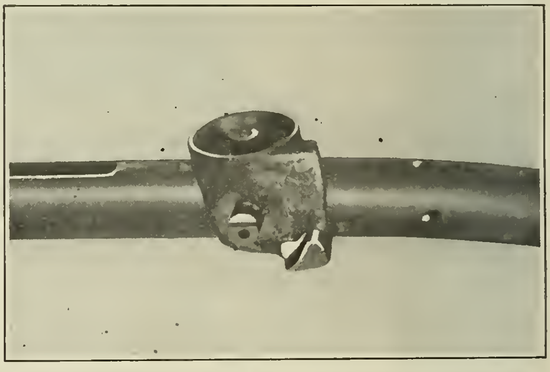

Fig. 2. Machined Casting showing Portion of Handle-bar

been successfully used ever since. Over a period of approximately four ten-hour days, two men have made 360 castings with ease, including the setting up and the removal of all the apparatus.

Applying the casting in this manner gives a firm foundation for the control levers and constitutes a simple way of performing an otherwise difficult job. V. B.

* * *

NATURAL FREQUENCY OF VIBRATION

The Aberthaw Construction Co. of Boston, Mass., has published a pamphlet entitled "The Effect of Vibration on Structures," which is a preliminary report of an extensive investigation carried on by Walter B. Snow for the Aberthaw Construction Co. Reference is made to the natural frequency of vibration of structures as follows:

> Every part of a building—beams, floors, columns, walls, etc., in fact the entire building itself—has its natural pitch of periodic number of vibrations which will result when it is set in motion. If the cause be intermittent and of a different frequency from that of the structural features, the result will be a breaking up of vibrations except for those intervals when they get in step; then the natural action will be exaggerated.
>
> The effect of coincidence between the natural frequency of vibration of a floor and that of its source of disturbance is well illustrated by the following experience in connection with the testing of a small engine upon a floor of timber construction. At a speed of about 550 revolutions per minute, the intensity of the floor vibration was so great that it was impossible to work in the drafting-room located on the same floor more than 100 feet away. But this effect entirely disappeared when the speed was either increased or decreased about 50 revolutions per minute. When the disturbing force is represented by a number of machines running at practically the same speed, the effect may be like that of dancers upon a floor or soldiers marching over a bridge, and prove most destructive to the entire structure or most disordering to its contents or occupants if the step time coincides with its natural pitch.

ORIGINATION VERSUS IMITATION IN DESIGN

BY R. H. McMINN[1]

The writer received his first instruction in mechanical drawing from a man employed as designer by a large manufacturer. This teacher's answer to the question as to how a person could most easily become a successful designer was, "Imitate other designs." The thought of being obliged to become an imitator was quite disappointing, so he secretly resolved not to follow this counsel. Later, when attending a technical college, the writer thought that when he entered upon commercial work he would be able, using the fundamental principles, to develop with great freedom new mechanisms for any desired end. During nine or ten years of practical experience, however, he has had cause to modify some of his early views.

Given the task of designing a machine to accomplish a certain result, an early reluctance to study and imitate known designs of that class of machines was partly due to a desire to accomplish the same result by means not used before because of the personal satisfaction which comes from originating. It was also due to a sort of sentimental disinclination to willfully copy the work of others as closely as is legally allowable. This attitude was perhaps rather inconsistent in view of the fact that everything learned up to that time was the result of other's work—all by instruction or from books; nothing by original investigation in new fields. But he had pictured the work of the mechanical engineer to be, for the most part, that of an inventor, and thought that to study and try to remember the maximum possible number of mechanisms used in various fields would operate against the cultivation of the inventive instinct.

Because of such opinions the writer failed to study books and current technical literature at the time when a man is perhaps best fitted to get the most out of reading with the least expenditure of energy—that is, when just out of school, for he has then a more intimate knowledge of mathematics than he will ever have again. A great many engineering graduates make the same mistake by thinking they are through with books and assuming that their main advancement thenceforth will come automatically from practical experience. But just at this time a varied reading of technical literature, properly chosen, can greatly increase a person's rate of advancement; for it is largely the lack of knowledge of minute details of design and manufacture which causes men fresh from school to be considered inexperienced. For this reason, technical schools should use text-books which are thoroughly up-to-date, so that the student may be drilled in the fact that he is studying not only principles but their embodiment in examples of the best American practice down to the smallest details.

One learns in a technical school the fundamental principles of chemistry, physics, mechanics, mathematics, and drawing, but becomes acquainted in a comparatively small degree with the practical application of these sciences to machine parts. When later the graduate is required to design a machine to accomplish a certain result, he must, if working independently, choose between the alternatives of using only his knowledge of basic principles and the few machine elements with which he is acquainted as the basis for design, or of finding out what others have done in some similar machine.

Theoretically, perhaps, the fewer machine details with which the inexperienced man is familiar, the wider opportunity there is for developing his resourcefulness in design. But when a person enters commercial work, the cultivation of his ingenuity must be incidental to his main activities. It takes more time and money to develop devices when one starts with a knowledge of a comparatively few simple mechanical forms, so that financial considerations demand that one learn as many as possible of the details which are applicable to the work at hand. The shapes of apparently minor machine details are determined by principles discovered in actual manufacture and operation. If a man does not know the approved forms of the details of the machine he is designing, he probably knows only a few of the principles involved. Certain forms come to be looked upon as good practice in a certain line, and if these are adhered to the machine is easier to sell than one which contains something strikingly original, but the successful operation of which will possibly be doubted.

Even if one thinks his design for a new machine to be largely original, he seldom compounds it out of purely single elements, but is usually unconsciously making many adaptations from combinations he has seen, however limited his knowledge may be. He gains no more credit for being an unintentional imitator than for being a conscious imitator. He may have given good training to his inventive faculties by working out a few entirely new mechanisms, but the result of his work will probably not be so successful as if he had incorporated as many previously proved combinations as were possible mechanically and legally. It is certainly unwise for the man just out of school to draw mainly upon what he has learned there and upon his imagination for his designs. From the basic mechanisms given in his text-books he can, perhaps, reason correctly concerning the operation of modifications, but he can make a great gain in efficiency if he stores his mind with all the designs he can observe in practice and technical literature.

There are comparatively few positions that offer to the designer the opportunity to use or develop his inventive faculties in sufficient degree to attain maximum advancement through knowledge gained during his work alone. About all most positions offer is an opportunity for one to use and cultivate an ingenuity for adaptation from known designs in his own or other fields. This requires observation and absorption to qualify one as a designer more than it does the ability to originate. A knowledge of the details of construction of a wide variety of machines will enable a person to adapt parts of them to other purposes, to modify them to suit special conditions, or to duplicate them if required, even if the designer has not come into contact with them. He can do this in much less time than when he knows only the fundamental principles of mechanics, in relation to the machine he is called upon to design, and is obliged to rely upon his inventive faculties for working out the details. Employers advertise for men experienced in a certain line far more often than they advertise for men capable of originating new devices. Before one is asked what can be developed for a certain purpose, he is asked what others have done. The more ideas of actual tested mechanisms a man can bring the better the employer likes it. Even an able designer, acquainted only with the general appearance of a lathe and unfamiliar with the details of construction, who should attempt to design one without first making a study of the machine, would undoubtedly produce the same comparatively inferior tool as the early designers.

The writer thought that the ability to originate was the most necessary qualification for success in the engineering world; but now believes that, in most positions, a qualification which is of more value to one's employer, and consequently more lucrative to oneself, is having such an intimate knowledge of machine construction in many fields that it is rarely necessary to originate. If a designer can modify and adapt to his needs some combination of elements previously used and known to have worked successfully, he has made a commercial gain, even if he has not made as great a scientific gain as if he had spent more time and money in evolving a new combination of elements. Also, if a designer is not familiar with the ground already covered in his field, he will probably retrace the steps of others and believe the combination he is developing is new. It should be possible, when one is thoroughly acquainted with a certain line of industry, to avoid the tendency to duplicate designs which he knows, if it be necessary. But he is more likely to avoid duplication than the man who knows nothing of the field, however prolific the latter may be of ideas which he thinks have been unused. Where there is one position in which the ability to originate new forms or mechanical combinations is the prime requisite, there are possibly one hundred draftsmen's or engineers' positions demanding a knowledge of the employer's product, acquaintance with the design of some machine which he wishes to build, and experience in production, erecting or operation. Therefore much of a designer's training should consist in becoming acquainted with machinery used in all fields, in order to modify and adapt known combinations to the work in hand.

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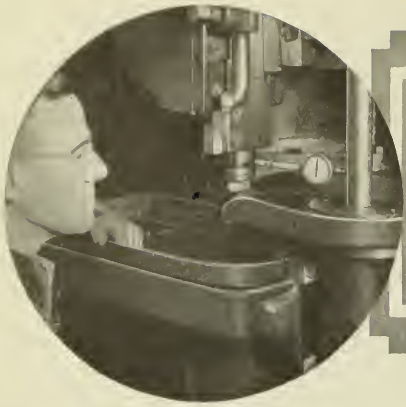


Profile and Indicating Gages[1]-I

by Douglas T. Hamilton[2]

MANY different types of gages have been devised for testing surfaces, measuring shoulder distances, and determining the amount of eccentricity or the truth of cylindrical parts. The ordinary plug or snap gages, while extensively used in interchangeable manufacture, do not indicate the amount of error that exists in the part; they simply determine whether the parts are small or large. The solid profile gage has a similar disadvantage in that it does not show how much the profile of the part is out; on the other hand, properly designed indicating gages can be so applied that any error in the part can be determined with a reasonable degree of accuracy. Gages built on this principle are now being used with satisfactory results in the manufacture of munitions, automobiles, balls and ball bearings, typewriters, adding machines, and many other products which are made by the interchangeable system of manufacture. In the following, different types of gages working on the indicating principle will be illustrated and described.

Templet and Profile Gages

Templet and profile gages which are generally made from sheet steel are used for measuring shoulder distances, profiles of irregular shape, and angles on parts. These gages are usually comparatively cheap to manufacture, and in most cases are sufficiently accurate for the work they are intended to inspect. Take, for instance, the gaging of the over-all length of a shaft as shown at *A* and *B* in Fig. 1. For work of this kind a templet gage can be satisfactorily employed. It should be made as shown at *B*, however, rather than as shown at *A*. The reason for this is that there is less liability of the operator's springing the gage by forcing the work into it. In the type shown at *B*, work which will enter the "Go" end of the templet cannot be forced as easily into the "Not Go" size as in the type shown at *A*. On the other hand, the type shown at *A*, when used with care, has the advantage that there is less liability of the operator's fitting the work to the "Not Go" end, instead of to the "Go" end.

Another case where a combination gage can be used with satisfactory results is shown at *C*. In this case the templet controls the shape of the head as well as its thickness. Although more than one point is being tested by this gage, the work is not usually required to be very accurate, and a templet gage of this nature is satisfactory. Reference to this illustration will show that the work on the "Go" end should bear all over on the gage, whereas on the "Not Go" end it will not go completely down into the slot. Where the thickness of the head from a shoulder is the only point that is necessary to hold accurate, a gage of the swinging arm type is much more satisfactory than the templet form. This matter, however, will be dealt with more fully later.

A simple templet for testing work of angular shape is shown at *D* in Fig. 1. In this case the templet is used to test the diameter of the screw and the thickness and angle of the head. For accurate work, too many points are being tested, but for the average run of flat-head screws a templet gage of this type gives satisfactory results. When greater accuracy is required on work of this shape, a progressive gage covering each individual point would be the most satisfactory one to employ.

Another application of the templet system of gaging in the production of shoulder shafts is shown at *A*, *B* and *C* in Fig. 3. At *A* is shown a templet which is used for controlling the shoulders of one end of the shaft—for the first operation; at *B* is shown the gage for controlling the length of the shoulders on the opposite end of the shaft—for the second operation; whereas at *C* is shown the gage used by the inspector for covering the entire length of the shaft. It is much more satisfactory to supply the workman with a gage of the type shown at *B* for the second operation than it is to supply him with the type shown at *C*. The latter should only be used by the inspector for the reason that as long as the work goes in this gage it is satisfactory. If it does not go in the gage, it is unsatisfactory. This gage is therefore given as wide a permissible tolerance as possible. For the second operation, as shown at *B*, the shoulder *a* would be controlled by the end *b* of the gage. When the length of certain shoulders is required to be accurate, this system of inspection is not recommended, and a limit gage as described later should be employed.

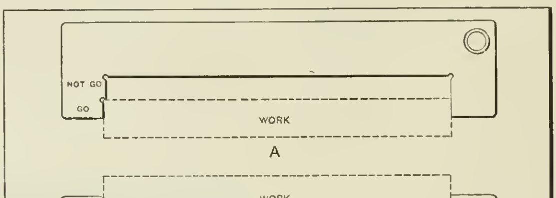


Fig. 1. Diagram illustrating Application of Templet and Profile Gages to Simple Parts

A form of templet gage which is used extensively in the manufacture of engine lathes and other similar machine tools is shown at *D*. This gage is used for testing the angle on the ways of the lathe on which the carriage operates, and at the same time for determining if the center distance is correct. Extremely accurate results are obtained by means of this templet gage in the hands of an experienced operator. Either a feeler or thin piece of tissue paper is used to test

[1] For information on gages and gaging previously published in MACHINERY, see "Gaging and Inspection Methods" in the October number, and articles there referred to.
[2] Associate Editor of MACHINERY.

both the angle and the center distance of the ways. When templet gages of this shape are accurately made and carefully applied, satisfactory results are obtained.

Another application of the templet system for testing the arc of a circle is shown at *E* and *F*. In this case the part being tested is a ring for a ball thrust bearing. At *E* the curve on the lower surface is being tested with a templet, whereas at *F* two knife-edge shaped disks are used to test the center distance of the raceway. Inaccuracy of the work is indicated by light showing between the gage and work, but the gage does not determine how much the work varies from the size or shape required. For this purpose, an indicating gage should be used in preference to the templet form.

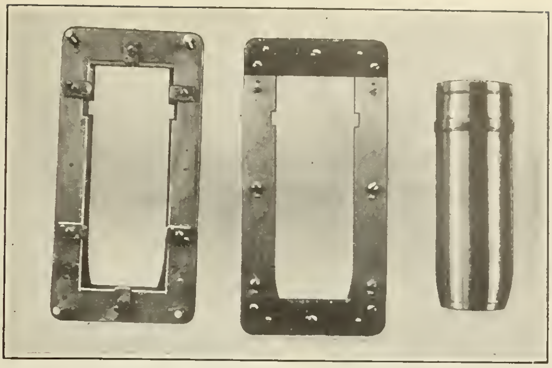


Fig. 2. A Built-up Type of Profile Gage for Russian Shrapnel Shells

An application of the templet form of gage to curve and length measurements is shown at *G*. In this case the piece being tested is the ogive or nose end of a shell. Two points are tested: one is the shape of the nose, and the other the location of the lower end of the bourrelet. It might be mentioned in passing that the bourrelet is the cylindrical portion on the head end of the shell which rests in the gun and is formed by the termination of the ogive and the beginning of the reduction on the body, this being allowed to facilitate manufacture and also prevent the shell from bearing for its entire length in the bore of the gun. In this case it will also be noticed that the templet is so made that it can be used in connection with the limit system of manufacture, having two lines on it, one indicating the minimum and the other the maximum position of the bourrelet. The position desired is, of course, between these two points.

Built-up Templet Gage

A built-up templet or profile gage which was made to supersede one made from 5/32-inch sheet steel is shown in Fig. 2. This is used for the final inspection on a 3-inch Russian shrapnel shell. Work which passes through it is satisfactory, while work which will not pass through it is rejected. The gage is provided with legs which support the outline plates at a distance from the surface plate equal to the radius of the shell. In construction, it consists of a base made from mild stock 5/16 inch thick with a clearance hole of approximately rectangular shape. On one side of this baseplate are screwed and doweled four strips of hardened tool steel which form the gage proper. It is also provided with six bumper pieces attached to the lower side of the gage body. These bumpers are tapered back so as to form a bell-mouth and locate the shell approximately as it is about to enter the gage. When the profile of the gage wears, any one of the four strips is moved inward, correctly placed, and then the dowel holes are re-reamed for a slightly larger dowel-pin.

Limit System Applied to the Gaging of Shoulder Distances

Fig. 4 shows a gaging device for inspecting shoulder shafts, that works on the limit principle. This gage consists principally of a base *A* carrying a V-block *B* in which the work is clamped by means of a strap *C* and the swinging bolt *D*. The relative locations of the two shoulders is determined by two levers *E* and *F*, respectively, which carry limit buttons of the form shown at *G*. These levers are fulcrumed on one side of the gage on a pin *H*, and fit in slots in the hardened, ground and lapped block *I*. In using this gage, the work is put into the V-block, and the operator holds it with one hand while he moves down lever *F* with the other hand until the shoulder *J* on the work contacts with the "Go" limit on the plug held in lever *F*. The swinging strap *C* is then clamped by means of bolt *D*, holding the work rigidly in position. The operator then brings down lever *E* and tests the location of the second shoulder in relation to the first. In this way shoulder shafts can be held within very close limits when necessary. If the limits were very close, it would be possible for the operator to spring the "Not Go" surface on the plugs past the work, but as in practically all gaging devices the sense of touch is necessary, there is no reason why an operator should apply greater power when he has the leverage to do so than is necessary to bring the measuring surfaces on the gage in contact with the work.

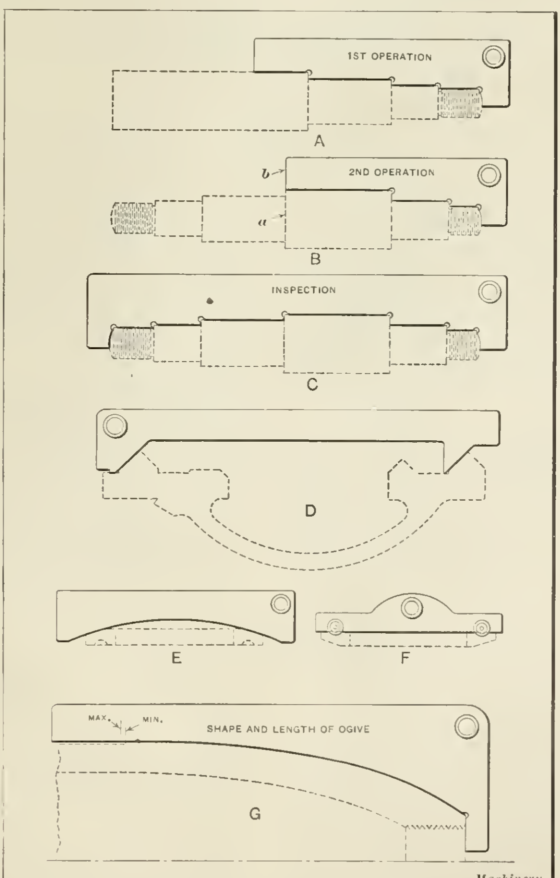


Fig. 3. Various Forms of Templet and Profile Gages

Progressive or Combination Gages

Gages which are used for inspecting a number of points on one particular piece are generally termed combination or progressive gages. One type of gage which illustrates this principle is shown in Fig. 5. In this case the gage is being used for testing the body, over-all length, head, slot and thread of a fillister screw. The only part on which a limit of tolerance is provided is the thread. This is tested in a "Go" and "Not Go" threaded bushing inserted in the templet. Gages of this kind have one marked disadvantage in that as soon as any one position or point on the gage becomes worn, with the exception of the threaded bushings, the entire gage has to be destroyed. For work such as screws which do not require to be extremely accurate, this gage gives fairly good results and is quite extensively employed. When the work demands greater accuracy, however, separate gages should be provided for testing each particular point. This necessitates a more costly outlay, but when very accurate work is essential, the cost of upkeep is less.

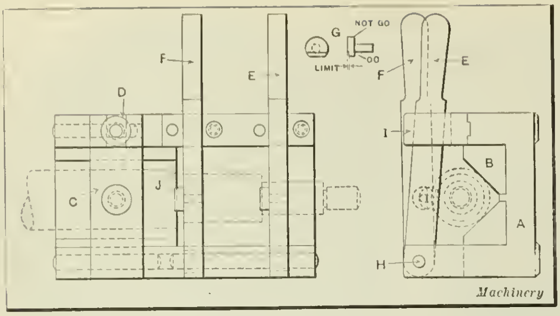


Fig. 4. Diagram illustrating Application of Limit System to gaging of Shoulder Shafts

Progressive Gaging of Cartridge Chamber in Rifle Barrel

Another example which could come under the class of progressive gaging is shown in Fig. 7. This illustrates the tools and gages used in machining and inspecting the cartridge chamber of a rifle barrel. Those experienced in this work know that it is not an easy problem to produce a perfectly chambered rifle, and it requires both a high degree of workmanship and a complete and practical gaging system for its accomplishment. The chart shown in Fig. 7 illustrates the counterbore, roughing and finishing reamers, and also the roughing and finishing gages used for machining and gaging the chamber in a 0.303 Ross military rifle. At first glance it would appear that there is an excess of gages used; however, this is not the case, as the following explanation will show.

The manner in which these tools and gages are used is as follows: The chamber is first roughed out with a counterbore *M* and then gaged at the mouth and in the bore with the gage *A*, to see that the counterbored hole is of the exact diameter and is concentric with the bore in the barrel. (It is necessary that this point be carefully determined, because any eccentricity would be difficult to correct in the following operations.) The chamber is now reamed with a roughing reamer *N* and gaged with the gage *B*. The reamer shown at *O* is then used for finish-reaming the taper and neck and also for roughing the cone diameter. It would be impossible to make one gage so that it would act as a detector for all the various diameters finished by this reamer, and this inspection operation requires the use of gages *C*, *D*, *E* and *F*, the limit lines on which should come flush with the end of the barrel when the reamer is of the correct size and is inserted to the proper depth.

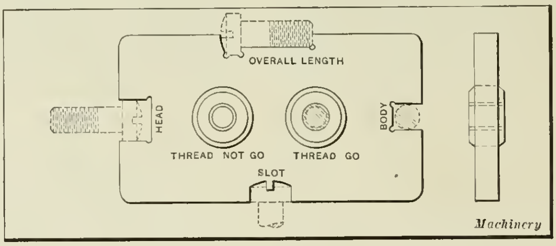


Fig. 5. Progressive Type of Templet Gage for inspecting Fillister-head Screws

This finishes the rough-reaming and respective gaging operations, after which every part of the chamber is again finished with finishing reamers and gaged. The operations accomplished by the reamers *P* to *T*, inclusive, are inspected with the gages *G* to *K*, inclusive, which are made so that a slight change in diameter can be noted by shaking the gage. The reamers *U* and *V* and the gage *L* are used for machining and gaging the lead to the rifling grooves. The lead may be briefly defined as the conical funnel which leads from the chamber to the bore. If the chamber ended abruptly at the beginning of the rifling grooves in the bore of the barrel, the sharp ends of the lands would cut strips out of the nickel jacket case of the bullet and the latter would fly to pieces when it left the muzzle of the rifle. The lead, therefore, must be concentric with the chamber and bore, or else the bullet will be likely to wobble or tumble after it leaves the muzzle. Hence all points along the chamber must be concentric with the bore, and the progressive system of gaging is necessary to obtain the desired accuracy.

Progressive Gaging of Screw Machine Products

The two previous examples of progressive or combination gages illustrate the types in which it is necessary to apply the gage to the work. When a considerable number of points on the work require gaging, and especially when the work is quite large, it is necessary to have a large gage of the type shown in Fig. 5, which is rather bulky to handle. On the other hand, in gaging work like the cartridge chamber in a rifle barrel, shown in Fig. 7, where a large number of gages are required, it necessitates lifting up and putting down each gage once for each barrel inspected. A method of progressive gaging which can be applied with particularly satisfactory results to screw machine products, such as the bicycle wheel hub shown in Fig. 6, is illustrated diagrammatically in Fig. 8. Here the gage consists of a large cast-iron plate, the top surface of which is carefully machined and preferably finished by grinding. It will be seen that various types of gaging points, plugs, swinging members, etc., are attached to the top surface of this plate.

Diameters *A*, *B*, *C*, *D*, *E*, and heights *F*, *G*, *H*, *I* and *J*, Fig. 6, can be gaged in a satisfactory manner as shown in Fig. 8. For instance, for gaging the diameters *A* and *B*, four sets (two each) of carefully hardened and ground blocks are fastened to the plate, the first two blocks in each set being known as the "Go" sizes, through which satisfactory work will pass, and the second set as the "Not Go" sizes, through which work of the required size will not pass. When it comes to the gaging of the hole diameters *C*, *D* and *E*, ordinary plugs are fastened to the surface plate, one being made to go in the hole and the other not to go in. For gaging the depth of the counterbore *F*, the work is placed on a spring plug, as indicated in the section of the end view of the fixture. Here the lower face of the work rests on a swinging arm, and in doing so forces down the spring-operated plunger. When the work is correct, this slips over the "Go" block, but will not go over the "Not Go" block. For gaging the height of the shoulder *G*, the work is let down into the swinging arm instead of on a plug, and the work itself, instead of a hardened plug, passes over the "Go" block when correct, and not over the "Not Go" block when too long. For the gaging of the height *H*, a similar scheme to that used for gaging the height *F* is adopted. For gaging the height *I* and also the taper, the plug is made with a tapered shoulder and the work rests on this taper and is guided near the bottom only by a shoulder on the stud. In this way, the height and diameter of the taper are controlled. For the over-all length, the work is simply passed under a height block; it goes under the "Go" block, but will not enter the "Not Go" block.

The facility with which work can be handled in this manner is remarkable. For instance, an experienced operator could gage all the ten points noted on this particular part in from eight to ten seconds, and when the tolerances on the work are from 0.003 to 0.005 inch, this type of gaging is sufficiently accurate. It is especially advantageous for the inspection of work which after being turned out on the screw machine or turret lathe is heat-treated and then must be finished by grinding. The grinding tolerances, of course, can be provided for on this rough inspection gage. Where a greater refinement is

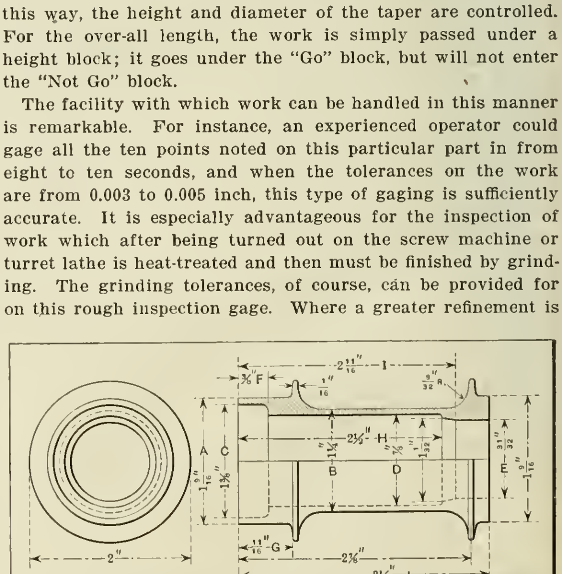


Fig. 6. Bicycle Wheel Hub which can be successfully inspected by Method shown in Fig. 8

iecessary on the work, accurate gages can be fastened at fre-
quent intervals to the top surface of the plate and the gaging
f the parts accomplished. For instance, it would be a simple
roblem to attach any type of indicating gage to a plate in
his manner and thus bring all the gages for any certain piece
ogether, so as to eliminate the necessity of lifting the gage to
he work or moving from one place to the other along a bench.
'his principle, of course, works out very successfully when
he work is comparatively light, clean and free from burrs.

In designing a gaging fixture of this type, it is desirable to
eep the work on the surface plate as much as possible.
'his feature has been adopted because it is simpler to slide
he piece along the plate than
t is to keep lifting it up from
oint to point. Of course
here are cases where this is
mpossible, but the aim in
iew should be to eliminate
s far as possible any feature
which would tend to tire the
nspector. Another advantage
f this type of gage is that
irls can be satisfactorily em-
loyed for the work.

Principles of Indicating Gages

Indicating gages may be
ivided into three distinct
lasses; namely, those em-
loying the sense of touch,
hose depending on sight, and
hose on hearing. These three
ifferent classes, of course,
re subject to considerable
ubdivision, but the main
rinciples involved remain the
ame. Gages which employ
he sense of touch are known
s flush pin or feeler gages;
hose employing the sense of
ight are multiplying lever or
ial indicating and microme-
er gages; whereas those de-
ending on the sense of hear-
ng can be grouped into those
mploying some means of in-
icating by sound when the
art is of the required size,
ension, etc. A common type
f gage employing this princi-
le is an electric gage, in
which a bell is rung if the
iece is O. K.

Indicating Gages Employing Sense of Touch

The most common form of
ndicating gage employing the
ense of touch is the flush pin
ype of gage shown in Fig. 9.
Reference to this illustration
will show that the gage con-
ists of a base A carrying a
racket B and a measuring
pindle or flush pin C. The
orward end of bracket B is machined to circular shape and
s provided on its top surface with a step equal in height
o the permissible tolerance on the work—in this case 0.005
nch. The lower end of spindle C is made sufficiently large
o seat on the counterbored seat in the work. The distance
rom the lower face of this enlarged portion to the reduced
houlder on the spindle is such that when work within
he required limits is being tested, the counterbored seat in
he work will lift the spindle up sufficiently to bring the
houlder on spindle C either flush with the upper or lower
houlder on the boss on bracket B or midway between these
oints. Of course, the desired condition is to have the

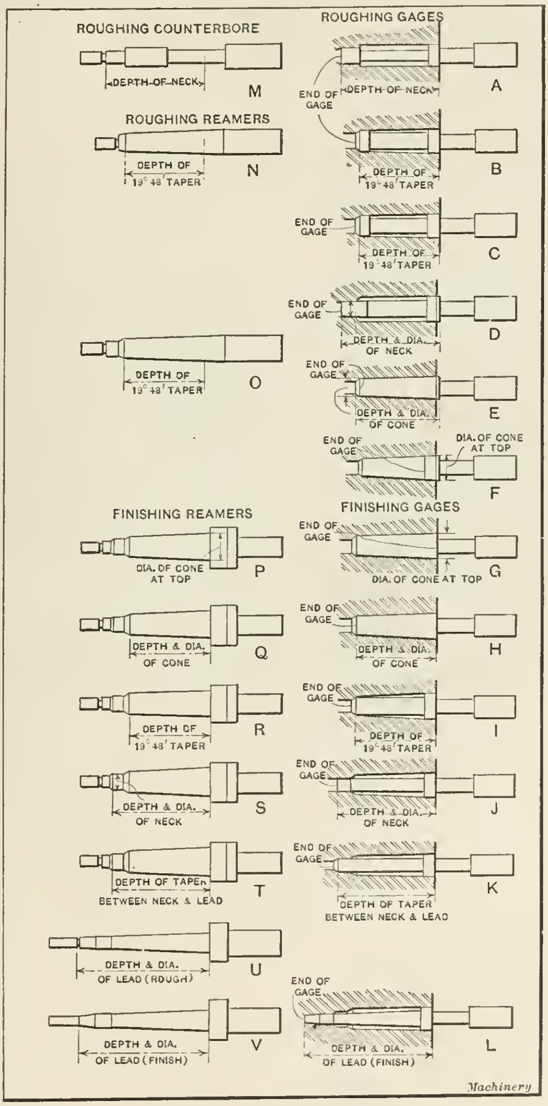


Fig. 7. Tools and Gages used in machining Cartridge Chamber in Military Rifle Barrel, illustrating Another Method of Progressive Gaging

shoulder on the flush pin midway between the plus and minus limits. While 0.005 inch can be seen with the naked eye, it can be detected more rapidly with the finger, so that this type of gage is known as the flush pin or touch type of gage. The sense of touch is much more accurate than most people appreciate, and as a matter of fact, it is possible to detect differences as small as 0.0003 inch.

Another type of gage which depends for its accuracy on the sense of touch or feel is shown in Fig. 10. This gage is used for testing the position of the milled groove on the under side of a bolt sleeve for a military rifle. The sleeve proper is held in a fixture on hardened and ground plugs A, B and C. Plug A is provided with a knurled head and is made a good fit in the hardened and ground sleeve E. Plug B is made with a tapered shank and is held in a hardened and ground taper sleeve by a stud and nut as shown. The sleeve F is provided with a shoulder which abuts against the cast-iron boss on the base D. Plug C is tapered, fitting a hole in the handle of the bolt sleeve, and is driven into reamed holes in the boss on the casting. The inspection is done by means of what is known as a rocker block, which is made from steel, hardened, ground and lapped. This block works on the hardened and ground block G fastened by screws and dowels to the casting D, which acts as a measuring surface for the rocker gage. The rocker gage or block H has three bosses on the sides, two of the bosses on each side acting as supports, while the other boss is made lower than the supporting bosses an amount equal to the tolerance allowed on the work. This gage is also used for testing the height of the shoulder I on the bolt sleeve, the rocker H being located on the hardened and ground block J in a similar manner to that previously described. In applying this rocker, it is laid on the hardened and ground surfaces on the fixture and then moved forward to see if it will pass over the work. The "Go" end passes over the work and the "Not Go" does not, if the work is satisfactory.

A flush pin gage which is used for determining the depth of a slot in a rifle part is shown in Fig. 11. In this case the slot A in the part is inspected by two flush pins B and C which are held in a swinging member D in the bracket E. Swinging member D carries a hardened and ground locating plug F which, when in position for gaging, comes in contact with a hardened and ground plug G in the base of the gage. These two pins insure that the swinging member is always brought to the same position. Then by feeling the height of the flush pins in the swinging member, the depth of the slot is tested; the piece being gaged is held on the base of the gage on dowel-pins, and is ejected after being tested by means of handle H through an eccentric movement.

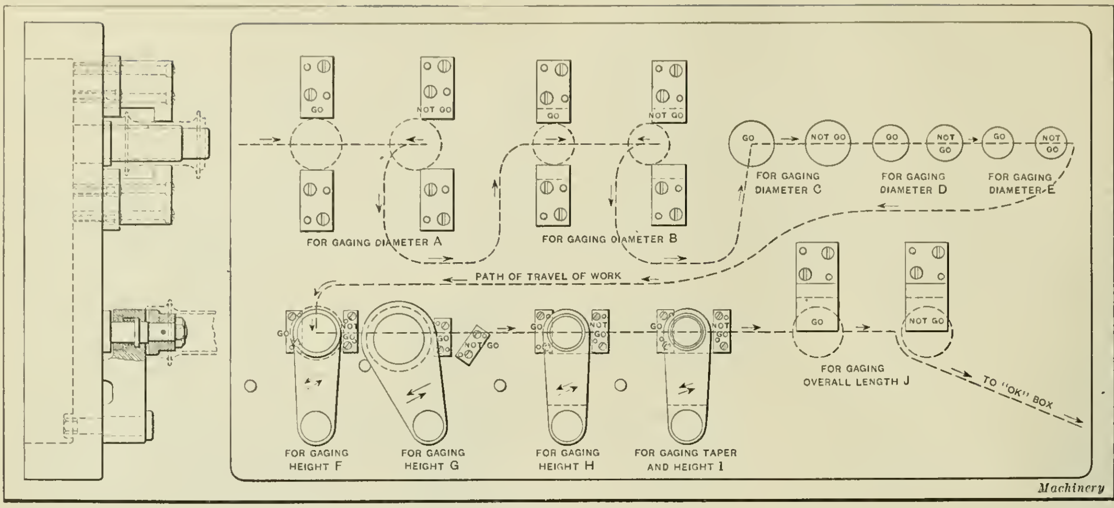


Fig. 8. Progressive Type of Gage particularly adapted for inspecting Screw Machine Products

Indicating Gages Employing Sense of Sight

Indicating gages employing the sense of sight can be roughly divided into five general classes, *viz.*, those of the multiplying lever type; those of the needle and dial indicating type; those employing a micrometer screw; those using the cross-hair microscope in connection with the micrometer screw; and those employing the reflection of light rays.

The average gage constructed on the multiplying lever principle, when used for fine measurements, has several disadvantages, chief among which is the weight of the moving parts. This can be largely compensated for, however, by the correct proportioning and arrangement of the levers so as to balance the weight of the various parts. When set by a master and used simply as a means of comparison, the multiplying lever indicating gage can be satisfactorily employed on a large range of work.

Needle and dial indicating gages are made in several different types, the type employing a train of gears for accomplishing the multiplying movements of the needle being the most common. This form of indicator has several objections which might be summarized as follows:

1. Backlash in the gears due to wear.
2. Fluctuation of the indicating needle.
3. Lack of brake or dash-pot to eliminate fluctuation of the needle.
4. Unequal wear of moving parts—especially gears.

As a rule, a gage of this type is used on one size of work for weeks at a time, with the result that those portions of the gears constantly in mesh wear down much more rapidly than the remaining or unused portions. This unfits the gage for anything but comparative measurements, and it must be corrected and set frequently by means of master blocks.

The fluctuation of the indicating needle is one of the most annoying features of this type of gage. It is due, of course, to the unbalanced action of the parts and, as previously mentioned, to backlash in the gears. For rapid inspection, a gage in which the needle continually fluctuates is of little or no value, and it has been suggested by inspectors that a brake or dash-pot be provided in order to eliminate this objectionable feature. The computing scale is a good example of a measuring instrument employing a dash-pot, and a similar arrangement adapted to an indicating gage of the needle type would greatly increase its usefulness. Unequal wear of the moving parts is also a factor which should receive careful consideration. The number of parts employed in a gage of this type should be reduced to a minimum, so as not only to simplify its construction, but also to decrease the chances for wear and consequent inaccuracy. As will be explained later, other types of needle indicating gages have been devised which do not have the objections previously mentioned.

The micrometer caliper is a type of gage which depends both on sight and touch for its accuracy. The micrometer screw has been applied to many different types of gages, and as will be subsequently described, this type of gage has certain advantages for work which cannot be measured by any other means or which is inaccessible to a regular snap or plug gage.

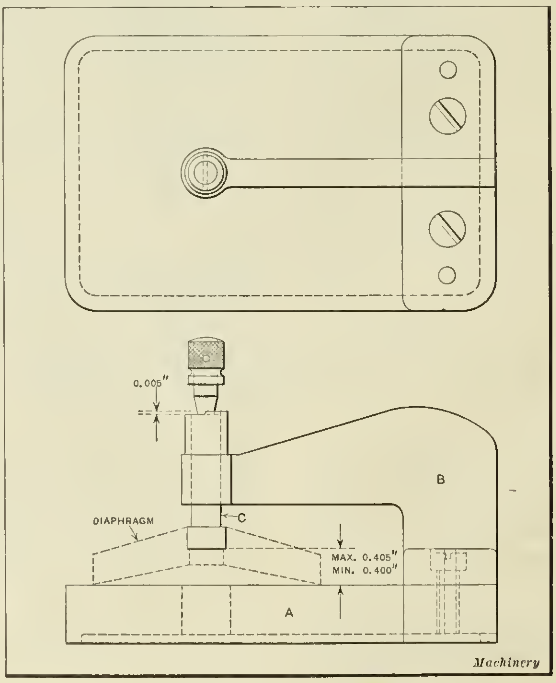


Fig. 9. Simple Indicating Gage of Flush Pin Type

The micrometer screw, of course, furnishes an accurate means of inspecting work, but it is necessary that a gage of this type be frequently checked up to see that the screw is not worn and that the measuring points of the gage are parallel with each other.

The cross-hair microscope in connection with the micrometer screw provides one of the most accurate methods of inspecting small articles, such as type, thread gages, ball races, fly-cutters, etc. The number of industries, however, employing this instrument is not nearly as great as its adaptability would seem to warrant. For many classes of work the accuracy which can be obtained by this method is much greater than that which would ordinarily be required.

For extremely accurate work, gages employing the reflection of light rays have been developed. These, however, are not extensively used

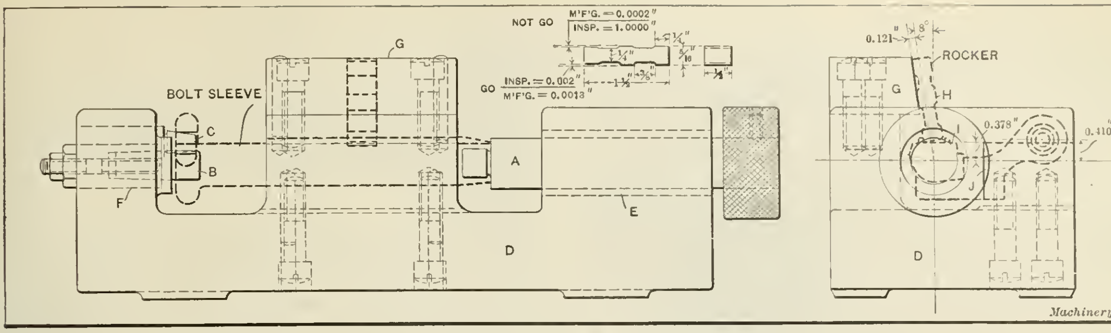


Fig. 10. Example of Feeler Block Type of Gage

and have only been adopted where extreme accuracy is necessary and where a large number of parts must be inspected in a certain time. The light ray presents a rapid means of ascertaining inaccuracies as small as 0.0001 inch, which can be read off from a screen with marvelous rapidity. For such work, a highly developed inspection and gaging system is necessary.

Multiplying Lever Indicating Gages

Multiplying lever indicating gages are made in so many types that it is impossible to cover them all here. An endeavor will be made, however, to deal only with principles of construction and operation. Fig. 12 shows a common form of multiplying lever indicating gage which, in this case, is being used for testing the depth of the powder groove in the ring for a combination time and percussion fuse. The gage, as will be seen, consists of a base *A* provided with a dovetail groove in which the work-holder *B* is free to slide. A stud *C* in the rear end of the base acts as a pivot for the swinging arm *D*, the latter carrying the indicating needle *E* and plunger *F*. The fulcrum point of pointer *E* is so placed in relation to the section which contacts with plunger *F* that a multiplying movement of 40 to 1 is obtained; that is, the lengths of the two arms *X* and *Y* are in this ratio. To insert the work under the measuring plunger, arm *D* is raised, its upper movement being stopped by the fillister-head screw *G*. For this arrangement it will be noted that a single multiplying lever is used.

There are several objections to this gage. In the first place, the necessity of raising arm *D* to insert the work makes it possible for dirt to collect under the seat, and thus cause the gage to read incorrectly. It is also unsuited for very accurate work because of the small multiplying movement of the lever, which gives only 0.025 inch between each graduation on the scale for each 0.001 inch variation in the work.

Multiplying Lever Gage for Internal Work

Another multiplying lever indicating gage, which is used for measuring internal work in this case, and is provided with two multiplying levers, is shown in Fig. 14. Reference to this illustration will show that the gage comprises a sleeve *A*, inside of which is fitted a member *B* milled out to receive the two multiplying levers *C* and *D*. The gage is provided with three contact points, only one of which—point *E*—is movable, the other two being adjustably held in the sleeve *A*. A coil spring, as shown, keeps the forward end of lever *C′* in contact with the lower end of contact point *E* and another spring keeps the forward end of lever *D* in contact with the rear end of lever *C*. In this way the point constantly follows any irregularities in the work which are indicated on the dial *F*. On the exterior of sleeve *A* is a bushing *G*, which can be moved back and forth. The function of this bushing is to keep the axis of the gage parallel with the center of the work as nearly as possible, the sleeve, of course, being pushed back and forth, depending on the distance from the face of the work that the measurement is being taken.

This gage has several objections: One is the small multiplying movement which can be obtained; another is the fact that two springs working against each other are employed; and a third is the unbalanced weight of the moving parts. In a gage built on the multiplying lever principle, the multiplication should not be less than 60 to 1, 100 to 1 being preferable. This provides for a movement of the indicating needle of approximately 1/16 inch for each 0.001 inch variation in the work. In the case of a multiplication of 100 to 1, the space between each graduation, representing variations in the work of 0.001 inch, would be 0.100 inch, which is still better.

Simple Type of Multiplying Lever Indicating Gage

A multiplying lever indicating gage which can be used for accurate work is shown by the diagram Fig. 13. This gage comprises two levers, which provide for a multiplying movement of 240 to 1; that is, variation in the work of 0.001 inch would cause a movement of 0.240 inch of the upper end of needle *A*. Segment *B* is, therefore, provided with graduations 0.024 inch apart, which is equal to a variation of 0.0001 inch in the work. The connection between levers *A* and *C* is by means of a rack tooth, and lever *A* is counterweighted, as shown at *D*, making a spring unnecessary. One objectionable feature of this gage is the relation of the lower surface of the upper or movable anvil to the center line of lever *C*. For accurate readings, the measuring point should be in line with the axis *X*—*Y*. As this gage, however, is only used for comparative measurements, and set by a master, this objection does not seriously affect its other advantages, which are simplicity of construction and magnification.

The Hirth Minimeter

A multiplying lever indicating gage which comprises some very valuable features from the standpoint of both accuracy and construction is shown in Figs. 15 and 16. This gage is now being used extensively by various concerns in this country, and can be adapted to almost any class of work by simply arranging suitable stands for holding the measuring gage proper. It is handled in this country by the Norma Co. of America, New York City. Fig. 16 shows a sectional view through this gage, illus-

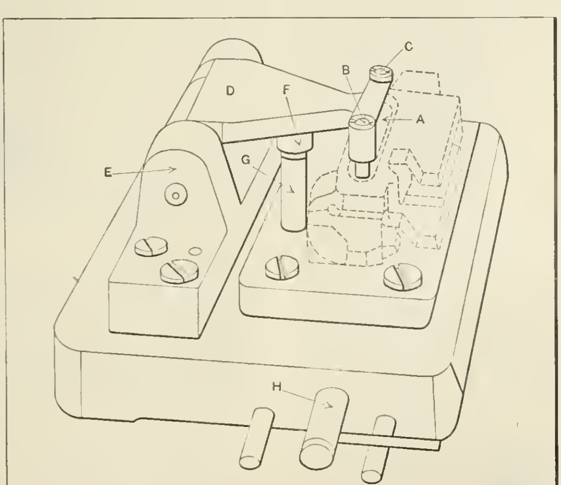


Fig. 11. Flush Pin Type of Gage employing a Swinging Arm

trating its working mechanism. The principle upon which this gage works is the introduction of a long lever arm *A*, which also serves as an indicating needle, and a short arm, the length of which is determined by the distance between the two knife-edges *B* and *C*. The bearing points of these knife-edges may be varied in order to provide adjustment for the apparatus.

One of the advantages of this device is that it eliminates the necessity for lubrication and overcomes the disadvantage of play on dead centers. As indicated in Fig. 16, a light spring *D* holds the lever against the knife-edge and returns

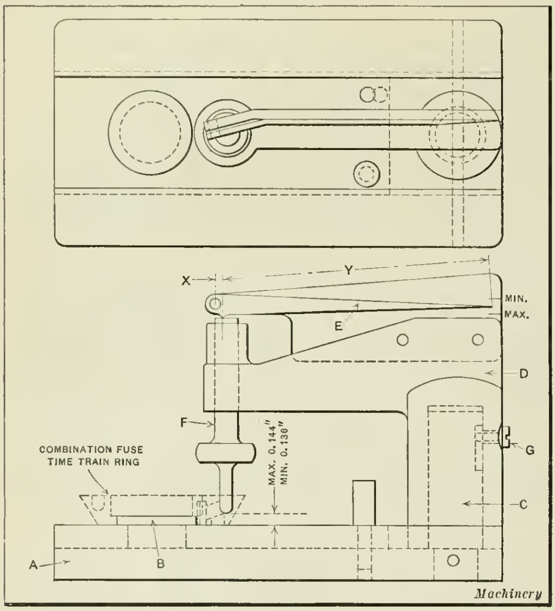


Fig. 12. Common Form of Multiplying Lever Indicating Gage

it to its normal position after measuring. A finger or pin *E*, bearing against the lower knife-edge, gives contact with the work to be measured. Movement of this pin causes the pointer *A* to swing over the scale *F* by displacing one knife-edge in relation to the other. The arc is graduated in different minimeters to give readings to 0.001 or 0.0001 inch. The entire mechanism is enclosed in a tube and the upper part is provided with an opening which permits the graduating scale to be seen and the indications of the pointer to be read off. The measuring instrument proper can be mounted in different holders, as will be described later.

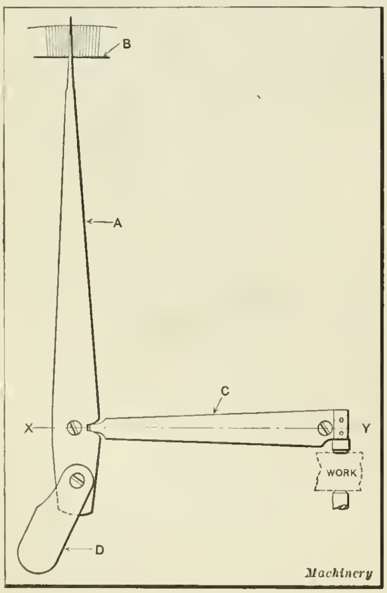


Fig. 13. Diagram illustrating Principle of Multiplying Lever Gage employing Two Arms connected by a Rack Tooth

Principles of Dial Indicating Gages

The chief difference between a dial indicating gage and a multiplying lever indicating gage is the substitution of a graduated dial for a graduated segment, and the provision for making the needle travel one or more times around the dial, instead of just covering the segment of a circle. The dial is usually graduated so as to give readings to 0.001 or 0.0001 inch. In the dial indicating type, as mentioned, some means must be provided for giving one or more rotations to the indicating needle, and for this purpose gears are generally employed. In the multiplying lever indicating type, however, no gears are necessary, as the pointer moves over an arc of a circle only and does not make a complete revolution. For the average run of work, especially in the inspection department, the multiplying lever indicating gage, when correctly designed, is much superior to the dial type. For instance, the type shown in Figs. 15 and 16, which is known as the Hirth minimeter, has been found to be one of the most accurate indicating instruments on the market. In the following, a description will be given of some of the principal features used in gages of the indicating needle and dial principle.

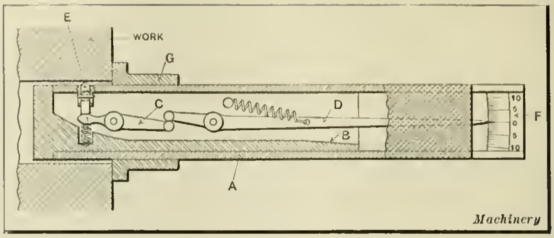


Fig. 14. Multiplying Lever Indicating Gage for Internal Work

The Ames Dial Indicator

In Fig. 17 is shown an Ames dial indicator attached to a simple holder and used for measuring the depth of the powder groove in a ring for a combination time and percussion fuse. The holder consists simply of a cast-iron block machined on the bottom and top surfaces and carrying a hardened and ground plug, which supports the fuse ring being measured. The bracket forming an integral part with this block is machined to receive the spindle of an Ames dial indicator. As has been previously mentioned, a dial indicator should not be depended upon when used on one job for any length of time; it is always advisable to provide a setting block, as shown in the illustration at *A* to check up the instrument periodically. A spring keeps the measuring pointer in contact with the work and it is lifted by means of lever *B*.

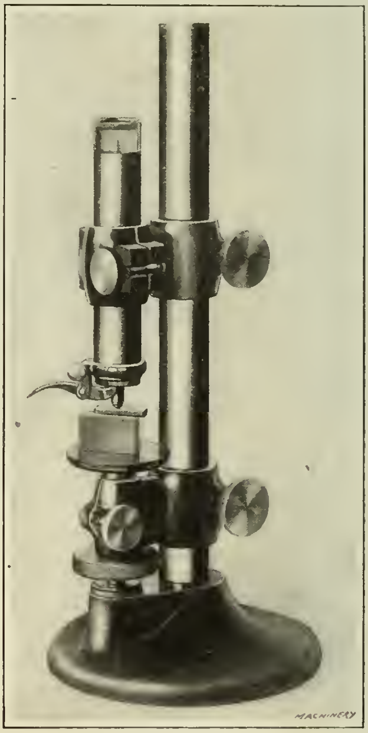


Fig. 15. Hirth Minimeter mounted in Stand Suitable for Average Run of Work

Dial Indicators Employing a Train of Gears

The internal mechanism of a dial indicator which is operated by a train of gears is illustrated in Fig. 18; it consists of a spindle *A* which works in hardened and lapped bushings

inserted in the case containing the measuring mechanism. The measuring spindle A is moved up and down by means of a handle B, to which it is connected by link C and collar D. When spindle A is raised, the rack teeth cut in it mesh with a pinion E, which transmits motion to the gear F, pinion G and needle H. Gear I is interposed to reduce the backlash. The dial is divided into one hundred equal spaces, and each graduation corresponds to a movement of the spindle of 0.001 inch. The table J is adjustable, and a plate K for holding the work to be measured is attached to it by screws. The stud on which table J is held is screwed into a babbitt bushing L, the latter being clamped on the stud by the screw M, the babbitt being poured in after the stud is put in place.

Another type of dial indicator which has a greater multiplying movement than that shown in Fig. 18 is illustrated in Fig. 19. This gage is used for measuring such work as balance staffs, pinions, etc., for watches. It is provided with a dial having two hundred graduations laid off on its face. The work to be measured is placed between the jaws A and B, which are separated by forcing in rod C to which jaw B is

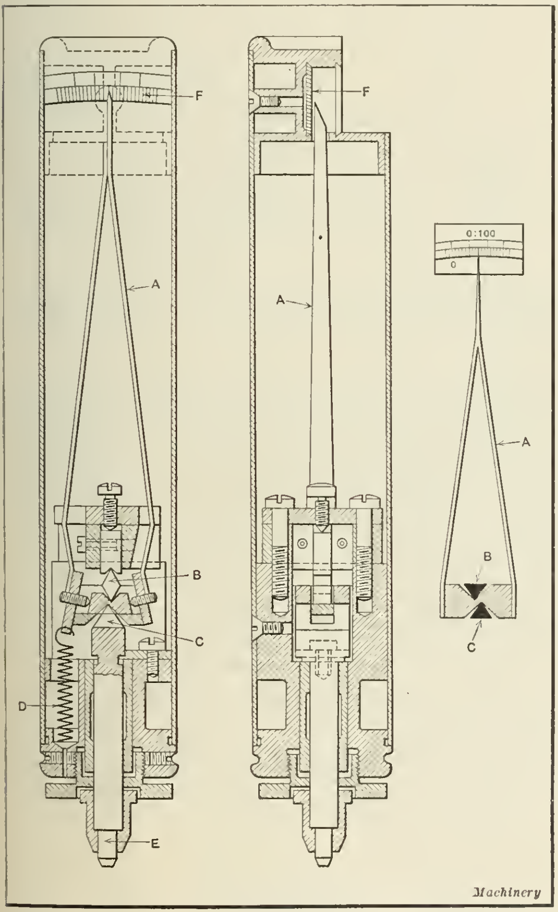


Fig. 16. Diagram illustrating Principle of Hirth Minimeter shown in Fig. 15

attached. Held on this rod by a screw is a rack D, which meshes with a pinion E having forty teeth. Pinion E is connected to segment gear F (the whole number of teeth in which should be 225), which meshes with pinion G attached to needle J. Jaw B, which is held by a screw to rod C, has a slot cut in its rear end which fits a flattened stud H, thus preventing the jaw from tilting. One complete revolution of needle J around the dial gives a corresponding movement between the jaws A and B of 0.080 inch, so that the space between each graduation of the dial represents a movement of the jaw of 0.0004 inch. The working mechanism of the gage is enclosed in a case and supported on a stand I, as shown.

A still more sensitive dial indicating gage or comparator is

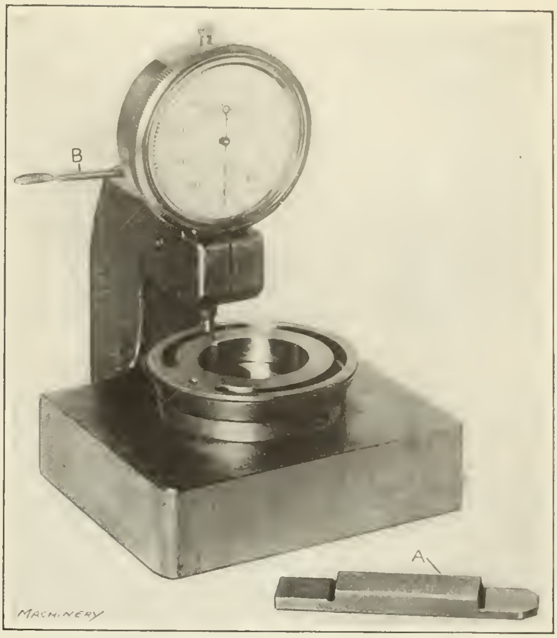


Fig. 17. Ames Dial Indicator used as Depth Gage

shown in Fig. 20. This gage also employs the pinion and gear feature, and is so arranged that one revolution of the needle around the dial represents a movement of the anvil or measuring spindle of 0.010 inch; as the dial is divided into one hundred equal spaces, this means that the space between each graduation is equal, theoretically, to 0.0001-inch movement of the anvil. Actually, of course, the movement of the needle varies somewhat over different parts of the dial. The working parts consist of a lever A, fulcrum screw B, plunger D, fan gear E and pinion G. The gage operates as follows: When brought in contact with the work, plunger D is moved and the flange on this plunger moves the short end of lever A with which it is kept in contact by the action of spring J on the segment gear and the spiral spring on the plunger. In this way a uniform contact is maintained between the long end of lever A and the pin C, and also between the flange of the plunger and the short end of lever A. The movement of lever A causes the required movement of the segment gear, which turns the pinion and the pointer.

Dial Indicator with Worm for Rotating Needle

An indicating gage of the dial type in which a train of gears is dispensed with is shown in Fig. 21. This indicator,

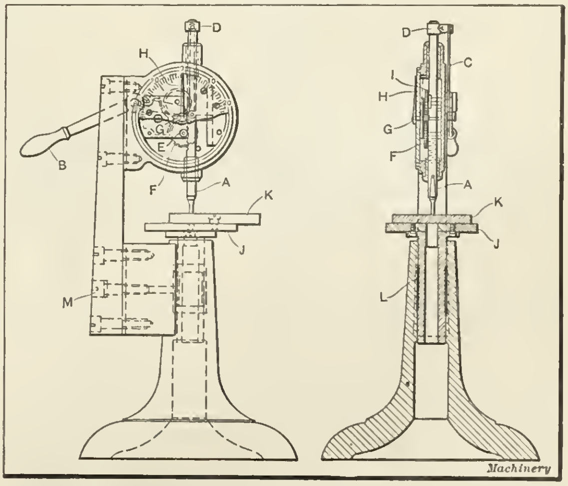


Fig. 18. Sectional View showing Construction of Dial Indicator operated by Gears

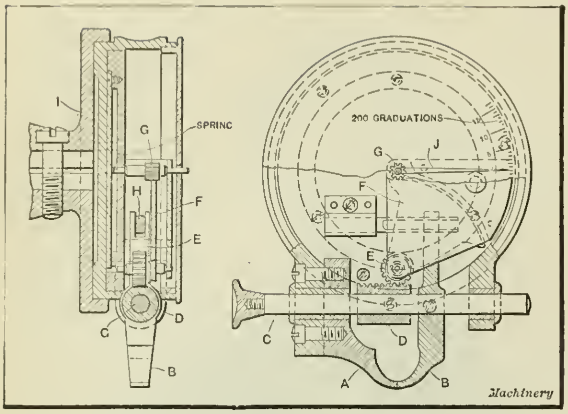


Fig. 19. Dial Gage of the Caliper Type

which is made by H. A. Lowe, Cleveland, Ohio, employs a worm in place of a train of gears for conveying the rotary movement to the indicating needle. As shown in the illustration, this gage consists principally of a body *A* milled out on one side to receive the indicating lever *B*, which is attached, as shown in the sectional view, to the forward end of the body *A*. The forward end of this lever is provided with

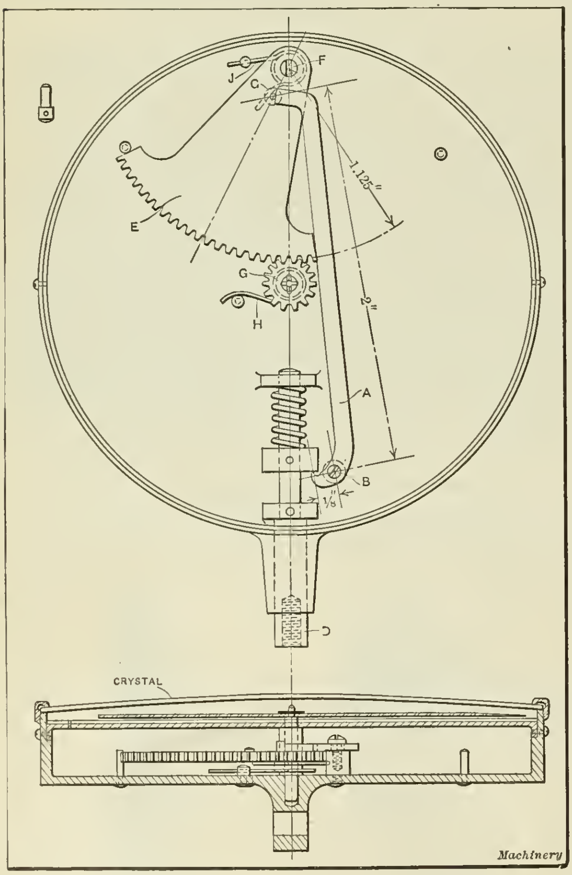


Fig. 20. Dial Test Indicator giving Readings to 0.0001 Inch

a friction joint, which allows the contact point to be moved around through 180 degrees to any required position, thus greatly increasing the usefulness of the instrument. The rear end of lever *B* is provided with a projection fitting in the groove in worm *C*. This worm is held in somewhat the same way as a staff in a watch, and on its extreme upper end it carries an indicating needle *D*. The needle is retained at zero by means of the flat spring *E* and a hairspring *F*. The dial *G* is divided into twenty-five equal parts, the distance between each graduation representing a movement of the lever *B* of 0.001 inch. The dial is so arranged that it can be turned around to bring the zero point in line with the needle when the latter is at rest. In this instrument the objectionable feature of backlash is avoided, and it has been found both reliable and sensitive. A plate, not shown, covers the internal mechanism by fitting in a dovetail groove in the side

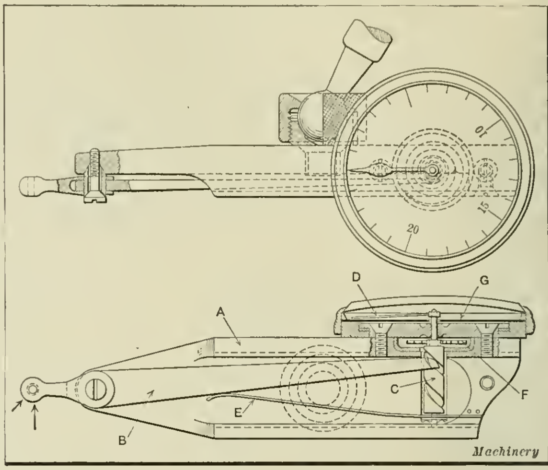


Fig. 21. Lowe Dial Test Indicator

of the body and is held in place by a screw. By the addition of several arms, etc., this device can be used for various purposes.

Dial Indicator of the Caliper Type

Another dial indicating gage which does not depend for its magnifying movement on a train of gears is shown in Fig. 22. In this gage the hand *A*, which travels around the dial, is operated by means of a fusee chain that is wound around the spindle, to which the hand is fastened and is connected to the movable jaw lever *B*. A hairspring, not shown, surrounds the lower end of the spindle to which the hand is attached in such a way as to pull the indicator hand toward zero and keep the chain wound up as far as the caliper jaw will permit. The jaws are separated by pushing the button *C* to the right, which operates the long lever *B* attached to the movable jaw.

Micrometer Indicating Gages

An indicating gage which is capable of wide application is the micrometer type of gage. This generally consists of a micrometer spindle held in a suitable frame, which as a rule also supports the work and enables measurements to be taken at several points when desired. A simple application of the micrometer type of gage is shown in Fig. 23; this is used for

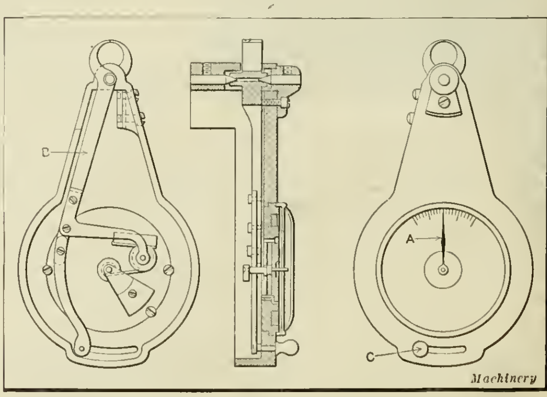


Fig. 22. Dial Indicator of Caliper Type

measuring the diameter of a military rifle bolt at the root of the spiral ribs. It consists principally of a frame *A* holding a split sleeve *B* and a micrometer spindle *C*. The sleeve *B* is held on a conical plug *D* by a nut and is split so that it can be made to fit snugly in the hole in the bolt. To lay off the manufacturing limits on the gage, the master plug *E* is placed on sleeve *B*, and the measuring point *F* is brought in contact with it. This master plug *E* is also used for checking up the gage at frequent intervals.

Another interesting type of micrometer indicating gage is shown in Fig. 24. This is used for testing the location of the guide in a receiver for a military rifle. The receiver is held in a gaging fixture, being located by plugs fitting in both ends. The upper surface of the fixture is provided with hardened and ground parallel strips, on which the micrometer gage is located, as shown. The gage consists of a base *A* provided with a lug which fits against the hardened and ground meas-

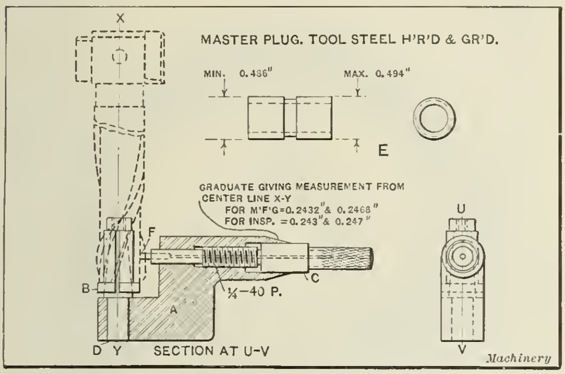


Fig. 23. Micrometer Type of Indicating Gage used for testing Rifle Part

uring blocks on the stand. A cone pointed and threaded spindle *B* extends downward through the center of the body of the gage and actuates a measuring finger *C*. This finger is held by means of a flat spring *D*, shown in the lower view, which fits in the slot in the finger and also in the base of the gage. A cap *E* is fastened to the stem of the gage by two screws, as shown, to prevent the finger *C* from dropping out. The spindle *B* is provided with forty threads per inch and is pinned to a thimble *F*. The graduations on this thimble are laid out after the gage has been assembled and set by means of a master.

A somewhat similar micrometer gage is shown in Fig. 25. This gage, however, is used for testing the distance from the center of the receiver to the bottom of the bolt sleeve guide slots. A stand similar to that used with the gage shown in Fig. 24 is used with this gage for holding the work; this gage

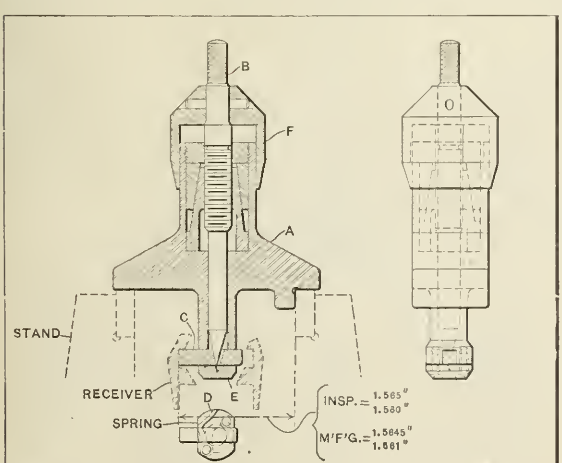


Fig. 24. Micrometer Gage for testing Location of Bolt Guide Groove in Military Rifle Receiver

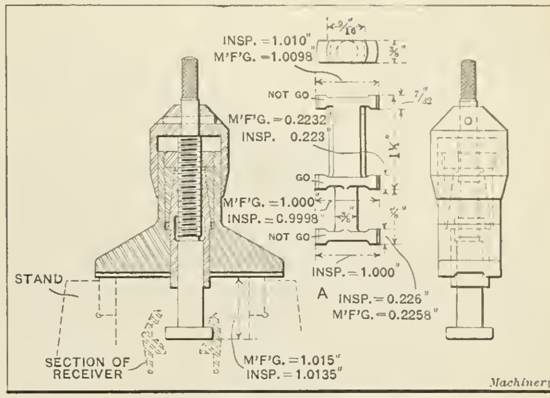


Fig. 25. Another Micrometer Gage for testing Bolt Guide in Military Rifle Receiver

is of practically the same construction as that shown in Fig. 24 except that the spindle is provided with a head which acts as a measuring point. A standard reference block is provided for use in setting the spindle when it becomes worn or inaccurate.

There are, of course, many other applications of the micrometer spindle to accurate gaging, but the examples presented here show some of the principles involved which are subject to considerable modification.

Three-point Indicating Gages

In machining work which is eccentric or unbalanced, considerable difficulty is sometimes experienced in producing a

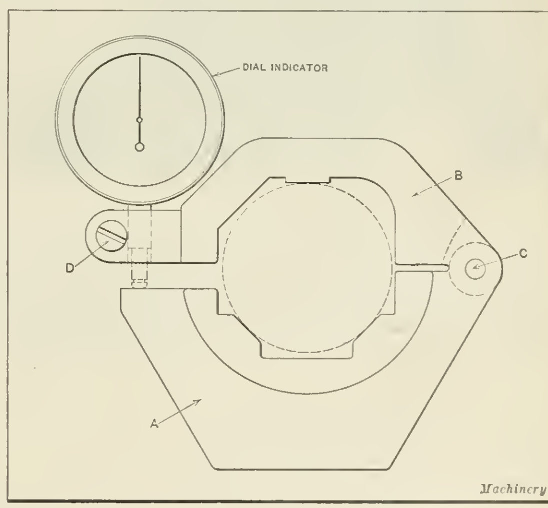


Fig. 26. Three-point Dial Indicating Device for testing Crankshaft Bearings

truly cylindrical hole or bearing, due to play in the machine bearings or other causes. When the forces opposed to each other are so unbalanced that a three-cornered effect is produced, the ordinary two-point measuring instrument will not detect the error that exists. The only way of successfully measuring the work to find whether it is truly cylindrical or not is to employ a three-point measuring instrument. Several devices have been made for this purpose, one of which is the ordinary micrometer provided with a special two-point anvil, the third point being formed by the spindle of the micrometer.

Another device which employs a dial indicator is shown in Fig. 26. This is used for measuring the crankpins of automobile crankshafts and, as shown in the illustration, consists principally of two blocks *A* and *B* hinged at the point *C*. The upper block *B* is machined on one end to receive the spindle of the dial indicator, which is held in place by means of the screw *D*. In use, the indicator is swung open, slipped over

the work and then brought down in contact with it, so that the spindle rests on the upper surface of the block *A*. It is then possible to tell whether the bearing is out of round or of the correct diameter. The gage, of course, is set to the zero point by means of a master plug made to the same diameter as the crankpin.

The three-point indicator illustrated in Fig. 26 has one disadvantage in that it is comparatively slow to operate and is rather bulky to handle. An improvement over this device, which has three points located 30 degrees apart, is shown in Fig. 27. This device is also used for testing the crankpin bearings of a crankshaft and is so constructed that it can be used very rapidly. In fact, it can be applied to the work while the latter is in motion. It comprises a main holder *A* formed at the forward end to hexagonal shape and carrying two hardened, ground and lapped blocks, as shown. The rear end of the holder is provided with a hook to facilitate gripping in the hand. The dial indicator, as illustrated, is fastened to this holder, and coming into contact with the spindle of the indicator is a special spindle *B* passing through two bearing supports in the holder proper. In use, this instrument is set to the desired diameter by means of a master and then can be applied directly to the work while the latter is in motion and the reading taken off on the dial indicator. For many classes of work this type of instrument will be found to be much superior to the micrometer caliper in that it is quicker to operate and can be used in connection with the limit system of manufacture.

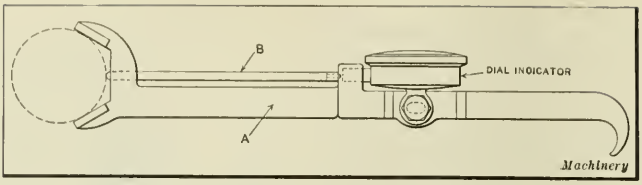


Fig. 27. Three-point Dial Indicator for testing Crankpin Bearings, which can be applied while Work is in Motion

Fig. 28. Hirth Minimeter fitted up for Use as an Internal Gage

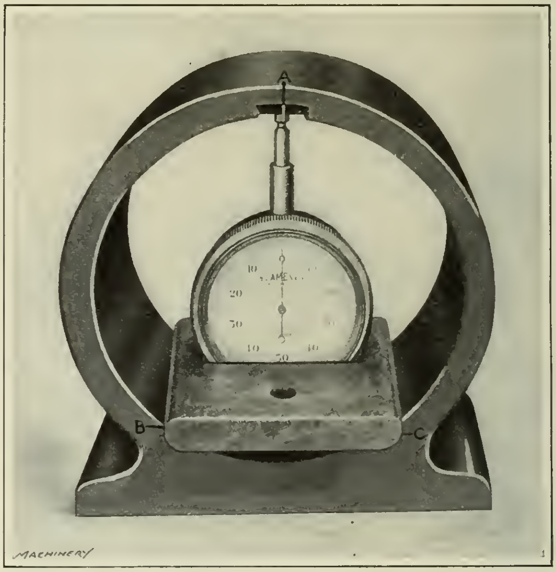


Fig. 29. Ames Gas Engine Cylinder Gage

Three-point Indicators for Internal Work

The indicating devices shown in Figs. 26 and 27 are used for external measurements. Fig. 28 shows a device which can be used for internal work. By the addition of a simple attachment, the Hirth minimeter, which has previously been described, is here used for internal gaging. The special holder is fitted around the body of the lower portion of the indicator, and carries one adjustable and two rigid points, the former being connected by means of a lever to the spindle of the indicating lever. Fastened to the bracket of this attachment are three rolls, against which the work is pressed, and which keep it straight while it is being tested. The two rigid points are adjustable for wear, and all three points are provided with ball points. With this device it is possible to tell whether the hole is of the correct size, or is out of round, tapered, etc.

Ames Gas Engine Cylinder Gage

A three-point dial indicating gage designed particularly for testing the bore of automobile cylinders is shown in Fig. 29. The illustration shows the gage inserted in the standard ring which is used for setting the needle at zero; this ring, of course, has a diameter equal to that of the cylinder it is desired to test. The base, holding the Ames dial indicator, forms two points, *B* and *C*, and the plunger of the indicator forms the third point *A*. With this device it is possible to tell whether the cylinder is large or small, out of round or tapered.

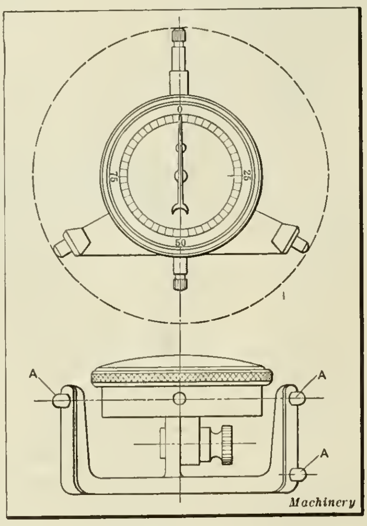


Fig. 30. Gas Engine Cylinder Gage having a Three-point Bearing on Its Base

Another three-point gas engine cylinder gage of simple construction is shown in Fig. 30. This gage comprises a standard dial test indicator, which is attached to a frame by a thumb-nut, as shown. In this frame, which is made of cast iron, are set three buttons *A*, two on one side and one on the other, giving a three-point bearing. The bearing points are set about 120 degrees apart, and two of the opposite points and the plunger of the dial gage are set in the same plane, the third being set lower a distance equal to about

one-third of the cylinder diameter. The dial gage is provided with a slip ring, so that the pointer may be set to zero no matter what its position may be. In using this instrument, it is pushed into the cylinder, dial first, from the head or compression end, assuming that the cylinder head is detachable. Then, with the aid of an electric flash light, the operator or inspector may easily watch the variations in the cylinder diameter. The instrument should be shoved through the cylinder slowly, care being taken to have all three corners bearing on the cylinder bore. If it is desired to use this instrument as a micrometer, it can be set by a standard ring.

Pratt & Whitney Star Gages

A type of gage which was developed especially to meet the demand for a convenient and accurate instrument for gaging the bores and jackets of guns of all sizes, from the one-pounder rapid-fire gun up to the largest caliber, is shown in Fig. 31. This gage consists principally of a body *A*, in which three measuring heads are held (four can be used if desired); these heads are radially adjustable, having tapped holes in the outer end to which various measuring points of any suitable length can be attached. The radial adjustment of the points is controlled by a central wedge or cone, which may be moved longitudinally, and the heads are fitted so that they may rotate freely when gaging the rifling of a gun or may be locked for regular work. The body of the gage is made of seamless drawn steel tubing, provided with means for readily coupling and uncoupling to produce any desired length. The tubular body *A* is graduated throughout its entire length in quarter inches. This is essential when it is desired to make a record of the condition of the bore by taking measurements at regular intervals.

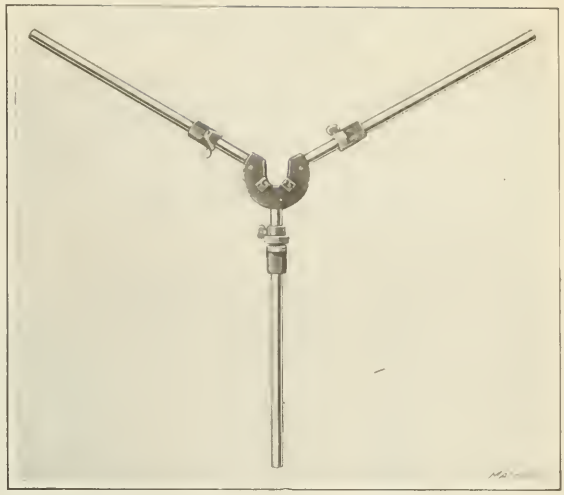


Fig. 33. Centering Device used with Pratt & Whitney Star Gages

The operating head shown to the left in Fig. 31 is made with a sliding member connected to the jointed rod by which the wedge in the measuring head is given its longitudinal movement. The operating lever shown is provided to give the necessary delicacy of movement, and also facilitates the operation of the gage. The scale and vernier shown at *B* enables the variations from the required diameter of bore to be read at a glance. For each diameter of bore to be gaged, a standard ring is usually furnished for setting the gage. Suitable supports hold the standard ring concentric with the measuring head when the points are brought in contact with it, and then the vernier is adjusted so that the zero lines coincide. For the smaller gages the vernier gives readings to 0.0005 inch, and to 0.001 inch on the larger sizes.

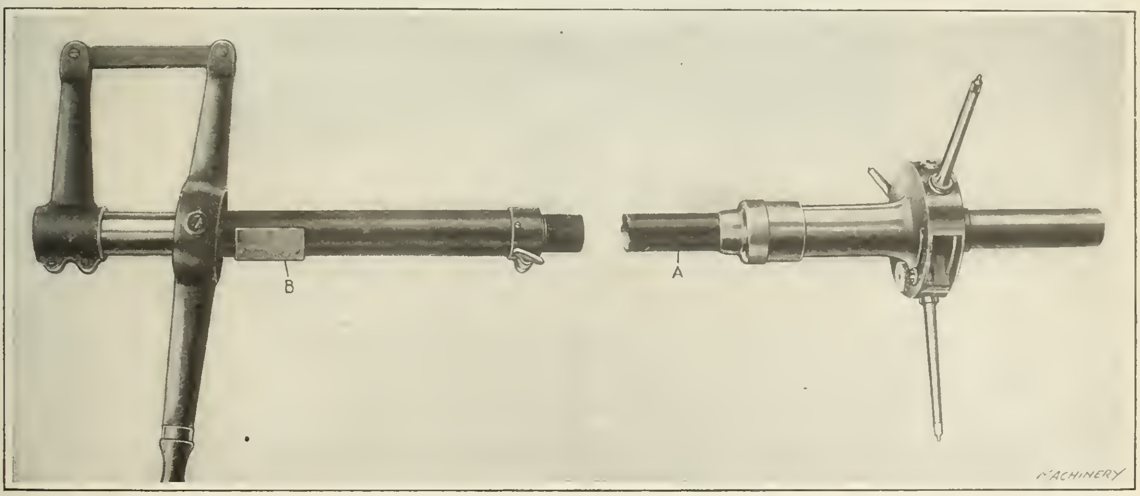


Fig. 31. Pratt & Whitney Star Gage with Three-point Measuring Head

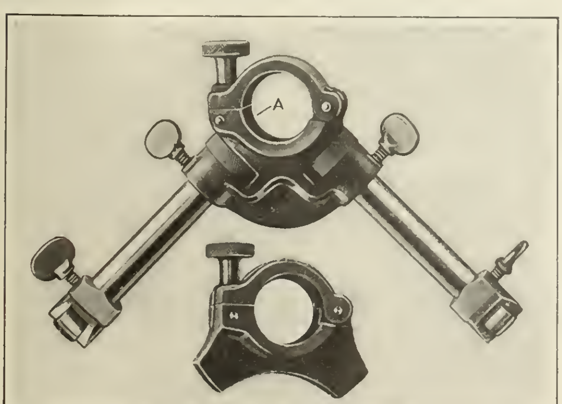


Fig. 32. Supports used for steadying Pratt & Whitney Star Gage when used in Long Lengths

When gaging bores of considerable length, it is necessary to support the gage and to keep it from sagging, which would introduce a small error in measurement. Therefore, supports such as shown in Fig. 32 are used. These are set in the bore of the gun being measured and the gage is slipped through the hole *A*. The legs of the supports are then adjusted so that the gage is held central with the bore of the gun. A centering device, as shown in Fig. 33, is also provided when desired. This consists of a central hub with three graduated radial arms, upon which are mounted sliding jaws that project into the bore; one of the jaws is provided with a screw adjustment for binding the device in the bore. The central hub has a slot at the top to receive the gage tube which rests on two rollers permitting the gage to move freely without danger of marring the surface of the tube.

DRAW TOOLS FOR AUTOMOBILE SIDE RAILS

BY P. BALDUS[1]

A common form of automobile side rail is shown in Fig. 1, and the tools used in its production are indicated in detail in Fig. 2. Work of this kind is frequently done on a very heavy type of hydraulic press or on one of the heavier types of drawing presses. Referring to Fig. 2, it will be seen that the back die walls *A*, *B*, *C* and the front die walls *H*, *I* and *J* are made of cast iron, well ribbed to withstand the pressure to which they are subjected. The back die walls are fastened with screws *O* to a die shoe *D*, which is also made of cast iron. The clamps *K* and screws *N* are used for holding the front die walls securely, adjustability for these walls being secured through the screws *L* which are locked by the nuts *M*. The number of clamps and screws necessary to hold the front die walls depends somewhat upon the size of the work. The punch sections *E*, *F* and *G* are made of cast steel and lined up by keys at *S* as indicated.

Fig. 4 shows an adjustable punch section as used by the A. O. Smith Co., Milwaukee, Wis. This punch consists of a punch-holder *T*, punch lining *V* and shim *U*. These three parts are screwed together with the screws *W*. It is evident that this construction permits the punch to be used for many different sizes of side rails by merely changing the shim *U* so that the punch will fit the new rail. The knock-out *P*, Fig. 2, is made of machine steel and is operated by knock-out rods.

[1] Address: 928 Right St., Milwaukee, Wis.

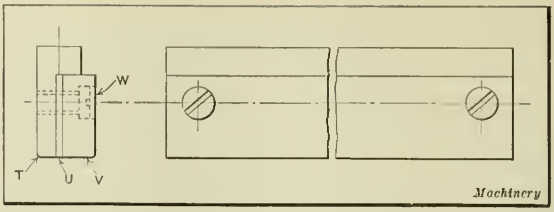


Fig. 4. Detail of Adjustable Punch

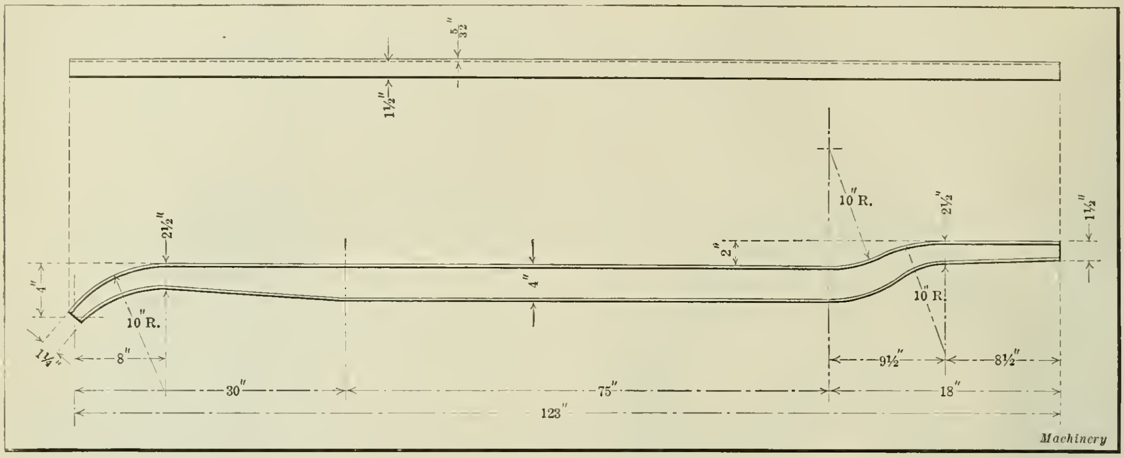


Fig. 1. Automobile Side Rail of Ordinary Design

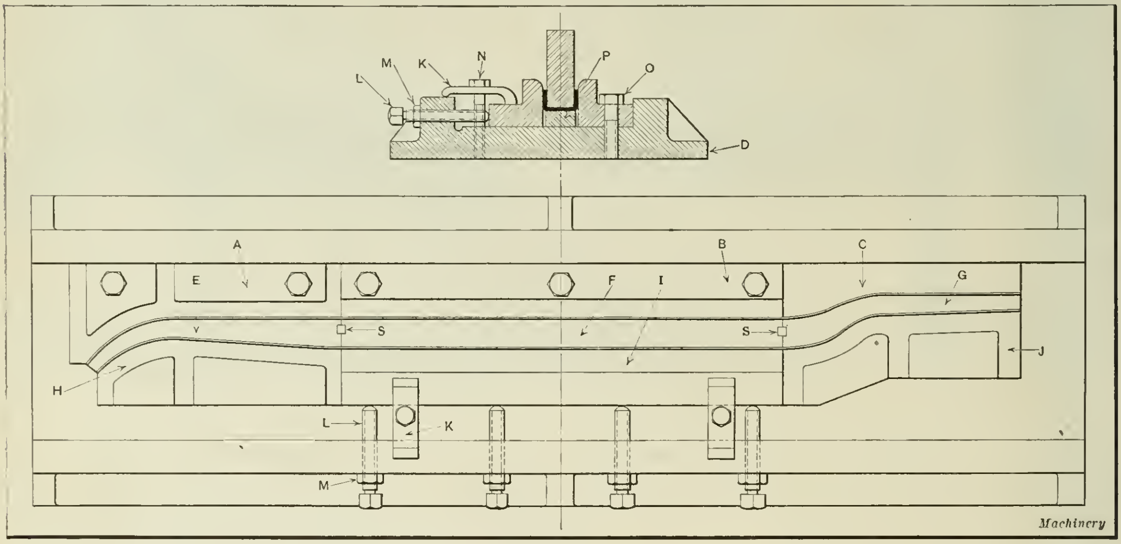


Fig. 2. Construction of Dies for Automobile Side Rail shown in Fig. 1

DRAW EDGES FOR CROSS AND SIDE BAR DIES	
THICKNESS OF STOCK	RADIUS "R" OF DIE
1/8"	1/4"
5/32"	3/8"
3/16" AND OVER	1/2"

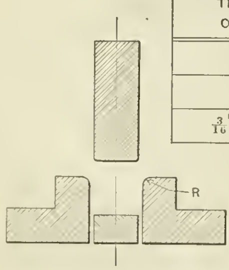


Fig. 3. Proper Radius for Drawing Edges of Cross and Side Bars

When drawing the metal across the edges of the die, the thickness of the metal makes considerable difference in the size of the radius which can be used to advantage. The diagram and table shown in Fig. 3 give the proper draw edge radius for the various thicknesses of stock in common use.

* * *

WATCHING THE METERS

In the September number of MACHINERY an article was published on "Common Cause of High Electric Power Bills," and it seems to me that a few more causes might be added to those already given. The high cost of electric power is due in many cases to uneconomical methods and unscientific lay-outs. Even without instruments, a shop management can check up on losses which occur so slowly as to be unnoticed. The meter is the check. Running idle for a short period once every six months and taking a meter reading will show whether the shafting is getting out of line or is "pulling harder." Shutting off motors promptly and not starting until ready will effect quite a saving. Overtime work increases a bill. In one shop, light and power meters are read "before and after," and this amount is added to the bill just as for any other material. The same thing is done with the gas; in figuring the cost of a job that requires the use of a gas furnace or forge, the charge for so many cubic feet is added. This is as it should be, for no shop charging, say, seventy cents per hour can afford to throw in thirty cents per hour for gas.

Fuses may greatly increase an electric bill. Overloaded motors, underfused circuits, and careless workmen are responsible for this loss. When the writer was visiting a planing mill, he was shown a ten-horsepower motor driving an exhaust blower that gave continual trouble with blown fuses. Besides, the motor ran too hot all the time, so the mill owners had decided to replace it with a larger size. A study of conditions, however, showed that while the motor was overloaded, the blower was not, so it was recommended that the speed of the blower be reduced one-third. This change proved to be the solution to the problem, and a substantial saving was effected in the power bill. The writer believes that many blowers in planing mills and pattern-shops, and many grinder exhaust systems could be run slower, for the reason that it is common to install over-size blowers. D. A. H.

REVERSING PLANER MOTORS

BY C. C. GRAY[1]

Planers do not operate economically for all jobs, and even on a single kind of work a change in cutting tools or in the hardness of the metal often makes a change in cutting speed desirable. For instance, when cutting chilled castings it is necessary to operate the planer for the roughing cut at a low speed and for the finishing cut at a higher speed. This cannot be accomplished with belt-driven planers except by means of complicated speed-changing devices, and such devices will only permit a few speed changes to be made. Furthermore, with a belt drive, the countershafts and belts run much of the time while the planer is doing no work; *i. e.*, between jobs and while setting up work. Direct-connected reversing planer motors with automatic control permit a flexibility of speed adjustment which cannot be equalled, and which is only limited by the number of control steps provided; the cutting and return speeds of the planer can be promptly adjusted to the maximum speed permissible for any job. The operating expenses of a machine tool can be listed under four heads, *viz.*, interest and depreciation on machine; cost of power; miscellaneous expense; and supervision and clerical work. The hourly cost of operating various sizes of planers, as determined by data compiled in a shop using a number of these machines, is indicated in the accompanying table. The item of miscellaneous expense includes general repairs, storage, haulage, tool-room charges, and the interest and depreciation on cost of buildings and auxiliary apparatus. The figures are based on 2800 hours' annual operation. In practical operation, reversing motor equipments have, in most cases, increased the output of planers by 33 per cent or more, thus reducing by that amount both the labor charge and the machine overhead charges.

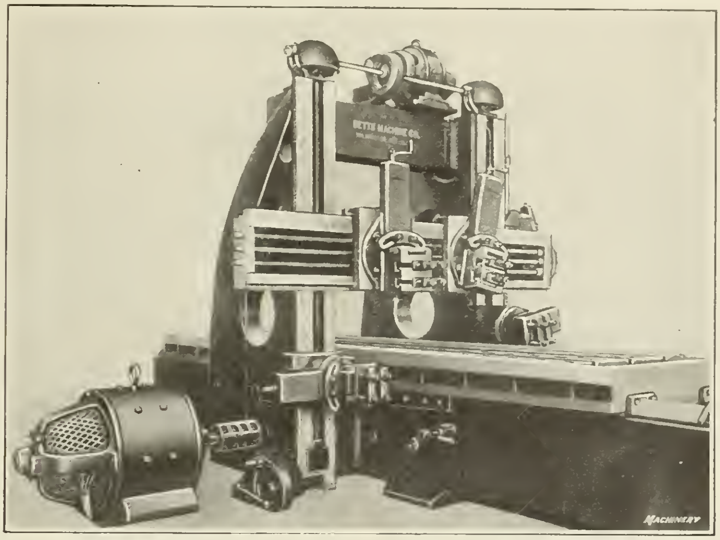


Fig. 1. Westinghouse Reversing Planer Motor, 20 H. P., 250 to 1000 R. P. M., driving a 48 by 12 by 12 Betts Planer

The economies effected by the use of reversing planer equipments all tend toward increased production at a lower cost. The advantages may be classed as given below, and it will be apparent that each item has a definite bearing on increased production, which is the result desired.

1. Adjustment of speeds. Production is increased because the maximum speed is readily obtainable by a simple operation of adjusting the

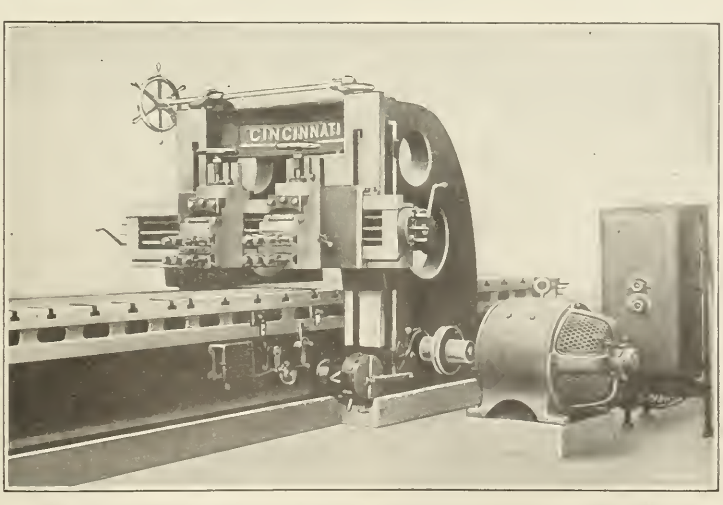


Fig. 2. Westinghouse Reversing Planer Motor, 50 H. P., 250 to 1000 R. P. M., driving a 48 by 24 by 20 Cincinnati Planer

[1] Address: Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.

HOURLY OPERATING EXPENSE OF STANDARD PLANERS WITHOUT REVERSING MOTOR EQUIPMENT

Width of Planer, Inches	Interest and Depreciation	Cost of Power	Miscellaneous Expense	Supervision and Clerical Work	Total Machine Hour Rate
36	$0.04	$0.02	$0.49	$0.25	$0.80
48	0.12	0.02	0.59	0.30	1.03
56	0.09	0.04	0.69	0.35	1.17
60	0.18	0.04	0.70	0.35	1.27
84	0.19	0.04	1.05	0.53	1.81
120	0.28	0.04	1.26	0.64	2.22
120 heavy	0.82	0.06	2.04	1.13	4.05
130	0.22	0.06	2.68	1.35	4.31
168	0.60	0.06	2.79	1.42	4.87
168 heavy	0.97	0.06	3.89	2.14	7.06

Machinery

field rheostat. This applies equally to the cutting and return strokes, independently of each other.

2. Time saved in setting up work. This saving is accomplished because all the movements of the planer are under accurate control of the operator at all times. After the work is properly located on the platen, by simply pressing a button in the pendant switch, the platen may be "inched" along and the tool located at its proper position with the minimum amount of time and attention from the operator, whereas with belt-driven planers the operator must manipulate a belt-shifting device until the work is properly located under the cutting tool, so that it can be set at the right angle and position in the toolpost.

3. Elimination of time and power losses due to belt slippage. On belt-driven planers there is a certain amount of belt slippage at the end of the cutting and return strokes. This cuts down the number of strokes per minute, because it is impossible to keep the belts tight enough to prevent slippage. Also, power is lost at these times. In contrast to this, with the reversing planer equipment the motor is directly coupled to the planer mechanism, thus eliminating all loss of time and power which is an objection to the belt-driven planer; the motor reverses at the end of each stroke and is immediately stopped and accelerated in the reverse direction at the greatest possible speed. Further, there is no slow-down due to belt slippage under heavy load. This is a very important point, as it becomes quite troublesome when the machines are carrying heavy overloads. If belts are tight enough to prevent slippage, their life is so short that the upkeep and maintenance charges on the planer equipment are almost prohibitive. Thus the time and power losses due to belt slippage, countershafting and tight and loose pulleys are eliminated. On heavy planers this is particularly important, since the repairs cost considerable and the belting is very expensive. Furthermore, the elimination of time required to make these repairs is an important point, as the machine is out of production service while these repairs are being made. This point in itself highly recommends the reversing planer equipment.

4. Saving in power requirements. While the cost of power in proportion to maintenance charges, labor, interest and depreciation is small, it is a point which should be considered. The power required in connection with reversing planer equipments has been found by actual test to be materially less than on a belt-driven equipment doing the same work.

The motor which is a part of the reversing planer equipment illustrated in Figs. 1 and 2 has been designed after a thorough study of the requirements of planer drive. The armature of the motor is designed with a very small diameter, which reduces the flywheel effect to a minimum, and it is this characteristic which permits the equipment to reverse in minimum time and enables the planer to take care of short-stroke work without distress on the part of motor or control. Perfect commutation is secured under all conditions of operation. The control equipment consists of a controller, a master switch and a pendant switch. The controller is mounted at any convenient place near or on the planer. The pendant switch is usually placed over the platen so that it can be held in the operator's hand while he is observing the cutting operations or measuring the work. The master switch is mounted on the planer bed and is tripped by dogs attached to the platen.

When the "run" button on the pendant switch is pressed, the motor starts and automatically accelerates to a speed corresponding to the setting of the control. When the end of the stroke is reached, the master switch is tripped and the motor stopped by dynamic braking and immediately started in the reverse direction, accelerating to the proper speed. This cycle is repeated over and over again until the "stop" button on the pendant switch is pressed. The cutting and return speeds can be adjusted independently and within wide limits, so that the speed can be used which gives the maximum production for any length of stroke, depth of cut, or weight of platen. For the average planer the platen speed can be adjusted between the limits of 25 and 50 feet for the cutting stroke (motor speed, 250 to 500 revolutions per minute) and between 50 and 100 feet per minute for the return stroke (motor speed, 500 to 1000 revolutions per minute).

The equipment illustrated employs dynamic braking for stopping at the end of each stroke. Since the current used for the dynamic braking is generated by the motor itself and not taken from the line, a minimum amount of power is required for the operation of the planer. Oscillograph records show that the maximum currents drawn, both at the time of dynamic braking and at the instant of reversal, do not exceed 1¼ times full load current of the motor, so that there can be no objection to putting a reversing planer equipment on any shop circuit.

* * *

STATISTICS OF STEAM RAILWAYS

Statistics of the steam railways in the United States for the year ended June 30, 1915, as given in a report of the Interstate Commerce Commission, show the following figures. The roads covered by this report, which does not include switching and terminal companies, represent 257,569.32 miles of line operated, including 11,279.64 miles used under trackage rights. The aggregate mileage of railway tracks of all kinds was 391,141.51 miles. These figures show an increase of 3933.20 miles over those given for 1914. There were 65,099 locomotives in service on the various railways. The total number of cars of all classes in service was 2,507,977, assigned as follows: passenger service, 55,705; freight service, 2,356,338; company service, 95,934. The roads covered by the report are divided into three classes: Class I roads are those having annual operating revenues above $1,000,000; Class II roads are those having annual operating revenues from $100,000 to $1,000,000; and Class III roads are those having annual operating revenues below $100,000. Class I and Class II roads, operating 224,858.89 miles of line, reported 1,409,342 as the average number of employes in their service during the year. The total wages paid during the year by roads of the same classes, operating 224,371.01 miles of line, were $1,164,844,430. The number of passengers carried on Class I and Class II roads in 1915 was 976,303,602, as compared with 1,053,138,718 in 1914. The operating revenues of railways in the United States were $2,956,193,202, or $11,538 per mile of line operated. The operating expenses were $2,088,682,956, or $8152 per mile of line operated.

* * *

PLATINUM SUBSTITUTES

A substitute for platinum must satisfy the following conditions: Its melting point must be well above 1200 degrees C.; it must not be affected by chemical compounds formed in its application; nor should it oxidize at a soldering temperature; it must possess sufficient strength to resist deformation and at the same time be sufficiently pliable to be worked to the desired shape; its coefficient of expansion must be low; it should readily unite with gold, silver and other metals, and their solders; its cost should be low as compared with platinum. In the electrical industry platinum has largely been replaced by tungsten, molybdenum and nickel-chrome alloys. Various alloys have been perfected to meet different conditions under which platinum was formerly used. One of the latest is a copper-jacketed nickel-steel wire, having an outside coating of platinum. This wire is said to have a coefficient of expansion which is such that in feeding an incandescent lamp a tight joint is assured.

CHART FOR SELECTING RAWHIDE PINIONS

BY N. G. NEAR

Fig. 1 shows a chart which will be found useful in selecting rawhide pinions to replace metal pinions that have proved unsatisfactory in service. It is used by simply laying a straightedge across the chart three times, which solves the problem without the necessity of doing any figuring. For example, suppose it is desired to replace a noisy metal pinion with a quiet-running rawhide pinion, and it is desired to find out whether a given pinion is strong enough to transmit the power from a seven-horsepower motor; the pitch diameter of the metal gear is 4 inches, the circular pitch ½ inch, the face width 4 inches, and the motor runs at 1000 revolutions per minute. The dotted lines drawn across the chart illustrate the way in which the problem is solved. From 4 on column *A* for the pitch diameter, lay the straightedge across to 0.5 on column *C* for the circular pitch, and locate the point of intersection of this line with column *B*. Then from 4 on column *E* for the face width, lay the straightedge across to 1000 on column *G* for the number of revolutions per minute, and locate the point of intersection of the straightedge with column *F*. Now lay the straightedge across from the point of intersection on column *B* to the point of intersection on column *F*, and the point where the straightedge cuts column *D* for the horsepower transmitted will show the capacity of the rawhide pinion; in this case it is found to be 9.4 horsepower, which is more than sufficient to transmit the power developed by the seven-horsepower motor. It will be evident that where a pinion of wider face is required, the chart will show instantly that such is the case, and the danger of employing an unsatisfactory pinion is eliminated. Knowing any three factors given in columns *A*, *C*, *E* and *G*, the fourth one can be quickly found.

It is not a difficult matter to construct an alignment chart directly from a slide-rule; an alignment chart is a logarithmic chart, and a slide-rule is a logarithmic rule. Fig. 2 shows the principle of construction well enough to enable any reader who has a slide-rule or table of logarithms to develop a similar chart of his own. Column *A* is a direct copy of the 1 to 10 scale of a slide-rule, as is also column *C*. On my drawing I placed the lines three inches apart and parallel. Exactly in the middle between these two lines, I erected column *B*, and on it copied the 1 to 100 scale from the slide-rule, and placed it in such a position that the chart is nothing more nor less than a multiplication table. The dotted line drawn across the chart, for example, shows that $2 \times 3 = 6$; or the same dotted line would indicate that $6 \div 2 = 3$, or $6 \div 3 = 2$, as the case might be. By copying all the small lines from the slide-rule, the answer can be read more accurately, where fractional numbers are to be divided or multiplied by fractional numbers, as in the case of the "rawhide chart," Fig. 1.

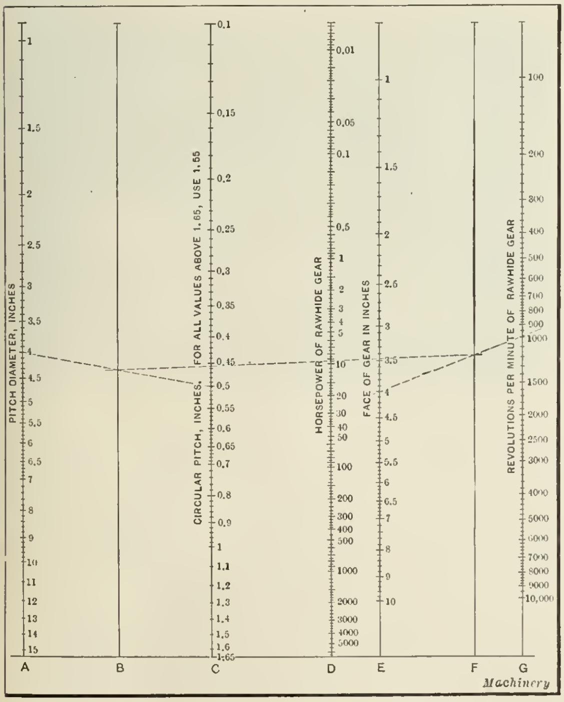


Fig. 1. Chart that facilitates making Calculations for checking up Rawhide Pinions substituted for Cast-iron Pinions

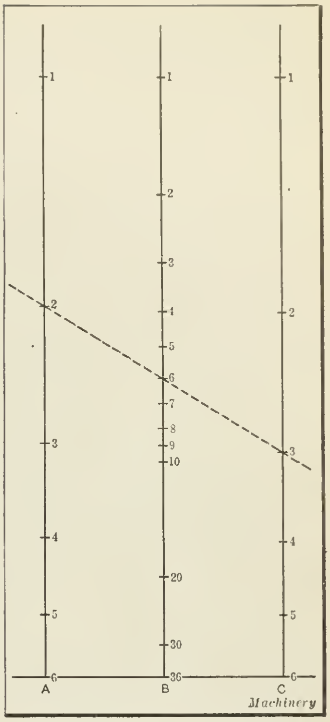


Fig. 2. Diagram showing Principle of Construction of Chart shown in Fig. 1

Now, suppose it should be desired to make a chart from the formula:

$$\frac{PV}{550} = \text{H.P.}$$

where P = pressure in pounds;
V = velocity in feet per second;
H.P. = horsepower.

Proceed as above by erecting columns *A* and *C*. If the pressures range from 1000 pounds up, insert the figures 1000, 2000, etc., instead of 1, 2, 3, etc. And if the velocities range from 10 feet per second up, do the same with the column that is to designate the velocity—either column *A* or *C*. Then lay a straightedge across the chart connecting two points, and figure what the middle column should read. That is, if $P = 11$ pounds, and $V = 100$ feet per second, H.P. will equal 2. The 1 to 100 scale of the slide-rule is then copied onto column *B* in such a way that 2 falls upon the point of intersection with the straightedge, and the chart is correctly made. In case it is desired to multiply H.P. by some other figure, this is easily done by extending the chart and adding more columns, the same principle being followed as before. The "rawhide chart," Fig. 1, is a good example of this, four figures being multiplied. I divided the multiplying process into two groups, as follows:

$$\underbrace{2 \times 3}_{6} \times \underbrace{4 \times 5}_{20} = 120$$
$$6 \times 20 = 120$$

The constant in the rawhide formula used was cared for in the manner explained. To be sure, all of these scales cannot be copied from a common slide-rule, but with the aid of a pair of proportional dividers it is easily done. The 1 to 100 scale on the slide-rule, for example, is a one-half reduction of the 1 to 10 scale. In case the range of figures should be such that we would need a 1 to 10 scale on column *A*, and a 1 to 100 scale on column *C*, it is plain that a 1 to 1000 scale would be needed on column *B*; but column *B* would not then fall exactly in the center, as on this multiplication chart: it would fall at a "third distance." That is, the distance *AB* would be two inches, and distance *BC* would be one inch. Column *A* would then be a full-size scale; column *C* a half-size scale; and column *B* a third-size scale. Proportional distances would be as follows: $BC = 1$; $AB = 2$, and $AC = 3$.

After studying this brief description of the method of making charts and application to the "rawhide chart," little difficulty will be experienced in making a similar chart on some other subject. Unless logarithms and the slide-rule are understood, it will be difficult to make charts of this kind; but understanding these subjects, as I believe all readers of

MACHINERY do, further details will be unnecessary. Should it be desired to study the subject more fully I would recommend J. B. Peddle's book, "Construction of Graphical Charts," or Lionel S. Marks' new "Mechanical Engineers' Handbook," which gives a good brief summary of nearly all methods of constructing graphical charts, including the one here described.

* * *

CATALOGUE INDEXING

When anyone picks up a catalogue for the purpose of looking up some matter presumably contained therein, he naturally looks for the subject in which he is interested according to the alphabetical arrangement in which it would most likely be found. For example, if a man were looking for information on the subject of milling machines of the Lincoln type, he would first look under the heading "Milling Machines, Lincoln Type," which should be found under "M." If the machine were not found under this alphabetical arrangement, due to a faulty method of indexing, one would look next under "L" for "Lincoln Type Milling Machine." Failing to find it under either of these heads, the next step would be to seek for the machine itself by looking through the pages of the catalogue.

Now an index is for one purpose and one only, and that is to give a seeker after knowledge the knowledge that he seeks, and unless it is arranged so as to give the seeker this information, it is without value as an index. There are a number of ways in which the index to a catalogue can be arranged so that the information contained therein will be conveniently accessible. There are other ways in which the information can be so classified that the only method of finding anything is to look entirely through the index until the part wanted is discovered. As a general thing, the preparation of catalogues is under the supervision of the sales or publicity department or the advertising department of the factory. The viewpoint of any one of these departments, in regard to the catalogue itself, is that it should be first, last and all the time, a medium by means of which the particular merits of the machines can be exploited. Under these circumstances the index naturally receives scant attention, and in some cases it is even left out altogether. When a manufacturer is advertising only one line of tools and has prepared a catalogue containing a very few pages, the index is not of great moment, because it takes little time to look through and find the information. On the other hand, a manufacturer who makes several different types of machines in a number of sizes, together with attachments of various kinds used in connection with these machines, should use every effort to make the index of his catalogue both comprehensive and convenient for reference. Under these conditions, there would seem to be little excuse for an index which does not fulfill these requirements.

A catalogue is not infrequently found in which the index is arranged by page numbers entirely, no attention being paid to alphabetical arrangement. For example:

	Page
Milling Machines, Single-spindle..................	3
Milling Machines, Duplex..........................	7
Single-spindle Profiling Machines.................	14

and so on right through the catalogue. Now it is evident that where there is no alphabetical sequence anyone looking for any particular type of machine must go through the whole index in order to find it.

Another index of a type which is to be deplored is one in which the indexing is not done under the proper letters. For example, "Hand Milling Machine" might be found under "H," which would be all right providing there were a cross reference to it under "M" for "Milling Machine, Hand." Then again, there is the type of index in which there is an attempt at alphabetical arrangement, but where other data such as

No. 5 Milling Machine
No. 6 Milling Machine, or
Universal Milling Machine

come before the head under which the machine properly should be indexed.

Many manufacturers of the present day are issuing their catalogues in the form of leaflets, each one of which contains information on a certain type of machine. No doubt this is an excellent arrangement from the viewpoint of economy, and it is also very good for anyone wanting information on one particular thing. It is then unnecessary to look through an entire catalogue to find the machine desired, as all necessary data will be found in the leaflet. Going a step further, however, these leaflets are sometimes bound together to form a catalogue, a printed page or two being added for an index. When this is done, the index page serves no other purpose than to indicate the kind of machines contained within the outside covers, so that if anything is wanted a search through the pages must be made to find it.

It would seem that the index to any catalogue should be of sufficient value to take a little trouble with it in order to make it as comprehensive as possible, so that it would not be necessary to search through the book to find any desired information. As a suggestion, the following is offered in the hope that it may prove useful to those engaged in the preparation of catalogues:

1. Arrange index alphabetically according to the principal name of the machine tool or other mechanism.
2. Cross index under as many heads as may be consistent with the commonly accepted name of the mechanism.
3. Place the index either in the front of the catalogue or at the back—not in the middle.
4. When a number of leaflets are bound together to form a complete catalogue, either have the entire group of leaflets paged, with an index in the front, or put a table of contents in the front and place colored inserts between the various sections so that they can be easily distinguished.

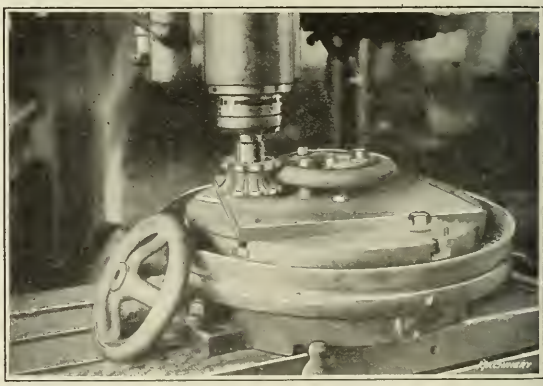
Any advertising, sales, or publicity manager will find it of advantage to look into the manner in which a new catalogue is being indexed and endeavor to arrange it so that it may be of some real use to a customer rather than a source of annoyance. A. A. D.

* * *

FINISHING HANDWHEELS BY MILLING

In the manufacture of contract machinery at the plant of the C. H. Cowdrey Machine Co., Fitchburg, Mass., a regular job is the machining of large numbers of handwheels. These particular wheels are 8 inches diameter, and the rim is 1⅛ inch diameter. The ordinary way of finishing the rims of these wheels is to mount them on arbors in the lathe and turn off the exterior with a radius-turning attachment.

The accompanying illustration shows how these handwheels are finished in this factory by milling on a vertical milling machine. By mounting these wheels on the rotary table of a vertical miller and inserting a concave cutter in the spindle, they are finished at one revolution of the table. About 1/16 inch of metal is removed from the surface, and when the castings run uniform fifty wheels may be milled before it is necessary to grind the cutter. The result is a better piece of machining, and the operation requires less attention from the workman than when done by the old method. C. L. L.


Finishing Handwheels on a Vertical Miller

* * *

The wax of old phonograph records may be used with satisfaction on tracing cloth when erasures are necessary. The wax rubbed over the erased portion gives the paper a gloss and finish similar to the original surface and prevents the ink spreading in the lines.

MANUFACTURE OF AUTOMOBILE CUSHION SPRINGS[1]

MEANS AND METHODS OF FORMING, CONVEYING AND TREATING WIRE SPRINGS IN A MODERN PLANT

BY E. F. LAKE[2]

Fig. 1. Roller Conveyor on which Coils of Wire are brought into Shop

WHEN the Detroit Wire Spring Co., of Detroit, Mich., moved into its new building last November, it started to manufacture the seat and back springs for motor cars by methods that have eliminated hand labor to a great extent. Gradually other places were found where savings in labor cost could be effected, and now this firm is manufacturing at a minimum cost of production. For several years manufacturing was conducted in buildings that were not adapted for improved methods; and during this period L. A. Young, president of the company, had conceived many ideas that were awaiting the proper time to be given a practical application. When the company outgrew its old quarters, it built and equipped an entirely new plant from the ground up. This gave Mr. Young an opportunity to exercise his inventive genius to a marked degree, and the apparatus that was installed completely changed the process of producing such springs. This lowered the cost of production to such an extent that it is the talk of the spring-making industry.

Fig. 1 shows about half of the second floor of this new shop, and it is here that production may be said to start on seat and back springs for automobiles, or cushion springs for any other use. As this firm manufactures all the cushion springs used by the Ford Motor Co., one might think that the latter has had an influence on the Detroit Wire Spring Co. as regards the application of conveyor systems for handling work. After investigating the appliances in this shop, however, it will be seen that Mr. Young has advanced beyond the achievements of the Ford Motor Co.

In Fig. 1 is shown how the coils of spring wire enter the shop and are delivered at the various stations, where they are manufactured into springs by the coilers and knotters. These coils are loaded onto an elevating conveyor at the freight car on a track outside the building. This raises them to the second story and drops them onto the roller conveyor shown in the illustration. The coils then enter the building at *A*. After that they travel down over the rollers, as can be seen, and are dropped into chutes at the different points marked *B*. These chutes deliver the coils to the floor just back of the coiling machines, which can be seen at the left running in a long row through the center of the building.

The roller conveyor can be switched open at five different points to allow the wire to pass through chutes to the floor. Coils are needed at three other points below the lowest switch in the rollers, but at these stations the rollers are so low that the wire coils can easily be lifted off and thus switches are not needed. This roller conveyor is approximately 200 feet long and serves one-half of the shop, which is 400 feet long and 80 feet wide. Fig. 2 shows how the roller bed is broken to allow the wire to slide down chutes to the floor. Directly underneath at *C* is shown the reel of the coiling machine, on which the wire coil is placed to be made into springs. As the coiling machines form a line along one side of the columns and the conveyor follows the other side, the coils of wire drop to the floor within three feet of the spot where they are to be used.

Fig. 3 shows a close view of one of the coiling machines as it is set up ready for work and just about to cut off a spring which has been coiled. These coiling machines are manufactured by the Frank Wells Machine Co., of Kenosha, Wis. The spring wire in the coils is placed on reel *C* and passes into the machine through guide *D* and rollers *E*. Guide *D* has a set-screw to govern the tension of the wire, the same as the thread on a sewing machine. The diameter of the coils of the spring is governed by the wire passing through clamp *F*, which moves up or down toward a given center or away from it. This movement is caused by lever *G*, which rides on cam *H*. Thus, cam *H* is the only part of the machine that has to be changed for making different kinds of springs. Each size and shape must have its own cam, but to change these it is only necessary to manipulate one nut, shown on the side of the cam.

The only limit to the size and shape of springs that can be coiled is in the limitations of these cams, which are located where they can be given a larger diameter than would ever be required for springs of this kind. When the spring has the correct number of coils, tool *I* is tripped and cuts off the wire. The operator of such a machine only has to place the coil of wire on the reel, start it feeding into the machine, and grab the springs as fast as they are cut off. He then bunches them and puts them in the pan of truck *J*. This sounds easy, but the men are kept exceedingly busy and are paid by the piece. After watching them for a while one wonders how they can handle so many pieces and keep it up for ten hours every day. At many of these coilers troughs are arranged so the coilers can slide the springs to the knotting machines, where the second operation is performed. One coiling machine usually turns out enough work for two knotting machines.

In Fig. 4 is illustrated one of the knotting machines. At *K* is shown a sample of the spring that the pan contains, in the shape in which it is left by the coiler. Coiled springs would not be very successful if they were left in this condition, for when used in seats the ends would be likely to get as many cuss words as the boy with the bent pin. Hence, machines were invented for looping each end of wire around the coil below, so they would not cut through the upholstering. These loops, or knots, tied in each end of the wire spring, are shown on the spring at *L*. The operator of the machine first places the spring in the position shown at *M*, and the lower coil is then gripped by jaw *N*. Cam *O* controls its movements

Fig. 2. Close View of Chute down which Coils drop from Conveyor to Floor

[1]For previous articles on spring manufacture, see "Automobile Cushion Springs" in the August, 1916, number of MACHINERY, and other articles there referred to.

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Fig. 3. Close View of Coiler with Spring ready to be cut off

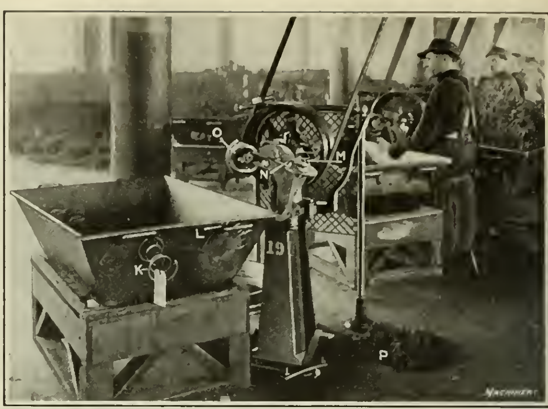

Fig. 4. Knotting Machine that secures Ends of Wire to Spring Coils

and also the movements of those parts of the machine that tie the knots. When the knots are tied, the operator merely drops the springs into a hole in the floor at *P*. and they pass through chutes to the workmen on the floor below. The knotting machines, which are fed by the coiling machines, form a line through the center of the shop only a few feet away from the coilers. Approximately one-half the length of the shop is taken up by these two rows of coilers and knotters.

In Fig. 5 are shown the chutes through which the springs come from the knotting machines on the floor above. There are 106 of these chutes; half are on the side here shown, while the remainder are placed to the left, back to back with these chutes. They occupy the center of the shop, lengthwise. An operator sits at the machine in front of each pair of chutes and takes the springs from them to form them into what are called "strips." To make these strips, sheet metal ribbons are bent to a U-shape like those shown at *Q*. One of these is clamped to each side of four springs, and the whole is long enough to give the completely assembled spring its desired width. One strip that has just been formed is shown in the first machine, and others can be seen on the rack and floor. These strips are passed over the rack at *S* to other workers, who assemble them into full-size seat springs. When the strips are made faster than the assembler can handle them, they are stored underneath the rack, as shown at *T*.

Fig. 6 shows the benches where large seat springs for Ford cars are assembled. The assembler starts with a foundation frame like that at *U*, which is in two pieces. These pieces are made by passing band iron or strip steel through rolling machines that form it into a shape similar to channel iron. When these two pieces are riveted together, they form a foundation frame that gives the completed seat spring its size and shape. The first work of the assembler is to fasten the strips, consisting of four springs each, to this frame. First the two end strips are located as shown at *V*, and then the center strips are filled in as illustrated at *W*. After that the wire frame shown hanging on the column at *R*, is clamped to the top of each coil spring around the outside of the assembled seat spring. The ends of this frame are welded together to make it continuous.

The next operation is to fasten all the individual springs to this wire top frame with specially bent wires that pass from side to side of the assembled springs. Next, similar bent wires are run lengthwise of the seat spring and are clamped to both sides of each coil spring, and to the wire frame at both outer ends. The final operation is to clamp the centers of all the coil springs together. To do this, hoop iron or band steel is cut to length and bent into shapes that hook over and are bent around the center coils of the springs that are nearest together. Thus each spring is securely fastened at the top, bottom and center to each spring on its four sides. This keeps them in their correct position. Thus, when one spring is compressed it gets support from all the other springs in the assembled seat; and the more it is compressed the more support it will get. The reason for binding all the individual coils together so firmly is to prevent them from working loose from the hard usage an automobile seat gets when the car is traveling over rough roads. You will know what that means if you have ever taken a ride that bounced you up in the air until your head struck the top, which drove you back into the seat so hard that it flattened every coil spring, to say nothing of your bones.

In Fig. 7 is shown the overhead trolley system that passes over the assembling benches and conveys the seat spring through the japanning department and on to the shipping room. When the springs are assembled, they are hung on hooks suspended from gas pipe carriers, like those shown at *Y*. With bolts *X*, these are hung to four-wheeled roller-bearing trolleys that travel inside the tracks. As will be seen, single-track *Z* passes in front of the chutes and branches curve out from this to run over the assembling benches, with a switch

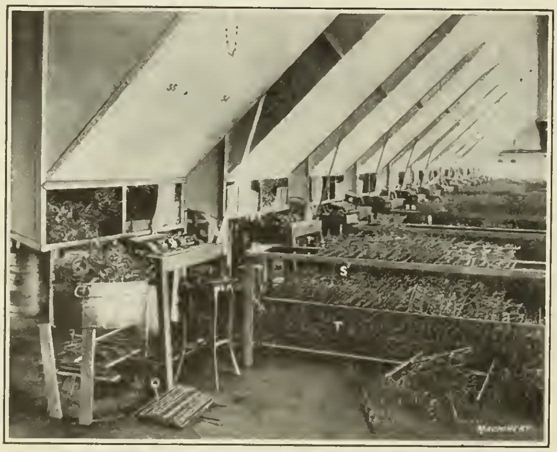

Fig. 5. Forming Springs into Strips ready for assembling into Frames

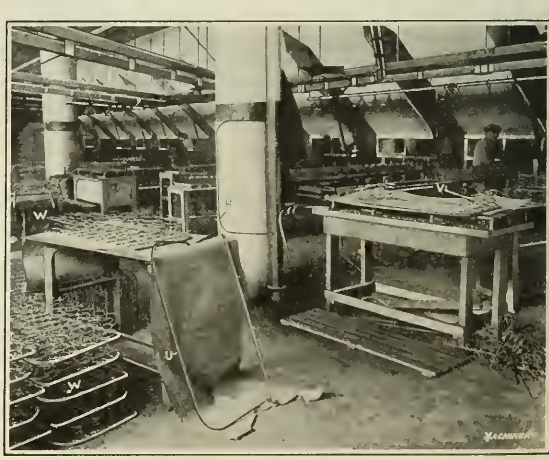

Fig. 6. Benches on which Seat Springs for Ford Cars are assembled

Fig. 7. Conveyor System for carrying Springs to Japanning Department

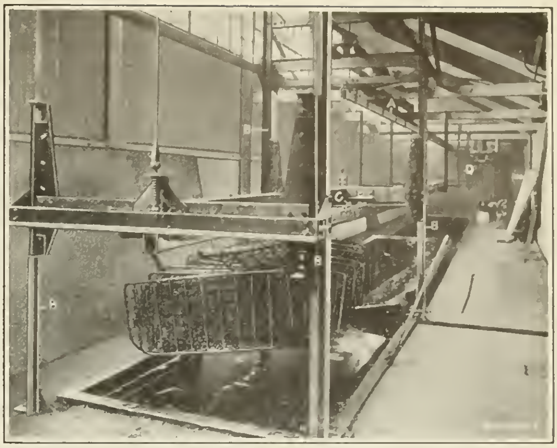

Fig. 8. Arrangement of Japan Dipping Tank for Assembled Springs

at each branch. These branches merge into one track again, next to the wall on the right, and at the far end this curves into the japanning room, which is at the other side of this wall. In front of the chutes will be seen the strip makers and in the center the assemblers.

With the methods of manufacture used in the old shop it took approximately two and one-half men to make as many springs as are made in the new shop by one man. The greatest saving in labor was effected at this point; but the japanning methods, described later, ran a close second, and important improvements in efficiency were made in the back springs department, now located on the third floor of the building. Here one can readily realize the saving in labor by observing how the coilers pass the coiled springs to the knotters; the knotters drop them through a hole in the floor (Fig. 4) into chutes; the strip makers pick them out of these chutes on the floor below, Fig. 5, make them up into strips, and pass them over racks to assemblers; the assemblers complete the seat springs, Fig. 6, and hang them on hooks overhead, while one man pushes the loads into the japanning room.

When the loads of springs enter the japanning room they roll onto a loose piece of track under the hoisting apparatus, which lowers them into the japan dip tank, as shown in Fig. 8. The springs enter the japan room on the track level shown at *A*, and the four posts *B* act as guides for the hoisting apparatus, so that the loose piece of track can be brought into alignment with the two different levels at *A* and *C*. This view shows one load of springs as it is being lowered into the japan. When coated with japan, the load is raised back to one of the two track levels, and the springs travel over a drain board some thirty or forty feet long, where the excess japan flows off. The japan is thinned with naphtha, and if this draining were not done the japan would be likely to catch fire from the heat in the baking oven. After that, the spring loads are rolled into the japan baking oven *D*, shown at the far end of the illustration.

This company had a serious explosion with gas-fired japanning ovens in the old shop, which ripped apart the oven and blew out one side of the shop. Hence, it was decided to use fuel oil for heating the oven in the new shop. Incidentally, the saving in fuel bills is something over $200 per month—with fuel oil at the war price of 5½ cents per gallon. How dangerous the japan baking proposition is, if the work is not drained properly, and the baking done in an oven that is not constructed, fired and vented correctly, is shown by the fact that electric heaters exploded the japan fumes in an electric oven used in Detroit and nearly caused the death of the oven tender, who remained unconscious for two days. It also caused so bad a fire in this works that the management decided to throw out the electric plant and not do any more japanning.

Fig. 9 shows the opposite end of the japan baking oven, where the springs are pulled out and sent into the shipping room. Alleyway *I* is where the oil burners are located for heating the ovens. These burners are of the megaphone type and shoot the flames into 10-inch pipe coils. The spent gases leave these pipe coils through sheet metal pipe *J*, which conveys them to a central stack. It will be seen that four tracks, on two different levels, carry the springs through the oven; and the door of one compartment stands open, ready to pull out the springs. The springs seen in the oven seem to occupy a very small part of the space, but they fill the oven much more completely than this view would indicate, the illusion being due to the fact that the springs were some ten feet back from the door. The two different track levels are shown at *F* and *G*. Two tracks *F* switch into one, and the springs travel

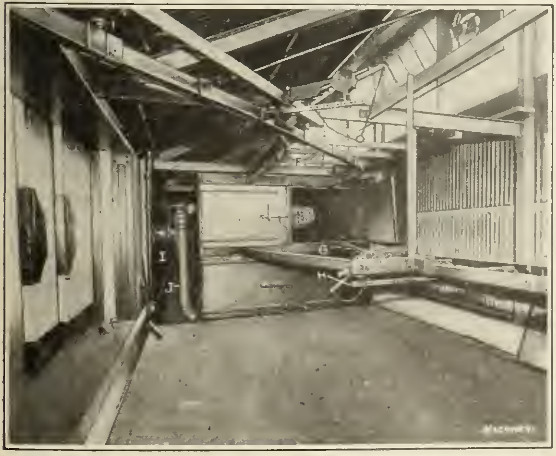

Fig. 9. Delivery Door of Japan Baking Oven and Conveyor leading to Shipping Room

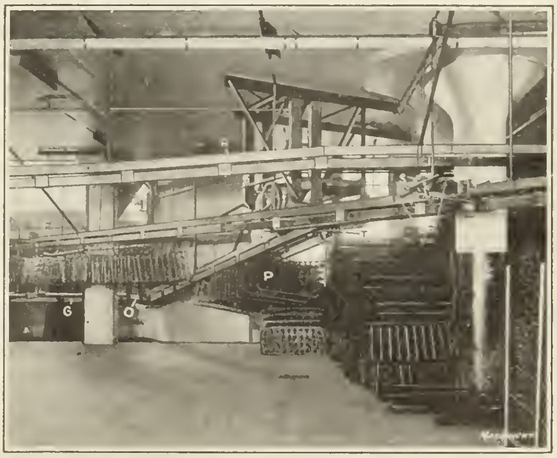

Fig. 10. Means of elevating Springs from Track Level G to Upper Level F

over this directly into the shipping room; tracks *G* are merged into one by switch *H*. This track curves into the shipping room, which is located just to the right of this view. There the work is raised to the track *F* level, and from there on all the work travels over the same tracks.

Most spring makers consider that 450 degrees F. is the best temperature for the japan baking ovens. They claim the work of coiling, knotting, etc., sets up strains in the wire, which this temperature will relieve. While the wire is supposed to be hardened and tempered properly before it leaves the wire manufacturer, they say it must be drawn again at 450 degrees F. to prevent breakage of the springs after they are coiled. This temperature has proved to be the best for drying out the japan and producing a very hard coat. It may be, however, that the japan makers have made their japans fit this temperature on account of the necessity of tempering the steel. However that may be, these two things are accomplished by heating the springs to 450 degrees F. while the japan is being baked.

In Fig. 10 is shown the apparatus that brings the work from lower track level *G* up an incline to the level of track *F*. An electric motor moves a conveyor chain around two sprocket wheels, one of which is shown at *T*. When the load of springs reaches the position marked *O*, the hooks on this conveyor chain grip the load and haul it up the incline, as shown at *P*. At switch *S* the springs from both the upper and lower levels are switched onto one track; and from here onward they are either unloaded to be crated for shipment in freight cars or loaded directly into motor trucks to be carted to various shops in Detroit. The empty spring carriers are then sent over track *R* back to the assemblers, where they are reloaded for another trip. None of this apparatus is very high in first cost or cost of upkeep. Thus one can readily see that such costs are soon paid by the reductions made in the payroll.

* * *

PAROL CONTRACTS IN THE SHOP

BY ERIC LEE[1]

The rapid development of machinery and machine parts, the keen competition of the market, and the scarcity of skilled labor have often brought the management of machine shops face to face with untold difficulties. Oftentimes it is essential that fixtures or jigs be made for certain operations on production work within a time limit. In many shops the work of making such fixtures or jigs is let out to the workman by what is known as simple or parol contracts. Under this system one of the workmen agrees to do the work for a certain sum, and the firm usually agrees to pay him his regular wages and, if the bid is in excess of this amount, the balance of the bid.

The method of putting these contracts into the works is somewhat as follows: Contract sheets and the blueprints of the mechanical device to be made are sent to the shop foreman, who gives them to the workmen whom he thinks can do the work. These study the blueprints, put their bids in sealed envelopes, and return the prints, together with their bids, to the foreman. The bids and blueprints are then sent to the planning office and compared with the estimate which has been made out by the works estimator. If the bids are too high, the blueprints are again sent into the shop and other workmen asked to make bids for the work.

The advantages claimed for this method are: rapid execution of work, decrease in supervision required, and reduced cost of labor. Among the disadvantages are: inferior workmanship, excessive wear of machinery and tools, dissension among workmen, and higher cost of shop production.

In regard to the first advantage claimed, it may be said that while the work is done rapidly, the workmanship is frequently poor. As a result, an unsatisfactory jig or fixture must be used because there is not time to make another. Less supervision is required because a man building a jig or fixture by contract will stick fast to his work, and should he have any men or apprentices working for him, he will so plan the work that the men and boys are not at any time idle. He will see that one piece follows another, and that while some work is in the hardening shop there will be other material to work upon. He will also see that each piece is milled, ground, slotted, drilled or tapped properly; and that the proper screws, studs, dowels, etc., have been assigned to him.

The cost of labor is frequently decreased because apprentices are called upon to use more of their ability, and work is given to them that would be given to a journeyman if the work were done by the day instead of by contract. Besides, the contractor uses more ingenuity; he tries to devise some way to do this or that operation more quickly. For instance, he thinks out whether he can better rough-mill six pieces at a time with a gang mill or take each piece and finish it separately; he determines whether it would be more profitable to make a temporary jig for certain parts or to lay out each part individually. If a similar jig or fixture had been made before, he will try to remember what work of the other contractor should be copied and what work should be avoided.

The plan has the disadvantage that the work turned out is often of an inferior quality. A man who forms the habit of rushing work gets careless and slovenly, easing his conscience with the expression, "There's nothing particular about that; it will pass inspection all right." To inspect a complicated fixture requires considerable time for taking down and rebuilding. If a fixture is inspected and rejected two or three times, the cost of inspection should be considered dead loss.

Another disadvantage is the excessive wear of machinery and tools. Machinery has come to the scrap pile too soon through machine parts being made by contractors. One contractor, when spoken to about the abuse of a new Brown & Sharpe milling machine, retorted, "What spoils this machine helps to buy another." When busy, the contractor frequently forgets to lubricate the machine until some trouble arises. The cost of machine tools is a considerable item, and with the rush a mill or cutter is easily broken, a splining tool snapped, a drill burnt, or a tap or reamer put out of business. In addition, special cutters are often used, and the cost of making special cutters is well known.

Contracts also cause dissensions among the men. The contractor may tie up a number of the machines to the disadvantage of his fellow workmen. Besides, he may leave the machines dirty, for he can make money on his contract only by getting the work out at an early date.

Contract work increases the shop's production costs, for the contractor on a rush job has the privilege of breaking down the men's work because he needs that lathe or this milling machine, when perhaps it has taken two hours to set the machine up for the day-work job. Then again, the time taken by three or more men estimating upon one contract should be considered, as well as the extra clerical help involved.

All manufacturers are striving for maximum production with minimum cost, and many workmen have the best interest of the employers at heart. Experience, however, teaches that jigs and fixtures cannot be made hastily. One of the safeguards of good work is time, and oftentimes the good results are worth the additional time expended. It is comforting to know that the shop is working in perfect harmony. Each man is only capable of a limited amount of work, and a good foreman knows where that limit lies, and is keenly alive to the urgency of each particular case, so that by proper supervision he can speed up deliveries, unhampered by the trouble of carrying on individual contract work in the shop.

[1] Address: 195 Bassett St., New Haven, Conn.

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About the time when the low-priced automobile became so popular that everybody bought at least one, a gentleman down in Alabama who had some capital laid by and nothing of a commercial nature to engage his time and energies decided to re-enter commerce. After casting about for some time, he fixed upon the buggy business as an attractive venture, and accordingly bought an outfit for a buggy factory. A friend across the border, in Tennessee, heard of the new enterprise and was moved to write the proprietor a letter.

"Dear Charley"—he wrote—"I hear you are going to make buggies. I wish you good luck. But I would like to make a suggestion: If the buggy business should grow slack, why not do over your plant and go in for the manufacture of flintlock muskets?"—*Saturday Evening Post.*

NOTES ON THE MACHINERY INDUSTRY IN EUROPE[1]

PROBABLE CONDITIONS OF THE MACHINE TOOL MARKET AFTER THE WAR—RUSSIAN TRADE OPPORTUNITIES

BY ALEXANDER LUCHARS[2]

AMERICAN manufacturers are interested in the uses to which the European machine tool and munition plants will be put after the war. Most of the latter, not especially constructed for munition work, will return to their former products; but some will take up the production of machine tools and supplies, and of course the former will continue in their present lines with extensions, as is the custom with European manufacturers. Their weakness is the lack of specialization, caused by their generally limited markets. The English machine tool manufacturers are wide awake to the fact that they have neglected the European market, and they quote the German export figures of more than $15,000,000 in machine tools in 1913 against their own export figures of $3,750,000. When the war broke out they found that most of the machine tools in their factories were of foreign origin, and they are firmly resolved to change this policy. The production of British machine tools has acquired a strong impetus through the war demands. Manufacturers there have accumulated considerable profits in spite of the heavy taxes, and a fund of practical experience as well, which they will not fail to utilize in producing tools for their own and other European markets.

Besides the productive capacity of the machine tool plants of Great Britain we must also consider those in neutral countries like that at Oerlikon, Switzerland, and of A. S. Nielsen and Winther, Copenhagen, Denmark, said to employ one thousand hands. These and others like them are war developments and will continue in the same line of product. They probably will endeavor also to improve the quality of their product so as to approach that of the best American manufacturers, which is everywhere recognized as the standard. There will be no market in Europe for cheap American machine tools, but there will be for high-grade tools of reputation, such as milling machines, automatics, turret lathes and other highly specialized tools, some of which are not now made in Europe at all, or if they are, not in sufficient quantities to keep the cost low and the quality high. I believe that a home market is necessary to insure the successful manufacture of such products, and the American specialist who can keep his own costs down by producing in large quantities should be able to undersell the manufacturer in a limited market, even if the latter is protected by tariffs and freight charges. This condition can be met and overcome by a continued advance in our manufacturing methods, and by an increase in our ability to give better value in such products than can be obtained in Europe.

Women will continue to be employed in the European machinery industries: first, because their efficiency has been a revelation to employers; second, because they have never yet left an occupation in which they secured a foothold; and third, because many of them will be obliged to support crippled husbands and kinspeople, and the state will not countenance any effort to thrust them out of the shops under such conditions. High prices for all commodities, in my opinion, will continue to prevail; and with the reduced labor supply, wages will not decrease. Unless there is a period of general unemployment they may even go higher. This general increase in costs should bring production costs nearer those of American manufacturers, and with improved methods our manufacturers should be able to compete more nearly on a cost equality with those of Europe.

There is no hostility toward Americans except in Germany and Austria; but the national and industrial policies of Great Britain and her Allies are shaped to confine their purchases of war material and of every other kind to home products whenever possible, for the purpose of reducing their adverse trade balances and to keep the business at home. The Ministry of Munitions is endeavoring to reduce the orders for machinery and material placed in the United States, and when that is not practicable, to reduce the prices being paid. The recent contract clause which provides for cancellation after September 1 is made to provide for control over both. An order recently issued by the same authority requires "the most rigid economy in the use of skilled labor and material, and that no machine tools be purchased for carrying out government contracts unless it is impossible to use existing machines." In certain cases orders that have been placed for tools have lately been cancelled, and the work for which they were intended has been transferred to other firms who have facilities for doing it without purchasing additional equipment. These measures indicate the close, rigid and economical control which is now being exercised by the British government over the purchase of all kinds of war material. The period of waste and enormous profits is past.

This policy, in my opinion, will continue to be enforced by all the European nations, and will affect our exports of machine tools after the war; but we can hardly criticize them when we have made so many millions out of their necessities during the past two years.

It is thought in Great Britain that government control of the railways will be continued after the war, as it has worked out very satisfactorily; but it should be remembered that the British railroads are being run by their former experienced managers, who are working together in friendly cooperation, with all competition and wasteful duplication of service eliminated, and with the help of the government's autocratic power they have accomplished wonders. When these men are replaced with a bunch of politicians, the results may be different, as they were in France before the war.

Russia is now being widely exploited as an unlimited market for American products, and a number of statements have lately been published describing the opportunities for American manufacturers to establish plants in that country. This is doubtless practicable for industries like that of the International Harvester Co. or the Singer Sewing Machine Co., for whose products there is an expanding market; but there is no opening in Russia at present for the manufacture of machine tools and supplies, because the demand is too limited. Russia has vast natural resources, principally agricultural; also great mineral wealth and some manufacturing. Metal manufacturing has been undertaken there only to a limited extent and its growth will be slow, for while Russia will develop greatly after the war, if no revolution intervenes, its expansion will be along lines that will not immediately benefit our manufacturers of machine tools. Russia will buy from Germany very soon after the war closes. The feeling between them is less bitter than between any other two "enemy" countries. Germany makes many cheap products that Russia needs and cannot get elsewhere at as low prices and in the forms desired, and Germany pursues a commercial policy of granting long-time payments instead of demanding cash, as our manufacturers must until banking connections are much better than at present. Thousands of Germans have married in Russia, and there are many influential native Russians with German names and affiliations, so that while the German influence will probably not predominate as before the war, it will continue to be powerful, socially and politically, and will be exerted to help Germany commercially.

Americans are more popular in France than elsewhere in Europe, because they have been permitted to take a more active part in the war relief work there than in any other country. There are any number of American hospitals in France sustained by American money and operated by American workers; and as everyone knows, there are thousands of Americans actively employed, not only in war relief work, but in the French army. This and other well known causes have embittered the Germans against America, and we shall have difficulty in re-establishing our commercial relations with

[1] For previous articles on the conditions of manufacturing and the machine tool trade in Europe, see the September and October numbers.
[2] Publisher of MACHINERY.

Germany. The antagonism in that country against the different nations may be rated about as follows: (1) British, (2) American, (3) Japanese, (4) French, (5) Russian. As the European demand for machine tools has been confined to those used for munition work, it was rather difficult to get information about new machines which might be profitably exported from this country. There seems to be a market for relieving lathes, for tool grinders known in England as the Lumsden pattern (which are of a somewhat similar type to those made by Gisholt and Sellers for grinding lathe and planer tools), for "capstan" attachments for engine lathes, and for spur gear grinders.

There are numerous cases where machine tools employed on munition work have been worn out or broken up by bad usage, but I think that is the exception rather than the rule, and that the percentage of such machines will not be large. The amount of machine tools necessary to re-equip plants that have been destroyed or stripped by the Germans is difficult to estimate. On the Eastern front the amount will be small, because there are few machine shops there; in Belgium, if reports are correct, it will be quite large. How many will be replaced from equipment that will pass out of use when the war ceases is a question. If the present British policy in regard to the purchase of machines is carried out generally, none will be bought that can be replaced from "stock." The French and British governments are working in close cooperation on all such details. A considerable portion of the losses in the fighting area of France, outside of large cities, will be confined to building material and household furniture; and the reconstruction, for a time at least, will be of inexpensive character, similar to the buildings now being shown in the Tuileries Gardens on the Place de la Concorde in Paris. The number of machine tools required in the cities in that part of France will be considerable, but hardly sufficient to greatly increase the exports from this country in view of the possible way in which accumulated material will be handled.

It is almost as difficult to answer the inquiry as to our moral and business standing with European countries as to say when the war will end. The reputation of our well known, reliable manufacturers is just as high as ever; but some newcomers in the machine tool field, and others who should know better, have injured the American reputation by failing to keep their promises and by delivering machines which should never have left their shops—with all due allowance for labor and material troubles here. It surely pays in the long run to so deal with a customer that he will wish to continue the business relation; but some of our manufacturers have not followed that policy.

* * *

From time immemorial, manuscripts, plans and drawings have been rolled or folded with the back or blank side out. The reason, of course, is that it seems desirable to cover the face of a drawing and protect it from injury. The disadvantage of the practice is that a drawing rolled with the face inside is difficult to straighten out and use. It will curl up when lying on a table for a long time after being released. It was pointed out some years ago that it is better practice to roll drawings with the face out. Then when they are released and laid on the table face up the tendency to curl lifts the center rather than the edges. The result is that the drawing soon straightens out and lies flat. In view of this, it was suggested that the practice of publishers of magazines be changed so that the magazine be rolled or folded for mailing with the front cover page out. MACHINERY was one of the first publications to adopt the plan, and now the practice is becoming general. Many of the large publications, such as the *Saturday Evening Post*, the *Ladies' Home Journal*, etc., are rolled with the front cover out. A magazine so rolled may be laid on the table after removing the wrapper and in a few hours it straightens out and lies flat. Of course the same action would take place if rolled the other way, provided the magazine was laid down with the back cover up, but the universal tendency of everyone after tearing off the wrapper of a magazine is to lay it down with the front cover up. By simply reversing the process of rolling, the general practice is made to counteract automatically the defect caused by rolling or folding.

CASTING AND MACHINING MALLEABLE IRON PARTS

BY H. W. JOHNSON[1]

Malleable iron is a material with which all experienced mechanics have had to work, although shops engaged in the manufacture of pipe fittings, agricultural implements and hardware are probably the largest users. The production of small hardware parts and pipe fittings presents some of the most intricate problems which the foundry encounters; but such parts are comparatively easy to handle in the machine shop, owing to their small, compact form, which does away with trouble from distortion. Large quantities of thin, crooked malleable iron parts are used in the construction of all classes of agricultural implements, but more particularly on harvesting machinery; these parts have numerous lugs and bolting surfaces, none of which are machined, but which are required to bear a definite relation to each other and to certain holes drilled in the work. From the standpoint of production cost, it is desirable to drill out cored holes rather than to drill from the solid, and this still further complicates the problem, as the cored holes have to be brought into the proper relation to each other in order that they may "clean up" properly when drilled.

Among the difficulties commonly met with in the production of malleable iron parts, the following are worthy of special attention: (1) Variations in thickness due to poor or irregular ramming, excessive rapping or careless pouring of the metal. (2) Variations in length due to excessive rapping or unequal shrinkage. (3) Warping due to uneven shrinkage in

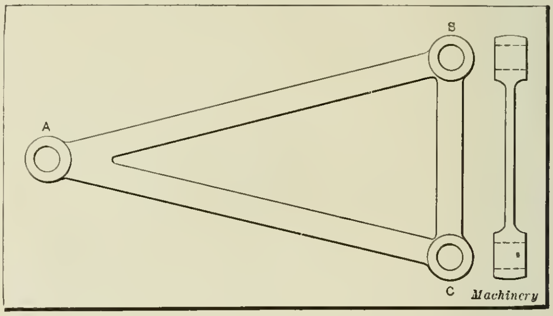

Fig. 1. Malleable Iron Casting with Three Cored Holes to be bored

the original hard iron casting or to poor packing in the boxes in which the heat-treatment is conducted. Variations in thickness are usually such that they can only be corrected by machining, the cost of which, in most cases, would be prohibitive. Occasionally, however, a casting can be hammered down at the working point by means of an operation performed under the drop-hammer with a die made to concentrate the effect of the blow at the important points on the work. A case in point is the knife head of a mowing machine, in which the knife is guided by a flange about ½ inch wide by ¼ inch thick and 4 or 5 inches long. This flange runs in a groove and must not be too thick. Where trouble is experienced with the casting, the steel die used on the drop-hammer sizes the head casting very nicely.

When castings are too thick to allow of the performance of the sizing operation of the kind referred to, trouble due to lack of uniformity in size can often be avoided by selecting the proper locating points when designing jigs or fixtures, if room has been provided for the excess stock to overhang where it will do no harm. The mowing machine knife head will serve as a further example to illustrate this point. In sizing the work to correct an error in thickness, the width must be neglected. In this piece a row of rivet holes is drilled to rivet the head to the knife, the work being located in the jig from the rear or guiding edge, so that the excess width overhangs on the front, where ample clearance has been provided. This point is one that must be carefully watched by every designer if he expects to secure uniformly

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satisfactory results in designing parts for which malleable iron castings are used.

Variations in length can sometimes be corrected if the casting has a curved section, into which excess stock can be forced or from which a small "draw" can be obtained without interfering with the usefulness of the casting. This is done by means of dies which will be described in a subsequent paragraph. A triangular casting with a cored hole in each corner, as shown in Fig. 1, would be hopeless if the cored holes had to be bored out clean with a definite distance between centers; but by changing the design to the form shown in Fig. 2, any ordinary error could be corrected by an operation performed under the drop-hammer. If such a change is not allowable, the only alternative would be to dispense with the cored hole in boss *A* and elongate the boss to provide the required compensation for variation in length; the hole would then be drilled from the solid metal to give the required distance between centers. The cost of production would be greatly increased by such a practice, because a twist drill running in solid metal cannot be depended upon to cut to size, while a three-lipped drill working in a cored hole will do uniformly good work. In other words, the drilling of holes from the solid would cost more in itself, and it would also be necessary to ream them in order to insure accuracy of size.

All ordinary errors due to warping can usually be corrected by "dropping" the malleable iron castings in cast-iron dies. If it is only necessary to bring the casting back to form in one plane the problem is a simple one, as a pair of dies parted on the horizontal center line of the casting will give the desired result. Should it happen that the casting requires considerable correction in a sidewise direction, as well as up and down, the dies will have to be made in such a way that the lower die is provided with a substantial wall which is a close fit around the important points on the work, but cut away to provide clearance for gates, etc. The upper die should come down inside without touching this wall, and provide pressure to give the desired form to the work. Such a die is well suited to the requirements of forming a piece of work of the kind shown in Fig 2, and it will not only form the castings, but will also correct errors in length and width.

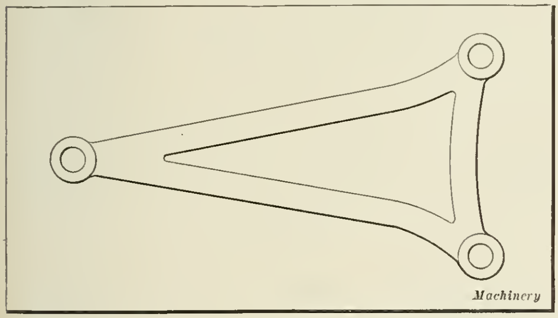

Fig. 2. Casting to replace the One shown in Fig. 1, with Curved Arms to compensate for Errors in Center Distance

In designing a lower die for sizing a piece of this kind, the bosses on the work should be made to fit snugly in the pockets in the die, but the webs should receive only a flat blow, the dies being designed to allow them to give in a sidewise direction to compensate for correction which must be made in the length and width of the work. If the bosses are longer on one side than on the other, the longest side should be placed underneath, because driving the bosses down into the pockets in the lower die results in providing the necessary correction in center distance. The bosses must be given plenty of side clearance in the top die to allow for the usual looseness of the head in the average drop-hammer found in malleable iron foundries, otherwise they are likely to be badly dented at the corners.

The angle at which the work is struck is a very important matter, and the patternmaker who makes the patterns for the die will have to turn his sample piece until he has found a position in which all important points will be adequately supported by the bottom die, and at the same time receive a fair blow from the top die. If one side of the casting is much stiffer than the other, the stiffer side should be placed in such a position that it will receive the heaviest part of the blow. Some pieces of work have so much spring that treatment under the drop-hammer has relatively little effect on them, and the best that can be done with such pieces is to use a heavy hammer with a relatively low lift, so that a slow, "soggy" blow is delivered without any rebound. Heating the work before hammering will help to make the blow of the hammer effective, but this is likely to damage the metal.

In machining malleable iron castings, the use of plenty of cutting compound is of the utmost importance, as a copious flow should be delivered to the work at all times. In drilling holes in solid metal, a moderate feed should be used with all the speed that the drill will stand; and for drilling cored holes with a three-lipped drill a cutting speed of about 65 feet per minute with a feed of from 0.030 to 0.065 inch per revolution will be found to give satisfactory results. In reaming holes, the best results will be obtained with a speed of about 30 feet per minute and the heaviest feed that can be employed. When facing operations are performed with sweep cutters, a flat blade should be used, which is set at an angle of 15 degrees top rake and a little ahead of the center to afford a shearing action. With plenty of lubricant, such a cutter will work rapidly and produce a good finish. For hollow-milling, the cutter requires a top rake of 8 degrees and a clearance of 3 degrees, with the teeth cut far enough ahead of the center to provide a free curling chip. Tapping and threading operations may be satisfactorily performed in malleable iron if plenty of lubricant is used; holes to be tapped should be slightly larger than in the case of steel, as the tool will produce a good full thread under such conditions.

In general, it will be found that malleable iron will hug the tool closely and finish to practically the size of the tool if plenty of lubricant is used; but if it is attempted to run the tools dry, their action is likely to be erratic, one hole coming large, the next small, and *vice versa*. Jigs and fixtures must afford support close to the cutting tools, owing to the springy nature of the iron; and facing and counterboring tools ought to be equipped with roller pilots to avoid scoring the bored holes in which they run. Cored holes can be drilled with three-lipped spiral drills within a limit of ± 0.002 inch, using feeds and speeds which afford a high rate of production. The drill should be one-third of the total tolerance larger than the small limit allowed on the work; for instance, to drill a 7/8-inch hole on which the limits are 0.875 and 0.879 inch, the drill would be made 0.8763 inch.

* * *

S. A. E. STANDARDIZES AUTOMOBILE NAMES

The Society of Automobile Engineers has sent out the results of six months standardization work, which has for its purpose the establishment of precise and expressive terms for motor car parts and accessories. There are many advantages in having uniform names of car parts. The motor car user would find it much easier to make replacements if there were general agreement as to the use and meaning of terms. The manufacturer would benefit for the same reason and the entire industry would welcome a list of names that will remedy the present chaotic condition in which each maker seemingly uses a different terminology.

The list of names recommended by the Society of Automobile Engineers was developed through the combined efforts of engineering and service representatives of a number of leading motor car manufacturers. Over six hundred separate names of the more important parts are given. No attempt was made to list minor parts, the names of which are well understood. Definitions are included for axles, brakes and bodies for which uses vary. The names of bodies particularly are in need of standardization because of the wide variety of names used by different makers. The term "engine" is recommended rather than "motor" to avoid confusion with electric motors used for starting the engines installed on cars.

RULES FOR CRANE OPERATION

Traveling cranes are an indispensable feature of modern plants. Their capacity for lifting and conveying parts and materials is practically unlimited, but unfortunately their operation is attended by many dangers. Crane men and chain men become careless, and green men on the floor are likely to give wrong signals or signals that may be misunderstood. F. B. Prescott of the Boston & Montana Reduction Works recommends in the *Anode* the following:

1. That there be established through the safety bureau uniform traveling crane signals to come into effect in all industrial establishments.

2. That men be appointed crane chasers who are well informed on such signals.

3. That every man aspiring to the position of either traveling crane operator or signal man shall pass an examination in signaling among the other requisites for his office.

Mr. Prescott points to the uniform signals used by shifting crews on railways the country over, and states that uniformity is equally desirable in the operation of traveling cranes. All railways put their engineers and firemen through official examination, and these men are not generally better paid than crane operators. The number of traveling cranes in use and men operating and attending them makes the subject of general importance in the industrial world. The recommendation in regard to the operation of cranes and the establishment of a uniform code of signals should meet with general approval by industrial works managers generally.

* * *

The oxide on high-speed steel melts at a temperature of about 1250 degrees C. (2300 degrees F.) which is the approximate temperature for hardening. A skilled hardener can observe the oxide melting and thus determine with fair accuracy the proper hardening heat.

CHANGE-GEAR TABLES FOR SCREW CUTTING

BY MARTIN H. BALL[1]

In December, 1910, I contributed an article to MACHINERY dealing with the subject of cutting fractional screw threads, and giving tables of the different available ratios for change-gears furnished with lathes having lead-screws with four, five and six threads per inch. These tables made it easy to determine the ratio of different combinations of gears without taking the time to make calculations, but in the present article the process has been carried a step further. In this case the arrangement of the tables is the same except that the pitch of the lead-screw has been taken into consideration, so that the number which appears at the intersection of vertical and horizontal lines through any two gears represents the pitch of the screw that will be obtained by using those two gears on the lead-screw and spindle of the lathe.

To illustrate the use of these tables, we will assume that it is required to cut a worm to drive a worm-wheel having teeth of 10 diametral pitch. Referring to Table IV, which gives the relation between the diametral pitch of worm-wheels and the corresponding pitch of worms which mesh with them, we find the pitch of a worm to mesh with a worm-wheel of 10 diametral pitch is 0.314 inch. Next referring to Table III, which gives the pitches obtainable with change-gears on a lathe with a lead-screw having five threads per inch, we find that the use of a 55-tooth gear on the spindle and a 35-tooth gear on the lead-screw provide for cutting a screw with a lead of 0.3142 inch. The error resulting through the use of this gear combination is only 0.0002 inch, which is not great enough to give any trouble except in cases where great accuracy is necessary.

As a further example of the use of the tables, suppose that a

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TABLE I. PITCHES OBTAINED USING LEAD-SCREW WITH THREE THREADS PER INCH

Number of Teeth in Lead-screw Gear	Number of Teeth in Spindle Gear																
	21	24	26	28	30	32	36	40	48	56	64	72	88	92	96	104	112
21	......	0.3809	0.4126	0.4444	0.4761	0.5079	0.5714	0.6349	0.7619	0.8888	1.0158	1.1428	1.3968	1.460	1.5238	1.6504	1.7777
24	0.2916	......	0.3611	0.3888	0.4166	0.4444	0.500	0.5555	0.6666	0.7777	0.8888	1.000	1.2222	1.2777	1.3333	1.4444	1.5555
26	0.2692	0.3076	......	0.3589	0.3846	0.4102	0.4615	0.5128	0.6153	0.7179	0.8205	0.9230	1.1282	1.1794	1.2307	1.3333	1.4358
28	0.250	0.2857	0.3095	......	0.3571	0.3809	0.4285	0.4761	0.5714	0.6666	0.7619	0.8571	1.0476	1.0952	1.1428	1.2380	1.3333
30	0.2333	0.2666	0.2888	0.3111	......	0.3555	0.400	0.4444	0.5333	0.6222	0.7111	0.800	0.9777	1.0222	1.0666	1.1555	1.2444
32	0.2187	0.250	0.2708	0.2916	0.3125	......	0.375	0.4166	0.500	0.5833	0.6666	0.750	0.9166	0.9583	1.000	1.0833	1.1666
36	0.1944	0.2222	0.2407	0.2592	0.2777	0.2962	......	0.3703	0.4444	0.5185	0.5925	0.6666	0.8147	0.8518	0.8888	0.9629	1.0370
40	0.175	0.200	0.2166	0.2333	0.250	0.2666	0.300	......	0.400	0.4666	0.5333	0.600	0.7325	0.7666	0.800	0.8666	0.9333
48	0.1458	0.1666	0.1805	0.1944	0.2083	0.2222	0.250	0.2777	......	0.3888	0.4444	0.500	0.6111	0.6388	0.6666	0.7222	0.7777
56	0.125	0.1428	0.1547	0.1666	0.1785	0.1904	0.2142	0.2380	0.2857	......	0.3809	0.4285	0.5232	0.5476	0.5714	0.6190	0.6666
64	0.1093	0.125	0.1354	0.1458	0.1562	0.1666	0.1875	0.2083	0.250	0.2916	......	0.375	0.4583	0.4791	0.500	0.5416	0.5833
72	0.0972	0.1111	0.1203	0.1296	0.1388	0.1481	0.1666	0.1851	0.2222	0.2592	0.2962	......	0.4069	0.4259	0.4444	0.4814	0.5185
88	0.0795	0.0909	0.0984	0.1060	0.1136	0.1212	0.1363	0.1515	0.1818	0.2121	0.2424	0.2727	......	0.3484	0.3636	0.3939	0.4242
92	0.0760	0.0869	0.0942	0.1014	0.1086	0.1158	0.1304	0.1449	0.1739	0.2028	0.2318	0.2608	0.3188	......	0.3478	0.3768	0.4057
96	0.0730	0.0833	0.0902	0.0972	0.1041	0.1111	0.125	0.1388	0.1666	0.1944	0.2222	0.250	0.3052	0.3194	......	0.3611	0.3888
104	0.0673	0.0769	0.0833	0.0897	0.0961	0.1025	0.1153	0.1282	0.1538	0.1794	0.2051	0.2307	0.2820	0.2948	0.3076	......	0.3589
112	0.0625	0.0714	0.0773	0.0833	0.0892	0.0952	0.1071	0.1190	0.1428	0.1666	0.1904	0.2142	0.2619	0.2738	0.2857	0.3094	......

Machinery

TABLE II. PITCHES OBTAINED USING LEAD-SCREW WITH FOUR THREADS PER INCH

Number of Teeth in Lead-screw Gear	Number of Teeth in Spindle Gear																	
	24	28	32	36	40	42	44	48	52	56	60	64	68	72	80	88	92	96	104	105	112
24	......	0.2916	0.3333	0.375	0.4166	0.4375	0.4583	0.500	0.5416	0.5833	0.625	0.6666	0.7083	0.750	0.8333	0.9166	0.9583	1.0000	1.0833	1.0937	1.1666
28	0.2142	......	0.2857	0.3214	0.3571	0.375	0.3928	0.4285	0.4642	0.500	0.5357	0.5714	0.6071	0.6428	0.7142	0.7857	0.8214	0.8571	0.9285	0.9375	1.000
32	0.1875	0.2187	......	0.2812	0.3125	0.3281	0.3437	0.375	0.4062	0.4375	0.4687	0.500	0.5312	0.5625	0.625	0.6875	0.7187	0.750	0.8125	0.8203	0.875
36	0.1666	0.1944	0.2222	......	0.2777	0.2916	0.3055	0.3333	0.3610	0.3888	0.4166	0.4444	0.4722	0.500	0.5555	0.6111	0.6388	0.6666	0.7222	0.7277	0.7777
40	0.150	0.175	0.200	0.225	......	0.2625	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.500	0.550	0.575	0.600	0.650	0.6562	0.700
42	0.1428	0.1666	0.1904	0.2142	0.2380	......	0.2619	0.2857	0.3095	0.3333	0.3571	0.3809	0.4047	0.4285	0.4761	0.5239	0.5476	0.5714	0.6190	0.625	0.6666
44	0.1359	0.1590	0.1818	0.2045	0.2272	0.2386	......	0.2727	0.2954	0.3181	0.3409	0.3636	0.3863	0.4090	0.4545	0.500	0.5227	0.5454	0.5909	0.5965	0.6363
48	0.125	0.1458	0.1666	0.1875	0.2083	0.2187	0.2291	......	0.2708	0.2916	0.3125	0.3333	0.3540	0.375	0.4166	0.4583	0.4791	0.500	0.5416	0.5468	0.5833
52	0.1153	0.1346	0.1538	0.1730	0.1923	0.2019	0.2115	0.2307	......	0.2692	0.2884	0.3076	0.3269	0.3461	0.3846	0.4230	0.4423	0.4615	0.500	0.5048	0.5384
56	0.1071	0.125	0.1428	0.1607	0.1785	0.1875	0.1964	0.2142	0.2321	......	0.2678	0.2857	0.3035	0.3214	0.3571	0.3928	0.4107	0.4285	0.4642	0.4687	0.500
60	0.100	0.1166	0.1333	0.150	0.1666	0.175	0.1833	0.200	0.2162	0.2333	......	0.2666	0.2833	0.300	0.3333	0.3666	0.3833	0.400	0.4333	0.4375	0.4666
64	0.0937	0.1093	0.125	0.1406	0.1562	0.1640	0.1718	0.1874	0.2031	0.2187	0.2343	......	0.2656	0.2812	0.3125	0.3437	0.3593	0.375	0.4062	0.4101	0.4375
68	0.0882	0.1029	0.1176	0.1323	0.1470	0.1544	0.1617	0.1764	0.1911	0.2058	0.2205	0.2352	......	0.2647	0.2941	0.3235	0.3382	0.3522	0.3823	0.3860	0.4117
72	0.0833	0.0972	0.1111	0.125	0.1388	0.1458	0.1527	0.1666	0.1805	0.1944	0.2083	0.2222	0.2361	......	0.2777	0.3055	0.3194	0.3333	0.3611	0.3645	0.3888
80	0.075	0.0875	0.100	0.1125	0.125	0.1312	0.1375	0.150	0.1625	0.175	0.1875	0.200	0.2125	0.225	......	0.275	0.2875	0.300	0.325	0.3281	0.350
88	0.0681	0.0795	0.0909	0.1022	0.1136	0.1192	0.125	0.1363	0.1477	0.1590	0.1704	0.1818	0.1931	0.2045	0.2272	......	0.2613	0.2727	0.2954	0.2982	0.3181
92	0.0652	0.0760	0.0869	0.0977	0.1086	0.1141	0.1195	0.1304	0.1413	0.1521	0.1630	0.1739	0.1847	0.1956	0.2173	0.2391	......	0.2608	0.2826	0.2853	0.3043
96	0.0625	0.0729	0.0833	0.0937	0.1041	0.1094	0.1145	0.125	0.1354	0.1458	0.1562	0.1666	0.1770	0.1875	0.2083	0.2291	0.2395	......	0.2708	0.2734	0.2916
104	0.0576	0.0673	0.0769	0.0865	0.0961	0.1009	0.1057	0.1153	0.125	0.1346	0.1442	0.1538	0.1634	0.1730	0.1923	0.2115	0.2211	0.2307	......	0.2524	0.2692
105	0.0571	0.0666	0.0761	0.0857	0.0952	0.100	0.1047	0.1142	0.1238	0.1333	0.1428	0.1523	0.1619	0.1714	0.1904	0.2095	0.2190	0.2285	0.2476	......	0.2666
112	0.0535	0.0625	0.0714	0.0803	0.0892	0.0937	0.0982	0.1071	0.1160	0.125	0.1339	0.1428	0.1517	0.1607	0.1785	0.1964	0.2053	0.2142	0.2321	0.2343	......

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lathe were available which had a lead-screw with three threads per inch and that the work to be done consisted of cutting the threads of a worm with a lead of 0.524 inch to mesh with a worm-wheel having teeth of 6 diametral pitch. This work could be done by using an 88-tooth gear on the spindle and a 112-tooth gear on the lead-screw, with compound gears introduced between them having a ratio of 2 to 1. It will be evident that the ratio 0.262 found in Table I is equal to the result obtained by dividing the desired ratio of 0.524 by 2; hence, it is necessary to compound the gears on the lead-screw and spindle with gears having a ratio of 2 to 1. Similarly, the ratio of the gears compounded with gears on the lead-screw and spindle may be reversed in order to get a thread of finer lead. Gears of other ratios may be compounded into the train, but the use of such gears is not as simple, and should be avoided wherever possible. The gears shown in Tables I, II and III are those most commonly found on lathes fitted with lead-screws having three, four and five threads per inch.

TABLE III. PITCHES OBTAINED USING LEAD-SCREW WITH FIVE THREADS PER INCH

Number of Teeth in Lead-screw Gear	Number of Teeth in Spindle Gear																
	20	25	30	35	40	45	46	50	55	60	65	70	75	80	90	100	110
20	......	0.250	0.300	0.350	0.400	0.450	0.460	0.500	0.550	0.600	0.650	0.700	0.750	0.800	0.900	1.000	1.100
25	0.160	......	0.240	0.280	0.320	0.360	0.368	0.400	0.440	0.480	0.520	0.560	0.600	0.640	0.720	0.800	0.880
30	0.133	0.1666	......	0.2333	0.2666	0.300	0.3066	0.3333	0.3666	0.400	0.4333	0.4666	0.500	0.5333	0.600	0.6666	0.7333
35	0.1142	0.1428	0.1714	......	0.2285	0.2571	0.2628	0.2857	0.3142	0.3428	0.3714	0.400	0.4285	0.4571	0.5142	0.5714	0.6285
40	0.1000	0.1250	0.1500	0.175	......	0.225	0.230	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.450	0.500	0.550
45	0.0888	0.1111	0.1333	0.1555	0.1777	......	0.2044	0.2222	0.2444	0.2666	0.2888	0.3111	0.3333	0.3555	0.400	0.4444	0.4888
46	0.0869	0.1087	0.1304	0.1521	0.1739	0.1956	......	0.2173	0.2172	0.2608	0.2826	0.3043	0.326	0.3480	0.3913	0.4347	0.4782
50	0.080	0.100	0.120	0.140	0.160	0.180	0.184	......	0.220	0.240	0.260	0.280	0.300	0.320	0.360	0.400	0.440
55	0.0727	0.0909	0.109	0.1272	0.1454	0.1636	0.1672	0.1818	......	0.2181	0.2363	0.2545	0.2727	0.2909	0.3272	0.3636	0.400
60	0.0666	0.0833	0.100	0.1166	0.1333	0.150	0.1533	0.1666	0.1833	......	0.2166	0.2333	0.250	0.2666	0.300	0.3333	0.3666
65	0.0615	0.0769	0.0923	0.1076	0.123	0.1384	0.1415	0.1538	0.1692	0.1846	......	0.2153	0.2307	0.2461	0.2769	0.3076	0.3384
70	0.0571	0.0714	0.0857	0.100	0.1142	0.1285	0.1314	0.1428	0.1571	0.1714	0.1857	......	0.2142	0.2285	0.2571	0.2857	0.3142
75	0.0533	0.0666	0.080	0.0933	0.1066	0.120	0.1226	0.1333	0.1466	0.160	0.1733	0.1866	......	0.2133	0.240	0.2666	0.2933
80	0.050	0.0625	0.075	0.0875	0.100	0.1125	0.115	0.125	0.1375	0.150	0.1625	0.175	0.1875	......	0.225	0.250	0.275
90	0.0444	0.0555	0 666	0.0777	0.0888	0.100	0.1022	0.1111	0.1222	0.1333	0.1444	0.1555	0.1666	0.1777	......	0.2222	0.2444
100	0.040	0.050	0.060	0.070	0.080	0.090	0.092	0.100	0.110	0.120	0.130	0.140	0.150	0.160	0.180	......	0.220
110	0.0363	0.0454	0.0545	0.0636	0.0727	0.0818	0.0836	0.0909	0.100	0.1099	0.1181	0.1272	0.1363	0.1454	0.1636	0.1818	......

Machinery

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POLISHING WHEEL SPEEDS

The nature of the work to be polished determines to some degree the proper speed of the polishing wheels. But for ordinary operations, it is the practice to run at a peripheral speed of about 7500 feet per minute. If the speed of the wheel is too low, the work tends to tear the polishing material from the wheel, and consequently the work suffers in quality and the wheel has to be set up oftener. But if the diameter of the wheel and the dimensions of the work are small, good results can be obtained with lower wheel speed. Loose muslin wheels used for buffing are operated at peripheral speeds of from 8000 to 10,500 feet per minute.—*Grits and Grinds.*

TABLE IV. THREADS PER INCH AND PITCH IN INCHES; DIAMETRAL PITCH OF WORM-WHEEL AND PITCH OF WORM IN INCHES

Threads per Inch	Pitch in Inches	Diametral Pitch of Worm-wheel	Pitch of Worm in Inches	Threads per Inch	Pitch in Inches	Diametral Pitch of Worm-wheel	Pitch of Worm in Inches
2	0.500	1 1/4	2.5133	20	0.050	12	0.262
3	0.333 1/3	1 1/2	2.0944	22	0.045 5/11	14	0.224
4	0.250	1 3/4	1.7952	24	0.041 2/3	16	0.196
5	0.200	2	1.571	26	0.038 6/13	18	0.175
6	0.166 2/3	2 1/4	1.396	27	0.037 1/27	20	0.157
7	0.142 6/7	2 1/2	1.257	28	0.035 6/7	22	0.143
8	0.125	2 3/4	1.142	30	0.033 1/3	24	0.131
9	0.111 1/9	3	1.047	32	0.031 1/4	26	0.121
10	0.100	3 1/2	0.898	34	0.029 7/17	28	0.112
11	0.090 10/11	4	0.785	36	0.027 7/9	30	0.105
11 1/2	0.086 22/23	5	0.628	38	0.026 6/19	32	0.098
12	0.083 1/3	6	0.524	40	0.025	36	0.087
13	0.076 12/13	7	0.449	42	0.023 1/3	40	0.079
14	0.071 3/7	8	0.393	44	0.022 8/11	48	0.065
15	0.066 2/3	9	0.349	48	0.020 5/6	..	....
16	0.0625	10	0.314	50	0.020	..	....
18	0.055 5/9	11	0.286	..	.....	..	....
				..	....	..	

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METHODS OF HEAT-TREATING MACHINERY STEEL GAGES

In manufacturing solid gages of the plug or ring variety, most gage-makers experience difficulty in overcoming warpage of the material. Machinery steel generally comes out of the fire after carburizing considerably distorted and shrunk, and in order to prevent this manufacturers have endeavored to treat it in various ways. One method is to anneal it previous to machining. This has been tried with more or less satisfactory results, but it does not entirely eliminate the possibility of the gage shrinking during the quenching operation.

A prominent manufacturer of gages employs the following method of heat-treating machinery steel gages: First they are rough-machined all over to within approximately one-sixteenth inch of the finished size. Then they are heated in an ordinary muffle furnace to 1400 degrees F., and quenched in oil, the same as in hardening tool steel. Owing to the low carbon content of open-hearth steel—between 0.15 and 0.20 per cent—the steel does not harden sufficiently to prevent free cutting. After quenching in oil, the gages are allowed to cool off. Then they are finish-machined all over to within the desired limit and packed in bone dust for pack-hardening. The box in which the gages are packed is then placed in the furnace, heated to a temperature of 1500 degrees F., and allowed to remain for not less than an hour, the exact time depending on the depth of penetration desired. After the box has been in the furnace for the correct length of time, it is removed, and the gages are quenched in oil, cleaned off and ground to the finished size. This method has proved satisfactory, resulting in practically no losses from shrinkage; the gages can be machined to within very close limits of the finished dimensions, and then pack-hardened without danger of warping beyond the amount left for finish-machining. In several gages that were carefully measured after carburizing it was found that they had not shrunk 0.0001 inch.

It is general practice to make large cylindrical plug or thread gages from rings and mount them on a hollow handle in order to lighten the weight. In making thread gages of this type, trouble has been experienced in preventing warpage of the rings, and owing to the time required to lap down large plug gages, these are generally machined within close limits of the finished diameter, from 0.0005 to 0.002 inch being left for lapping. Where this small amount had been left for lapping, the ring shrunk in some cases so that the gage would not clean up, and in order to avoid this trouble, the following method was tried: After the gage had been finish-machined, the hole was fitted with a cast-iron plug which was made a fairly good drive fit. The gage with the plug inserted was packed in bone dust, heated to 1500 degrees F., and quenched in oil. A gage carburized in this manner did not shrink 0.0001 inch, which is quite remarkable, considering the usual shrinkage of machinery steel.

MAKING LIMIT GAGES

BY F. B. JACOBS[1]

Limit gages must be classed as essential to the modern manufacturing plant, for without them it would be impossible to maintain a satisfactory working standard and at the same time allow a slight variation from the specified size, thus saving many pieces that otherwise would go to the scrap heap or back to the production department to be refinished. There are many varieties of gages, ranging from the expensive and intricate ones used in rifle and sewing machine manufacture to the rough templets found in the boiler shop. The object of this article, however, is to describe some of the efficient, economically constructed limit gages that are used in the production of automobile parts.

Perhaps the most important factor toward rapid production of the work in question is the setting of limits between which the dimensions may vary, it being obvious that if an attempt should be made to hold every dimension within 0.0001 inch of standard size, the production would suffer. A manufacturer who had adopted this practice would build one car while his more practical competitors would produce a number of cars in the same amount of time. Thus, where efficient production is imperative, the limits should be as liberal as possible — otherwise valuable time is wasted, not only in the production department, but through attempting to keep several thousand special tools up to an unnecessary degree of accuracy. On the other hand, the limits must not be too liberal; otherwise the completed cars, after being put in service, would soon sound more like agricultural machinery than automobiles. The limits should be established by a committee composed of the chief engineer, the chief draftsman, the shop superintendent, the production engineer and the foreman toolmaker. By this method every important point that might affect production, or result in unsatisfactory work, will be considered.

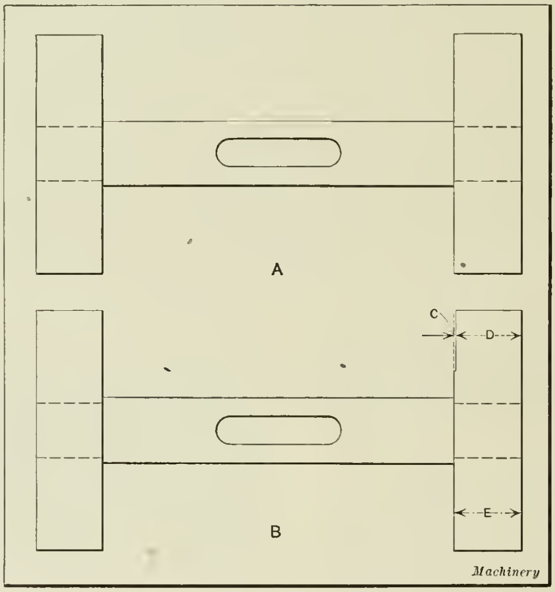

Fig. 2. (A) Limit Plug Gage for Large Work. (B) Combined Plug and Depth Limit Gage

A simple form of limit gage for testing a hole is shown at *X* in Fig. 1. Manufacturing standards for the principal dimensions of limit gages are slightly different in various factories, but the following system will be found satisfactory. *A* is always 3/8 inch, *B* 4 inches, *C* one and one-half times the diameter of the hole to be gaged, *D* 1/16 inch smaller than *E* and *F*, which, of course, are determined by the work to be inspected. The portion between the ends is knurled, and two flats are milled on opposite sides. These are for the purpose of stamping the part number and the gage sizes. Let it be assumed

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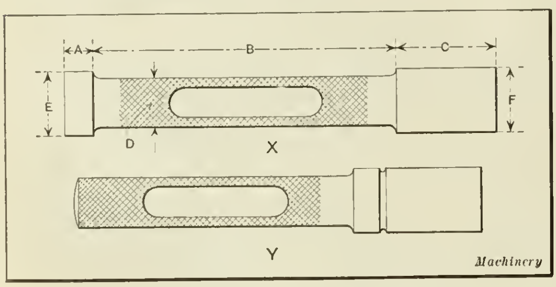

Fig. 1. Two Types of Limit Plug Gages for Small Work

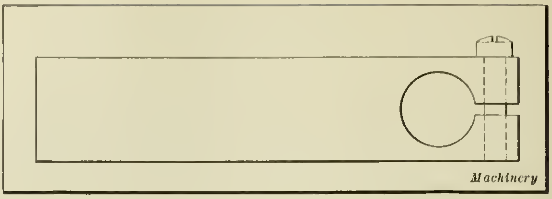

Fig. 3. Form of Lap used for lapping Plug Gages

that the hole to be tested is 7/8 inch and that a variation of 0.0005 inch is allowed; 0.0003 inch over size and 0.0002 inch under size. In this case the long end of the gage should be 0.8748 inch, marked "Go," while the short end is 0.8753 inch, marked "Not Go."

A form of limit gage called a two-step gage is illustrated at *Y* in Fig. 1. This arrangement is popular with many tool designers because the hole can be tested without withdrawing the gage to insert the other end, which would be necessary if using plugs of the type shown at *X*. This gage presents one decided objection, however, as it is impossible to tell what portion of the gage is bearing on the work in cases where the hole is slightly tapered. Notwithstanding this objection, these gages are frequently used by up-to-date concerns.

For testing comparatively large work it is not practicable to use either of these gages on account of the excessive weight involved. In cases of this kind it is a better plan to make the gage as shown at *A* in Fig. 2, with a handle having a disk forced on against a shoulder at each end. The disks are, of course, hardened and ground, while the handle, which can be a piece of cold-rolled steel, is left soft. This is an economical gage to maintain, as only the "Go" end wears rapidly. Thus the gage is cheaply brought up to standard by substituting a new disk in place of the one that is worn under size.

Fig. 2 illustrates at *B* a modification of gage *A* for testing the depth of a hole in cases where the shoulder must be within a certain distance from the face of the work. As an illustration, suppose it were necessary to maintain a limit of 0.002 inch in the depth of a hole one inch deep, allowing for 0.001 inch variation either way; it will be seen that part of the top of the "Go" end of the gage is ground away at *C*. The exaggeration in the drawing is for the purpose of showing the principle clearly. This ground portion *D* should measure 0.999 inch and is marked "Go," while the remainder of the disk *E* measures 1.001 inch and is marked "Not Go." In using the gage, a scale or other convenient straightedge is passed over the disk after it is inserted in the work. If it passes over the low portion and at the same time strikes the remainder of the disk, the work is within the established limits. If the straightedge passes over both portions of the disk, the hole is too deep, and if it strikes both portions, the hole is not deep enough.

Many manufacturers persist in making gages of a good grade of tool steel, which is a waste of expensive material and high-priced labor—a still greater factor; also it must be remembered that tool steel is a material that requires considerable time for machining. To be sure, a good grade of tool steel is to be preferred to a poor quality, which might harden in spots only. But why use tool steel at all—simply because grand-

father did? In this age of rapid production it has been demonstrated time and again that ordinary machine steel carbonized to a depth of 1/16 inch will give entire satisfaction on the work in question, as it can be made extremely hard at slight cost.

The lathe work on the gages described is a simple operation for a tool-room lathe hand and requires no comment here, except to state that the pieces should be recentered before hardening. The reason for this is that heavy roughing cuts, together with the operation of knurling, distort the centers to a certain extent, and this is sure to cause trouble in the grinding operation. To insure further accuracy the centers should be lapped after hardening to remove the fire scale.

Grinding and Lapping Gages

There are three kinds of material used for gage grinding, *viz.*, emery, corundum and artificial alumina abrasives, the last being variously known to the trade as aloxite, alundum, etc. Some years ago all grinding wheels were termed emery wheels, as indeed they are today by the uninformed. Genuine Naxos emery, however, will always be used to a certain extent on very fine work, owing to the fact that it gives a high finish. To be sure, emery wheels are comparatively slow cutting, but as gage work is an exacting operation at best, the extra time spent in the grinding operation is often overlooked by the manufacturer who desires the best finish possible. Corundum wheels are often used for the work in question with excellent results, as corundum is really a high-grade emery in that it contains more alumina and less impurities than the best grades of emery. In selecting corundum wheels, care must be exercised to obtain only first quality goods, as poor corundum makes a very unsatisfactory wheel. Both emery and corundum are natural products.

The artificial alumina abrasives are faster cutting than the natural ones, and for this reason and because they are readily obtained from almost any reliable mill supply house, they are extensively used for work of this kind. These wheels can be run safely at high peripheral speeds, 6000 to 7000 feet per minute, whereas emery and corundum wheels should never, under any circumstances, be allowed to exceed 5500 feet per minute surface speed.

To state definitely the exact grit and grade of wheel to be used for gage grinding is an impossibility, as the conditions vary so greatly. As a general thing, however, grits 60 to 80 and grades K to N are used. In selecting aloxite wheels it must be borne in mind that their grade scale is the reverse of the ones commonly used. As an illustration, an alundum wheel in J grade is quite soft, while an aloxite wheel in the same grade is several grades harder. Full and sufficient information on this point is given in MACHINERY'S HANDBOOK.

Gage grinding differs but little from any cylindrical grinding operation, except that extreme care must be used in sizing the work to leave just the right amount for lapping, for while 0.0001 inch is of little consequence in grinding, it often proves a large amount to remove by lapping in cases where the work already has a mirror-like finish. The correct amount to leave for lapping depends on the grit and smooth cutting qualities of the wheel used. It is evident that a 60 grit wheel will leave deeper marks in the work than a 70 or 80 grit wheel. Again, a wheel that is properly dressed leaves a smoother finish than one that has simply been roughed up. In general, from 0.0002 to 0.0003 inch is sufficient allowance for lapping.

It is imperative that a slight amount should be left for lapping after grinding, no matter what kind of wheel is used; otherwise the friction between the work and the gage will soon wear the latter slightly under size. This is because any piece of ground work (no matter how fine a wheel has been used) always shows innumerable scores and high spots when examined under a microscope. The high portions would soon wear away after the gage is put in use, and the object of lapping is to wear the high spots away and bring the gage to a mirror-like finish, which will resist wear for a comparatively long time. There are several methods used for lapping cylindrical gages, the most crude and unsatisfactory being to polish them with fine emery cloth. This is poor practice at best, and it is never resorted to by the toolmaker who understands his business or prides himself on his work. Another method is to use a wooden clamp not unlike the polishing clamps used for finishing shafting some years ago. Lard oil and rouge are used, and good results are possible in the hands of an expert workman, as the rouge has not enough abrasive action to remove much more than the actual high spots. Great care must be taken while grinding to leave just the correct amount for lapping if this method is employed, for after the actual high spots are removed the rouge cuts the finished surface very slowly indeed. The writer recalls spending an entire afternoon in removing 0.0002 inch from a gage 1 inch in diameter and 3 inches long in a certain instance where it was desired to reduce a gage that had previously been finished.

The most practical method is to use a cast-iron lap and carefully washed flour emery mixed with lard oil. A lap of this kind can be easily made as shown in Fig. 3. It consists of any convenient piece of open-grained gray iron with a hole bored in one end to receive the work. The extra length serves as a handle. Laps of this kind should be split and provided with a screw for taking up wear, as a lap to do good work should fit the piece snugly. The lapping operation should not be hurried unduly, as this procedure will sometimes result in an under sized gage; and while there is always a chance of saving a gage that is a little over size, one that is under size is an absolute loss. The work should be washed in gasoline before calipering and then cooled in water that has stood in a bucket long enough to acquire the temperature of the room through radiation. Otherwise a very slight error will be apparent even though the work may be done by a competent workman.

Gages made by the above methods are, of course, not absolutely accurate when compared with the famous Johansson gages. However, they are accurate enough for regular commercial work, and as they can be made at low cost, no great expense is involved when they go to the scrap box after being worn to the point of uselessness.

* * *

BABBITTED MACHINERY CONSTRUCTION

There is a general prejudice against the use of babbitted bearings in high-grade machines, although they are widely used in so-called low-grade machinery, and give long and satisfactory service when properly cared for. The prejudice apparently arises from the fact that a babbitt bearing is soft and is easily ruined. But on the other hand, a babbitt bearing properly proportioned for the load it is to carry, and constantly lubricated, will last as long as the best bronze under similar conditions. This fact is appreciated by those who know how dependable a babbitted bearing is when so proportioned that the load pressure does not break down the oil film.

Babbitted bearings have the important advantage of being easily made by mechanics provided with ordinary limited means, and in case of failure they can be readily replaced. Another advantage of babbitted bearings, well known years ago but which has been lost sight of in the development of modern methods of manufacture, is that a machine can be erected with shafts in parallel and accurately located without expensive boring and other machining processes. With an equipment of babbitting jigs, it is feasible to use castings from the foundry with practically no machining preparation and build machines with dependable bearings in line and accurately located. We are likely to look scornfully upon such mechanical products as being unworthy of an up-to-date shop, but in the effort to produce machine parts of mathematical precision, we may have neglected methods proved by long experience to be dependable, and which under certain conditions are superior to modern methods.

The best method of building machinery depends upon the conditions of use, accuracy required and number of machines to be built. When the refinement is not great and the number to be made is small, babbitted bearings may well be considered favorably.

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The annual index of MACHINERY, Volume 22, which concluded with the August number, will be sent to any reader on request.

SOME NOTES ON STEAM HAMMERS

CHARACTERISTICS AND CAPACITY OF COMMON TYPES

BY JAMES CRAN[1]

TWO types of steam hammers are in general use, namely, single- and double-frame hammers, either of which may be of the open-frame order. Open-frame hammers are not provided with guides to keep the ram and the upper die in alignment with the anvil and lower die; they have, however, a much heavier piston-rod, either of round section with one flat side to keep it from turning, or of hexagonal form working through a long gland of corresponding shape. While the alignment of open-frame hammers is not as perfect as those provided with guides, the former can be used for a much wider range of work owing to the fact that they are accessible on three sides, having no guides to come in the way of irregular shaped forgings, and the operator has an unobstructed view of the work. The more common type of steam hammer with guides is not so convenient for the majority of work, but is better suited to making duplicate parts in quantities, as special dies can be kept in almost perfect alignment.

The single-frame steam hammer shown in Fig. 1 differs but slightly from most of the others of this type in general use. It is built to run automatically and the hammer will continue to strike the same force of blow as long as the steam pressure remains the same after the throttle valve is opened and the controlling lever set in its quadrant. The length of stroke and the force of the blow can be increased or diminished within certain limits after the controlling lever has been set, by changing the position of the throttle lever to admit more or less steam to the cylinder. The automatic attachment on steam hammers performs the same function as the eccentric movement on a plain slide valve engine, opening and closing the ports that admit steam to the cylinders, the difference being that the ports of a steam hammer are opened and closed by a reciprocating instead of a rotary mechanism. On the back of the ram inside the frame there is a shoe or slide upon which a cam lever attached to the fulcrum of the controlling lever works, a short lever on the end of the fulcrum shaft being attached to the valve stem by a connecting-rod at the back of the hammer for the purpose of controlling the vertical movement of the valve.

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Keeping up Efficiency

The efficiency of this type of hammer depends to a considerable extent upon the correct setting of the valves. When the valve is adjusted so that the hammer (when running automatically) will take just sufficient steam at the lower port to raise the ram, and will open the top port to its full capacity with the shortest possible travel of the valve, the hammer will work at its maximum efficiency and will hold pieces firmly between the dies by throwing the throttle wide open and setting the controlling lever at the lowest point of the quadrant. After a certain amount of service, steam hammers frequently get into such a condition that they will not hold pieces firmly between the dies on account of lost motion through wear of the various working parts that connect the controlling lever with the valve stem. The reason for this is that the valve does not rise high enough to completely close the exhaust opening. The remedy for a condition such as this is to shorten the valve stem, which is adjustable, in order to compensate for wear on the connecting-rod and levers.

While most steam hammers in general use are constructed to run automatically, this does not mean that all of them can be used without an operator, as only the smaller sizes, say from 250 to 600 pounds' capacity, can be used to advantage with a foot-lever connected with the throttle valve. A man doing small work can use the foot-lever without inconvenience after the controlling lever has been set for the desired force of blow, but he is obliged to have the free use of both feet when doing heavier work, and this usually calls for a wider variety of blows than can be had through a purely automatic system of control.

Capacity of Steam Hammers

It is a difficult matter to state definitely the capacity of a hammer as regards the size of work which it can handle to

Fig. 1. Single-frame Steam Hammer

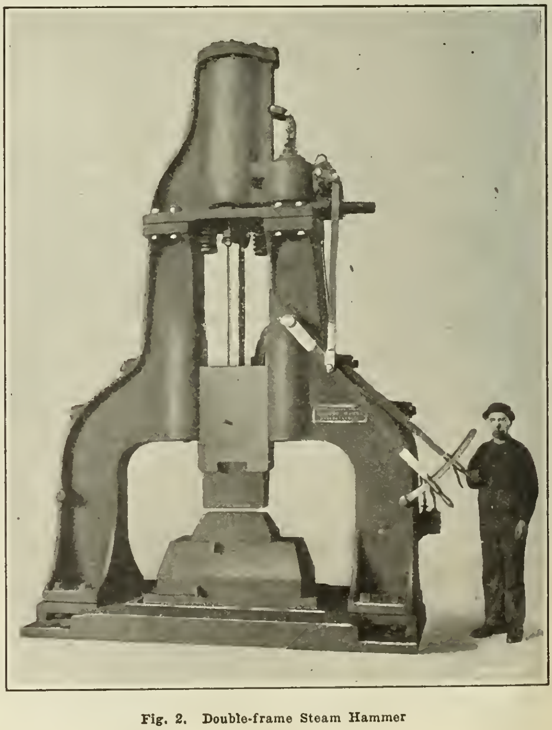

Fig. 2. Double-frame Steam Hammer

advantage; there are so many conflicting factors which affect the situation that it is impossible to give anything like a rating that will cover all conditions. The following data[1], which are given out by a well-known builder of steam hammers, may be safely used as a basis for estimating the size of hammer needed for a given piece of work:

Diameter of Stock (Round or Square)	Size of Hammer, Pounds
3½ inches	250 to 350
4 inches	350 to 600
4½ inches	600 to 800
5 inches	800 to 1000
6 inches	1000 to 1500

One of the most common mistakes made in selecting a steam hammer is getting one which is too light for the work on which it is intended to be used. When a light hammer is used to draw down heavy stock to smaller size, the effect of the blows does not penetrate to the center of the material, and as a consequence the outside is drawn more than the inside. When this happens, it will be easily discernible by examining the pieces, which will be found to be concave on the end. When the hammer is of sufficient size, the ends of the pieces drawn down will be convex, showing that the effect of the blows has penetrated to the center of the work.

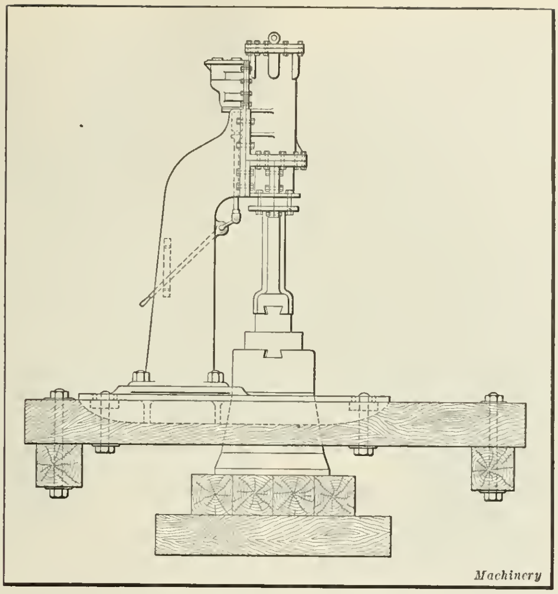

Fig. 3. Open-frame Steam Hammer with Foundation Details

If it were possible to operate steam hammers at all times with a full stroke and steam pressure at 100 pounds per square inch, it would be comparatively easy to give a rating for the different sizes, but as the variation in both steam pressure and length of stroke must be taken into consideration, the problem is more difficult. It will be readily seen that when a full length stroke of the hammer can be used in working under a full head of steam, the results both from momentum and steam expansion are very much greater in proportion than when a short stroke is used. Some of the information given out by the manufacturers of steam hammers is rather misleading to those not familiar with forging work. For example, an occasional forging may be made on a much smaller hammer than would be used for making the same piece in large quantity production. While forgings such as a 6-inch pinion or a short shaft can be made on an 800- or 1000-pound hammer, one of 1500-pound weight would be required to produce the same pieces in large quantities. To get the maximum output of 6-inch axles which must be forged from much heavier stock than the dimensions imply, a hammer from 6000 to 8000 pounds' capacity will be required. From the foregoing it will be seen that the selection of a hammer is dependent largely upon the work for which it is intended, and judgment must be used in regard to production and other factors mentioned.

Double-frame hammers differ from those described only in the shape of the frame, which is made in the form of an arch, the sides of which act as guides for the ram, the anvil being in the center, as will be noted by referring to Fig. 2. The open-frame steam hammer shown in Fig. 3 is a machine that merits more attention than has generally been given to it, owing to the fact that hammers of this type are to be found to some extent in nearly all factories where the making of forgings forms an important part of the work.

This hammer is simple in construction, as it has fewer working parts than any other machine of the same kind. By referring to the illustration, it will be seen that it is provided with only one lever, which performs the double duty of opening the throttle and controlling the stroke. The first movement of the lever upward opens the throttle and also the lower port to the cylinder, which admits the steam to raise the ram. Thus it will be seen that the lever and ram work in unison and that when the lever is raised, the piston and ram rise, while for the downward stroke the lever is lowered, although not to the extreme end of the guide in which it travels.

A hammer of this kind cannot be operated automatically, but this is an advantage in some ways, because after a blow has been struck, the ram will not start on the return stroke until the lever has been raised. This prevents rebound and a second short stroke which often follows a full blow delivered by hammers having an automatic attachment when attended by a poor operator. Another feature of this hammer is the absence of safety buffers which are intended to prevent the piston rising too far in the cylinder. This is taken care of automatically by a number of small ports near the top of the cylinder, which are arranged so as to admit just sufficient steam to act as a cushion. The piston when raised beyond a certain point moves automatically until the steam pressure under it has been released. The operation of steam hammers is a knack acquired by practice, and young boys generally become the most expert in this work. Science does not enter into the operation in any way.

In conclusion, a little may be said in regard to foundations. While most steam hammer manufacturers send out drawings and specifications to cover this part of the subject, the nature of the ground upon which the hammers are to be installed should always be taken into consideration. In sand or clay soil it is advisable to have the foundation of concrete up to within 6 inches of the anvil base and covered with a wooden cushion to bring it up to its full height. When a rock bottom is found, the pier of crossed timbers usually specified will give satisfaction.

* * *

GROWTH OF STEEL PIPE AND TUBE INDUSTRY

In no branch is the growth of the steel industry so apparent as in the manufacture of pipes and tubes. Between the years 1887 and 1905 this growth was steady from almost nothing to a tonnage that required 938,198 tons of skelp. Since then the growth has been more erratic, yet in the next ten years the demand for skelp grew to 2,037,266 tons. This growth was due partly to the reduction in the demand for wrought iron, but mostly to the increased use to which pipes and tubes have been put. Instead of being utilized mainly for the conveyance of water and steam, they are now employed in the manufacture of agricultural implements, automobiles, bedsteads, building columns, refrigerating machinery, hospital furniture, dry kiln apparatus, ornamental fences, flag poles, wheelbarrows, work benches, elevator grain spouts, playground apparatus, signal towers, lunch counter stools, etc. Still the popularity of the steel product over wrought iron is shown by the steady decrease in the use of the latter. In 1905, wrought iron pipe manufacturers required 452,797 tons of skelp and made 31.05 per cent of the pipes and tubes; in 1910 they required only 350,578 tons of skelp, for their share of the market had fallen to 19.02 per cent; in 1915, this had fallen to 11.4 per cent and they used but 262,198 tons of skelp.

[1] The rule given in MACHINERY's Handbook for the rating of steam hammers is: "Multiply the area of the piece to be forged in square inches by 80"; the result is the required falling weight in pounds. For example, a forging 4 inches square would require a falling weight of 4 × 4 × 80 = 1280 pounds. This rule gives the weight considerably heavier than that recommended in the foregoing, and may perhaps be excessive for many conditions of ordinary service.—Editor.

STORAGE OF ENERGY

BY GEORGE P. PEARCE[1]

In physical problems, the storage and release of energy frequently plays a more important part than is generally realized. Take a carpenter's chisel, for instance; the one with a long wooden handle cuts better than the one with a short, stubby handle under similar blows from the mallet. But how many have considered that the reason is due to the actual increase in energy that can be stored in the longer handle and released as a "push" for a longer time at the cutting edge? It gives more of a paring cut and less of a blow. The machinist using a two-pound mallet could deliver just as much energy to the chisel end of a wooden-handled cold chisel as when striking steel with steel, but he would not be able to chip as much metal. The reason, of course, is that the wooden handle will absorb the energy of the blow which would otherwise be instantly delivered at the cutting edge. The energy so absorbed is expended in rebounding the hammer, not in cutting the metal. The stiff chisel absorbs very little energy, it practically all being expended in cutting.

If a shaft is swung at the end of a rope and caused to hit something "end on," it will deliver a tremendous blow, because the steel shaft is in such a shape and condition that it cannot absorb much energy, and so it has to deliver it instantly. But if the shaft is turned sideways or coiled like a helical spring, it will no longer deliver the same smashing blow, although the amount of energy involved is precisely the same. The shaft can now store more energy and parts with it over a longer period of time; it gives more of a push and less of a blow. In one instance, it was impossible to speed up some automatic machines until the counterweights, which held the slides against the cams, were replaced with springs. Gravity could not deliver energy fast enough to the slides to keep them in contact with the cams.

A mild steel bar in direct tension does not make a good spring, because it does not absorb and return much energy; in fact, it will take up and restore from 5 to 8½ foot-pounds of energy only per pound of steel. Spring steel will take up 30 foot-pounds per pound in direct tension at 80,000 pounds working stress. A shaft in torsion is sometimes used as a spring; for instance, in some self-closing screen doors, because steel stressed under these conditions will absorb about 46 foot-pounds per pound of material. Helical springs are used because when the steel is so placed it is capable of absorbing 88 foot-pounds per pound of spring. But the energy absorbed is the same for a shaft or helical spring *at the same working stress*. A good rule to remember when determining the size of spring required for any purpose is: "Divide the foot-pounds of energy to be absorbed by 88"; the result will be the approximate weight of the spring in pounds.

Years before Professor Langley made his flying machine, a Frenchman made simple toys, which were driven by twisted elastic bands, that would fly fifty feet or more. These simple toys could fly because it is possible to store considerable energy in rubber; in fact, it is superior to the finest tempered steel spring in this respect, for almost 3000 foot-pounds per pound can be absorbed and delivered.

The flywheel is generally looked upon as an ideal device for the storage of power, but a cast-iron wheel reaches its limit at about 640 foot-pounds per pound. The energy of a good steel flywheel, however, will run up to around 3200 foot-pounds per pound. The energy of ordinary flywheels sinks into insignificance, though, when compared with that stored in the rim of a DeLaval steam turbine disk, where it may reach 31,000 foot-pounds per pound. The most efficient electric storage batteries cannot equal this, as they reach their limit at approximately 22,000 to 30,000 foot-pounds per pound, and many commercial batteries on the market do not exceed 3200 foot-pounds per pound of weight.

Ordinary air, when highly compressed, say around 2000 pounds per square inch, is capable of delivering 50,000 foot-pounds per pound, and is used for storage purposes in compressed-air-driven mine locomotives. But it is inferior to steam, which will deliver 240,000 foot-pounds of energy per pound when expanded from 250 down to 2 pounds pressure per square inch absolute.

If it is desired to obtain still more energy per pound, it can be found in fuels. Carbon, together with the necessary air to burn it, will deliver a little more than 900,000 foot-pounds per pound of mixture. Fuel oil, with air, will give 985,000 foot-pounds. Gunpowder has stored in it 1,000,000 foot-pounds per pound, while hydrogen and air give 1,362,000 foot-pounds, and hydrogen and oxygen mixed in the proportion of 1 to 8 give 5,365,000 foot-pounds of energy.

This may seem to be the limit, and it is a hard figure to beat, but there are everyday occurrences which are not much thought of and yet which represent much more energy than this. A common shooting star, which is seen almost any clear night, should average about seven miles per second—the velocity of a body falling from a very great distance upon the earth. These meteors give up to the earth and atmosphere 20,000,000 foot-pounds per pound. Meteors certainly have tremendous possibilities, but the old earth itself in its revolution around the sun has in every pound of its mass kinetic energy of 149,000,000 foot-pounds. But this force, enormous as it is, sinks into insignificance if some of the physicists are correct in their estimate of 1,400,000,000,000,000 foot-pounds as the total contained energy in one pound of radium. This agrees closely with the theory of ultimate velocity of material particles. Electrons have been observed having a velocity of 50,000 miles per second, which gives a kinetic energy of 108,000,000,000,000 foot-pounds. According to the electromagnetic theory of light, the maximum velocity which a material particle may have is 186,000 miles per second, which means a kinetic energy of 14,995,000,000,000,000 foot-pounds per pound.

[1] Address: 533 Tenth Ave., Moline, Ill.

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DANGERS OF HORSEPLAY

Many serious accidents happen in machine shops as the result of practical jokes, fooling and horseplay. A shop messenger was passing through a shop carrying a small can of gasoline. A would-be "Smart Aleck" working at a lathe turned around and knocked the can from the messenger's hand, spilling the gasoline onto his clothing. He happened to be near a lighted torch and the gas caught fire, causing serious burns of the messenger's arms and hands before the flames could be extinguished. The result was two weeks in the hospital and scars that will remain through life.

Throwing objects to attract attention or to annoy is especially dangerous practice. Serious injuries often result, especially if the missiles strike the eyes. To prevent horseplay without inflicting needless hardship is the problem of every shop management. One of the best ways of keeping men out of mischief is to keep them busy. The man who is always busy does not concern himself about his neighbors' business, nor does he indulge in unseemly and rude remarks. The ill-disciplined shop is generally one that is poorly managed as regards the distribution of work and constant employment of the men.

* * *

NEW RAILWAY STATION IN LEIPSIC

The new central station in Leipsic, which the German railway authorities completed in December, 1915, is the largest and one of the most convenient and luxurious railway terminals in Europe. Its construction was planned approximately thirty years ago, and work on it has been going on since 1901. The entire structure covers an area of 168,000 square feet, the main building having a front 984 feet long, and two wings, each 295 feet wide. The train shed is 785 feet long and contains twenty-six tracks. It is covered by a high roof of steel and glass built in the form of six arches.

It has been asserted that the Leipsic station is the largest in the world. It is probably the largest in Europe, but it is doubtful if it is as large as the Grand Central or the Pennsylvania station in New York. The station, although perhaps the busiest station in Germany, is not as busy as some of those elsewhere in Europe, notably the Gare St. Lazare in Paris—the busiest in the world—and the Liverpool St. station in London, both of which handle twice as much traffic as the busiest American station—the South station in Boston.

Manufacturing Radical Automatics

WHEN jigs and fixtures are used in manufacturing machine tool parts, the well-known advantages of interchangeability and higher rates of production are obtained; and the feature of interchangeability of parts is of exceptional importance when the machines are of a class extensively used in both domestic and foreign industries. But despite the benefits secured through the use of suitable manufacturing tools, there are many factories engaged in building machine tools which still rely upon expert workmanship and hand fitting to control dimensions of parts, instead of using jigs and fixtures that would not only insure a higher degree of accuracy than could be obtained by the best work done by hand, but would also effect a material increase in rates of production. Visitors to the plant of the Fitchburg Automatic Machine Works, Fitchburg, Mass., who are given an opportunity of making a careful study of the methods employed in manufacturing "Radical" automatics will be impressed by the exceptionally simple design of these machines and the small number of parts, as well as by the complete equipment of jigs and fixtures that has been provided to insure accuracy in the fitting of all important parts. It is the purpose of the present article to describe a part of this company's manufacturing practice, the aim being to show what excellent results may be obtained through the use of jigs and fixtures in machine tool shops.

Machining Operations on the Bed

In conducting subsequent machining operations on the bed, the carriage ways are used as locating points, and the first operation consists of setting up the bed casting in a planer fixture and planing the ways. After this has been done, the casting is transferred to a Universal boring machine, on which the cam-shaft bearing holes are bored in the proper relation to the ways, and when this operation has been completed both the ways and cam-shaft bearing holes are used as locating points. The bed casting is next set up in a boring mill fixture, in which it is located from and rests on the planed ways; and this fixture provides for rough-boring all holes in the tool knee and the driving shaft bearing holes, and for finishing the gage stop hole. After this, the indexing lever holes are drilled through a jig in which the work is located from the cam-shaft bearing holes. The jig used for drilling the holes in the bosses through which the threading mechanism rods pass locates the work from the finished tool knee holes and the planed ways; and a similar jig provides for drilling and reaming all the speed gear-box holes. Another jig provides for locating, drilling or boring and reaming all holes in the bed required for bolting and pinning the worm bracket, feed gear-box, driving shaft bracket, and oil pump bracket to the bed; and the saving of time effected by machining all these holes at a single setting of the work is obvious.

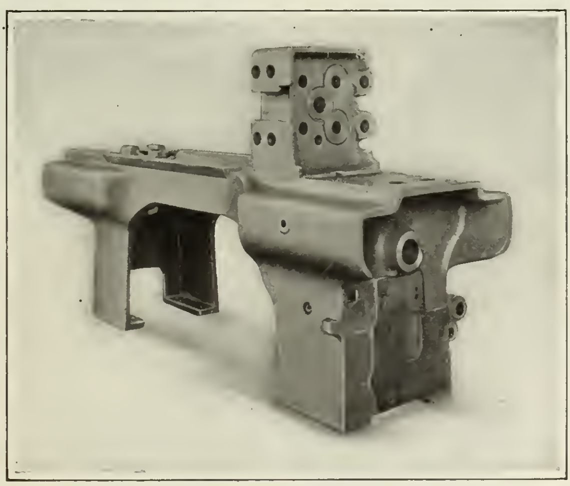


Fig. 1. Finished Bed of "Radical" Automatic ready to go to Assembling Department

Fig. 2. Aluminum Pattern which produces Perfect Pan Castings

Early experience in casting the pan for "Radical" automatics showed that trouble was experienced from shrinkage cracks and rough surfaces when molding was done from a wooden pattern; and to overcome this difficulty an aluminum pattern was made, which is filed and polished so that the surface is extremely smooth. This pattern, which is shown in Fig. 2, may be lifted from the sand without any trouble, and molds made from it produce perfect castings. A simple drill jig is provided for drilling the holes in the bed feet, pan and pan feet, which are required for bolting the bed to the pan and the pan to the floor. Construction of this jig follows familiar practice in tool design.

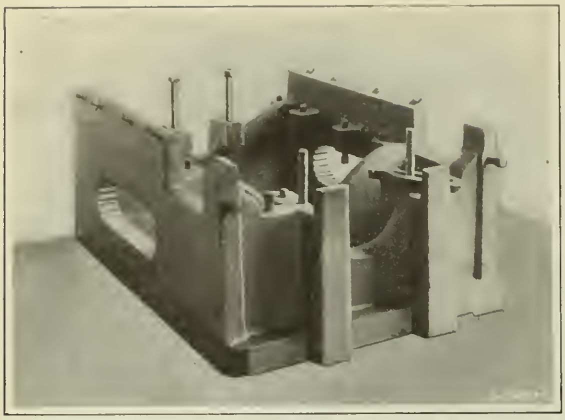


Fig. 3. Planer Fixture in which Carriage is held while planing Ways, Cross-slide Lever Bosses and Other Surfaces on Under Side

Fig. 4. Fixture mounted on Swivel Base to provide for planing Bearing for Taper Gib in Cross-slide

Machining Operations on the Carriage

Fig. 3 shows a planer fixture in which the carriage is held for planing the under side. While held in this fixture the ways are first machined, and accuracy in this part of the work is of great importance, because the ways are used as locating points for subsequent operations, as previously mentioned. In addition, the cross-slide lever bosses are planed and all other finished surfaces on the under side of the carriage are taken care of at the same setting. For the performance of these preliminary machining operations on the carriage, the rough surface of the casting is used as the locating point, the work being supported by screws which are clearly shown in the illustration; and four set-screws at each side of the fixture provide for holding the work down with the assistance of strap clamps.

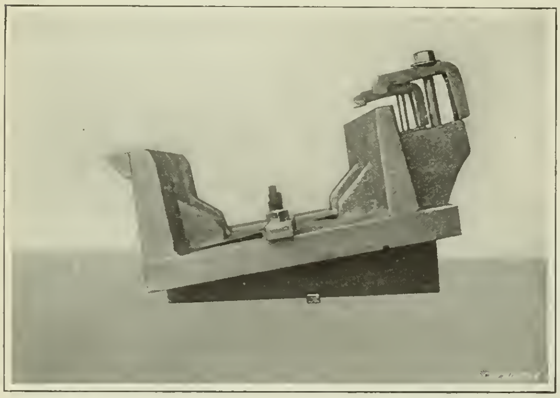


Fig. 5. Fixture held on Tapered Base to provide for planing Carriage Cap Bearing at Required Angle

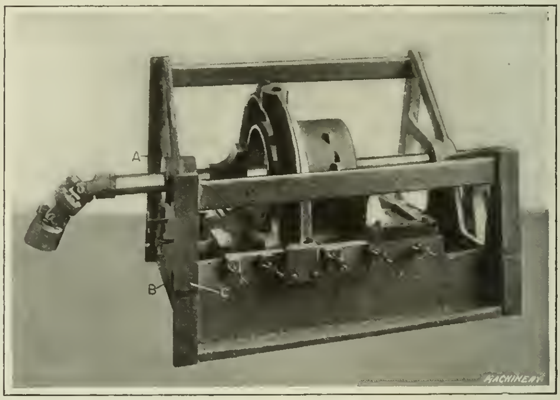


Fig. 6. Triple Based Fixture used for drilling, boring and reaming All Holes in Carriage at Single Setting

When the machining of the under side of the carriage has been completed, the casting is transferred to the planer fixture shown in Fig. 4, in which the work is held while all the top surfaces are planed with the exception of the bearings for the cap. The work is located from the main ways to provide for locating the cross-slide exactly at right angles to them; and it will be seen that the upper part of the fixture swivels on the base, graduation marks being provided at one corner to enable the fixture to be moved through an angle of one degree in order to plane the taper for the cross-slide gibs. Jacks are provided to give adequate support for the work at all points. All planing operations on top of the carriage can be performed in the fixture shown in Fig. 4, with the exception of planing the cap bearings which are located at an angle. For handling this part of the work, the casting is transferred to a fixture shown in Fig. 5, which has a tapered base for holding the work at the required angle. As in the previous case, the work is located from the planed carriage ways.

The next operation on the carriage consists of drilling, boring and reaming all holes, and a fixture shown in Fig. 6 has been developed for this purpose which enables the entire

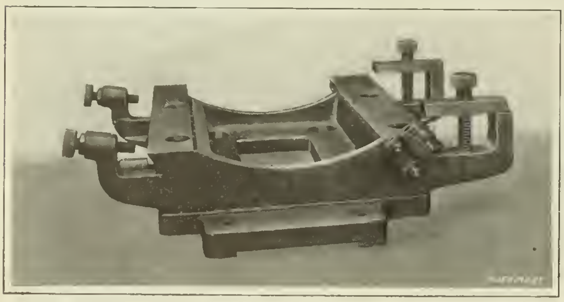


Fig. 7. Fixture used on Heald Planetary Grinder for grinding Cylinder Bearing in Carriage

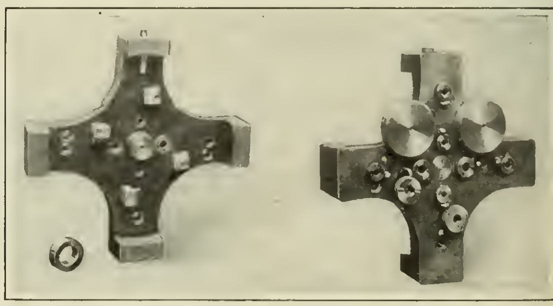


Fig. 8. Example of Multiple-purpose Drill Jig used in performing Four Operations

job to be done at a single setting. It will be seen that this fixture has three finished bases at A, B and C, which are slotted to provide for locating the fixture over a strip on the table of the Universal boring machine on which this operation is performed. The work is located from the planed main ways, and this illustration shows a special piloted boring-bar used for roughing out the two cylinder bearings in the carriage.

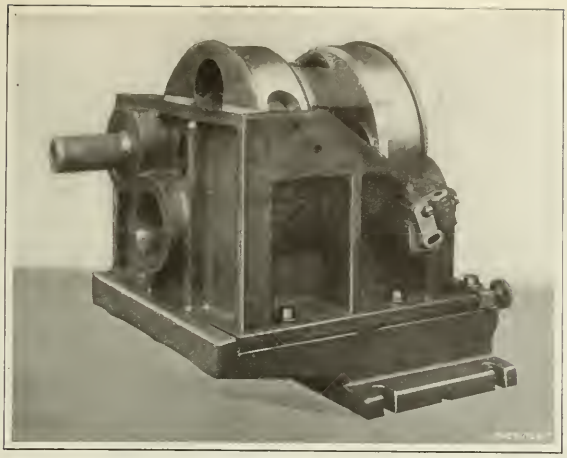


Fig. 9. Fixture used on Heald Grinder for finish-grinding Spindle Bearings and Index-pin Bushings in Cylinder

Grinding Cylinder Bearings in Carriage

A Heald planetary grinder is used for finishing the two cylinder bearings in the carriage, and while performing this operation the work is held in a fixture illustrated in Fig. 7. The table is removed from the grinding machine to enable this fixture to be mounted directly upon the bed. As in the case of the previous operation when the cylinder bearing was bored, the work is located from the main ways and strapped down on the finished locating surface on the fixture. Before being placed in this fixture, the planed ways of the carriage are carefully scraped to fit a perfectly accurate master bed in order to eliminate the slightest error in locating the work, as limits of accuracy on this operation are $\pm$ 0.00025 inch. After finish-grinding the cylinder bearing, the ends of the cylinder housing on the carriage are ground to accurate dimensions. The final grinding operation on the carriage consists of grinding an index-pin hole. A fixture provided for this purpose locates from the ground face of the cylinder housing and scraped ways of the carriage; this fixture is bolted to the table of a Heald planetary grinder which finishes the hole within a limit of accuracy of 0.00025 inch.

Grinding Operations on Cylinder

The two outside bearings of the cylinder which run in the carriage bearings are ground to an accuracy of 0.00025 inch on a grinder especially developed for this purpose by the Universal Grinding Co. A Heald planetary grinder is employed for grinding the spindle bearings in the cylinder and for grinding the index-pin bushing holes. The spindle hole and corresponding index-pin hole are located at right angles to each other, but the grinding of both sets of holes is completed in the fixture shown in Fig. 9. The spindle bearing holes are ground first, after which the fixture is turned through an angle of 90 degrees and the cylinder is reversed end for end in the fixture, so that the index-pin holes come opposite a cut-away section of the fixture and may be reached by the spindle of the planetary grinder. It will be evident that the work is located by a gage plug which fits in the ground spindle holes, as shown in this illustration, and the work is located in the fixture from the finished end and periphery. The spindle holes are ground within a limit of 0.0005 inch, both as regards diameter of holes and spacing between them; the lock-pin bushings are also held within the same limits.

Multiple-purpose Drill Jig

Factories engaged in manufacturing a large number of different parts that are required to be interchangeable often find the expense of jig and fixture storage a considerable item in their cost of production, even where no difficulty is experienced in keeping track of these tools. Obviously, it is an advantage to reduce the number of jigs and fixtures as much as possible, and this can often be done by making multiple-purpose tools. A good example of this kind is illustrated by Fig. 8, which shows opposite sides of a drill jig used for four distinct machining operations on the parts of this machine. This jig is used for drilling the index gear holes in rear of cylinder, independent gage stop spider, spider holes in front of cylinder, and wedge stop holes in rear of cylinder. All these operations are performed in parts closely related to the cylinder, and as the holes are distributed over areas of about the same size, it was found feasible to provide a single jig for handling them. Not only is the cost of tools reduced in this way, but such a practice in tool design is the means of materially reducing the amount of storage space required for jigs and fixtures. Tool designers in many factories where a lot of special equipment is needed for handling the work would do well to give this point careful consideration in working out their designs. In this way it would frequently be found possible to so group the operations that one tool could be made to serve for two or more purposes.

Fig. 10 shows a universal cam cutting machine used for producing the different forms of cams. It will be seen that the work is supported on centers in a headstock and tailstock carried by table A which is supported on slide B. The arrangement of the drive to milling cutter C and the means for transmitting motion to the rotary feed mechanism are clearly shown in this illustration, spur gear D being mounted on the headstock spindle to rotate the work. In addition to this rotary movement for feeding the work up to milling cutter C, provision must be made for securing the required longitudinal movement to obtain the required cam outline; and this is secured by means of wheel E, on which are mounted cam strips that engage with a roller secured to the end of table A. As wheel E rotates, contact of the cam strips with this roller results in imparting the necessary lateral movement to the table to secure the required outline. The roller is held in contact with the cam by a counterweight attached to the table. Wheel E and the cam strips

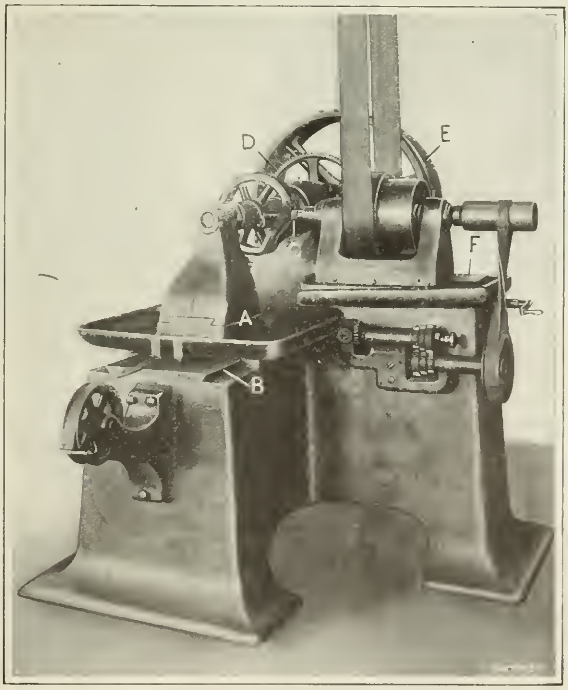


Fig. 10. Universal Cam Cutting Machine for making Cams used on "Radical" Automatics

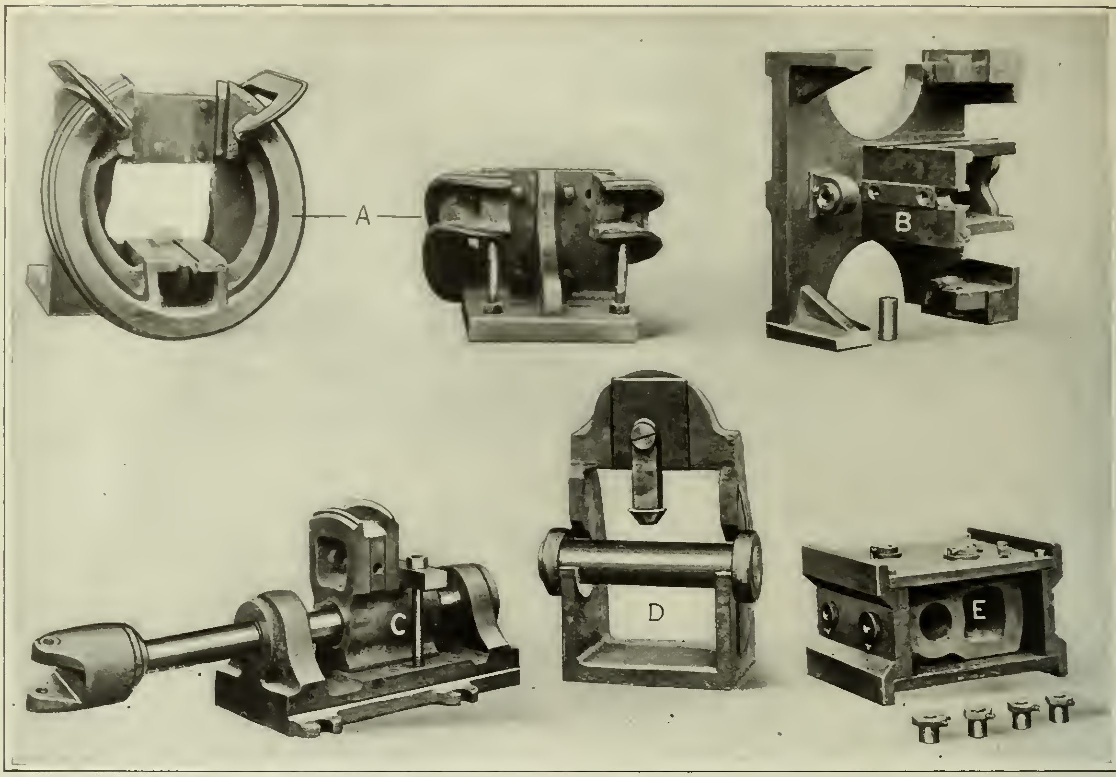


Fig. 11. A, Shaper Fixture for Lead Cams; B, Drill Jig for Lead Cams; C, Boring Fixture for Lead Cam Hubs; D, Die Cam Testing Fixture; E, Drill Jig for Lead Cam Hubs

carried by it are so designed that these strips may be set at different angles to provide for cutting the various forms of cams that are required. The cutter-head which supports milling cutter *C* is mounted on slide *F*, and to provide for cutting cams of various diameters the position of this head may be regulated so that milling cutter *C* is at the required distance from the line of centers on which the work is mounted when set up on the machine.

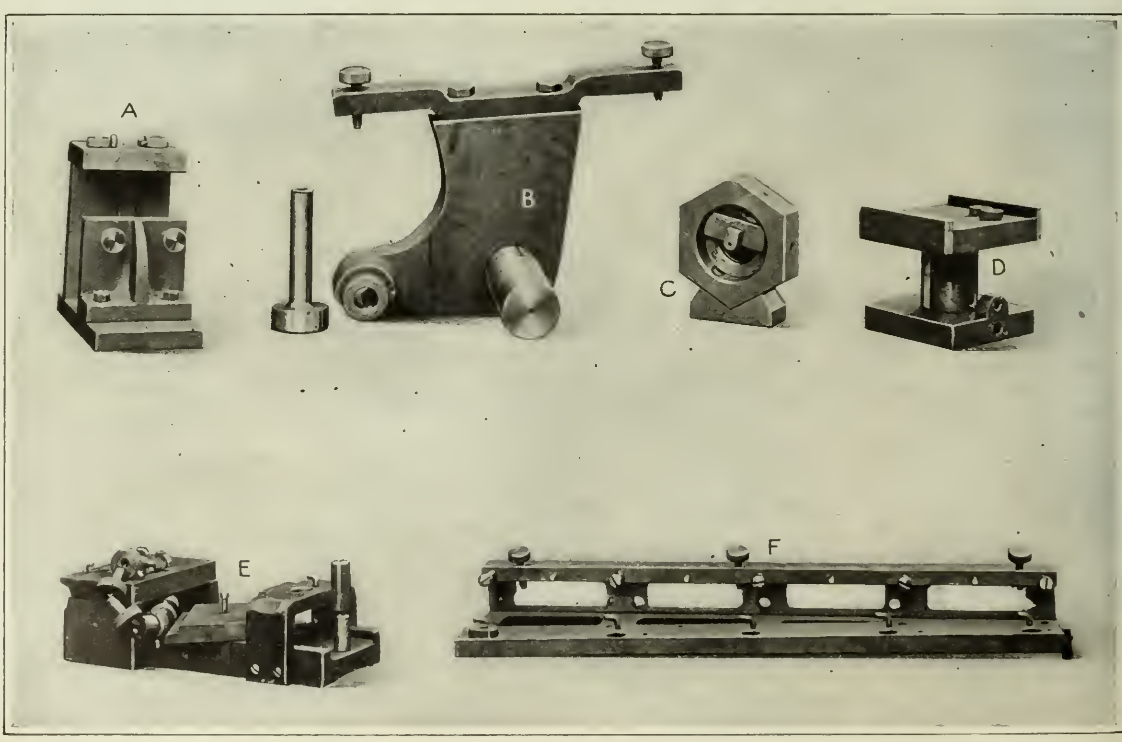


Fig. 12. A, Drill Jig for Cross-slide; B, Drill Jig for Index Lever Bearing on Bed; C, Drill Jig for Adjusting Nut for Spindle Rear Bearing; D, Drill Jig for Lock Bolt Cam; E, Drill Jig for Chuck Operating Slide and Shoe; F, Drill Jig for Cylinder Carriage Gib

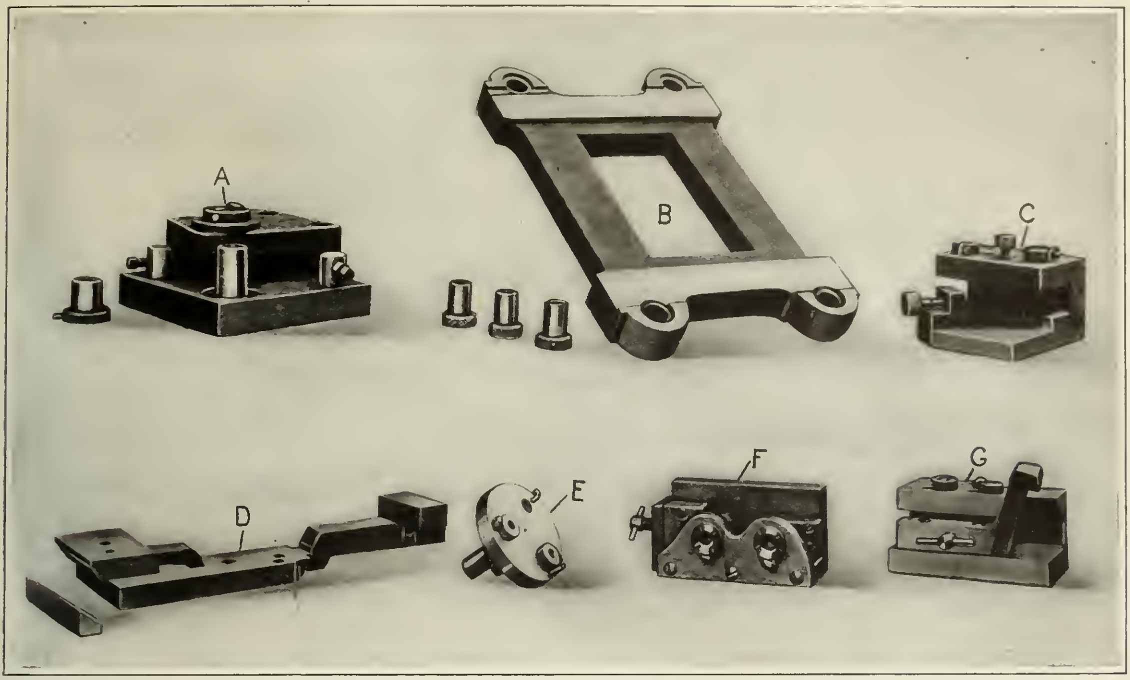


Fig. 13. A, Drill Jig for Index Levers; B, Drill Jig for Clamping Screws for Carriage and Cap; C, Drill Jig for Cross-slide Stop; D, Drill Jig for Cross-slide Cam Fork Bearing and Hole for Lock Bolt Spring; E, Drill Jig for Gear-box Pawl Holder; F, Drill Jig for Clutch Shifter Arm; G, Drill Jig for Feed Chuck Arm

Jigs and Fixtures for All Important Parts

The preceding description has covered in a general way the manner in which the machining operations are conducted on the bed, carriage, spindle cylinder and other parts. Lack of space precludes the possibility of presenting a complete description of all manufacturing methods, but it may be mentioned that wherever the accuracy of machine parts has an important bearing upon the perfection of the product, such parts are manufactured in jigs and fixtures so that their accuracy is insured. Figs. 11 to 14, inclusive, show miscellaneous examples of jigs and fixtures provided for machining various parts, and the captions which accompany these illustrations

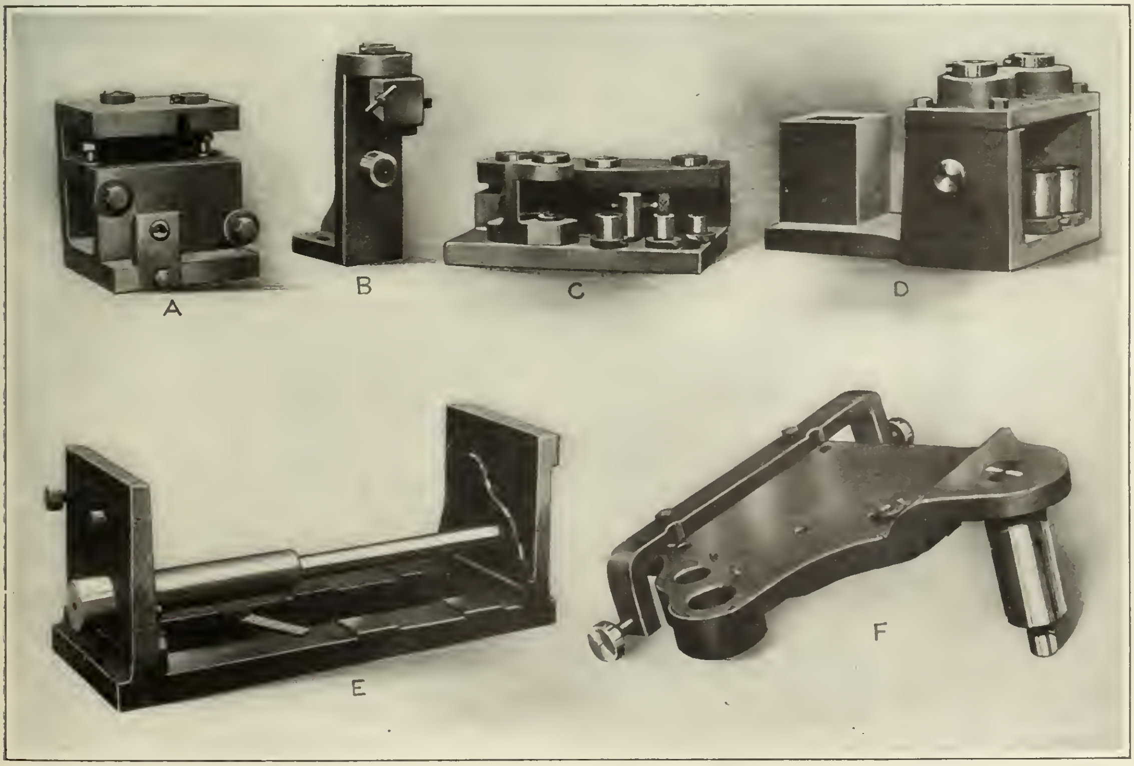


Fig. 14. A, Drill Jig for Index Segment Bracket; B, Drill and Facing Jig for Ends of Cross-slide Spider; C, Drill Jig for Index Levers; D, Drill Jig for Index Segment Bracket; E, Drill Jig for Cam-shaft Gear-box; F, Drill Jig for Cam-shaft Gear-box Bolt Holes

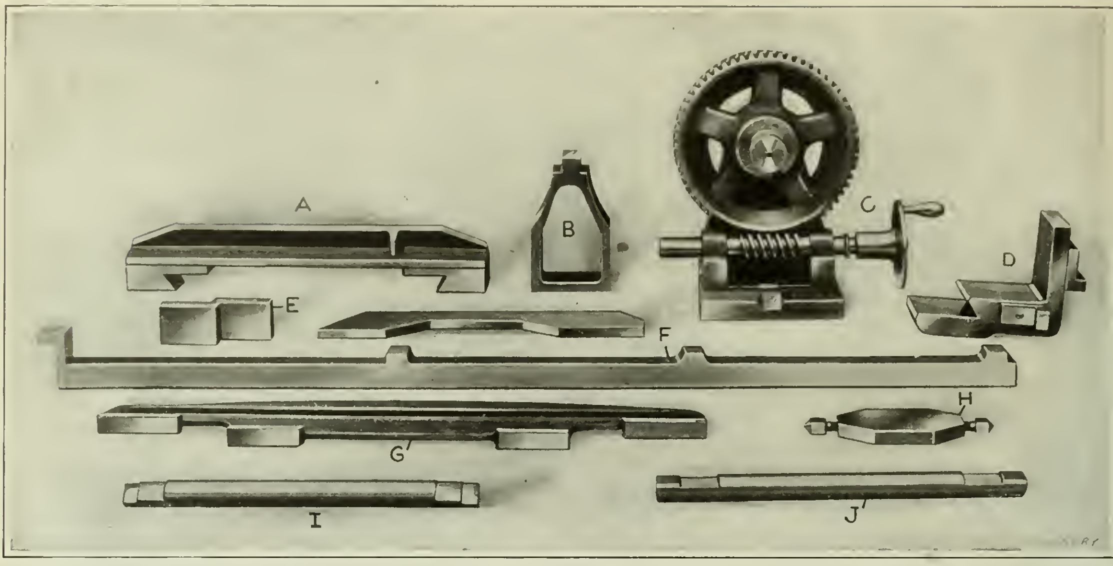


Fig. 15. A, Width Gage for Ways of Bed; B, Gage for Lead Cams; C, Cam-shaft Worm and Gear Testing Fixture; D, Gage for locating Index Bracket Faces from Ways; E, Locating Gage for Ways of Chuck Operating Slide; F, Gage for Gear-box, Table and Ways; G, Gage used with Boring Fixture; H, Center Gage used in planing Beds; I, Gage for Cylinder Carriage Cap Bearing; J, Gage for Cylinder Cap Bearing

give a brief explanation of the purpose for which each tool is used, which will be sufficient for any experienced mechanic.

Inspection and Gaging

As in all cases of manufacturing when a high degree of accuracy is required, it is necessary to take great care in inspection, and for use in handling this work the Fitchburg Automatic Machine Works have provided a complete set of gages and testing fixtures, miscellaneous examples of which are shown in Figs. 15 and 16. As it is not within the scope of this article to deal exhaustively with the manufacture of each part of the machine, no detailed description of these gages will be given; but from the illustrations and captions which accompany them, the reader will be able to gain a comprehensive idea of the manner in which all parts are inspected and tested for accuracy. Johansson limit and snap gages are used in inspecting and gaging work; and a complete set of Johansson block gages is used in making jigs and fixtures, testing micrometers, etc., so that provision is made for obtaining the maximum degree of accuracy. When this care is taken in manufacturing and testing all parts before they are assembled, the user of the finished machines is insured of satisfactory service; and he also has the advantage of being able to order duplicate or replacement parts for equipment he has in use with the assurance that such parts will go in place when they are applied without requiring fitting and realignment.

E. K. H.

* * *

NEEDLESSLY HEAVY RAILWAY EQUIPMENT

Henry Ford, the Detroit motor car manufacturer, struck the nail on the head when he criticized the useless dead weight of railway cars. The railways of the United States are generally equipped with cars made of low-grade materials, and as a consequence millions of tons of dead weight are hauled for which no compensation is received. This useless weight requires the expenditure of power and wears out the track and road bed needlessly. Mr. Ford stated that the railway companies could improve efficiency by cutting down the weight of their equipment, asserting that there is no greater waste in this country today than in the use of steel. Great weights in railway equipment are unnecessary and make for increased labor. The railway companies use steel having a tensile strength of about 60,000 pounds per square inch, whereas they might just as well use steel having a tensile strength of 200,000 pounds at very little increased cost. The use of the higher grade of steel would provide larger capacity cars with less dead weight.

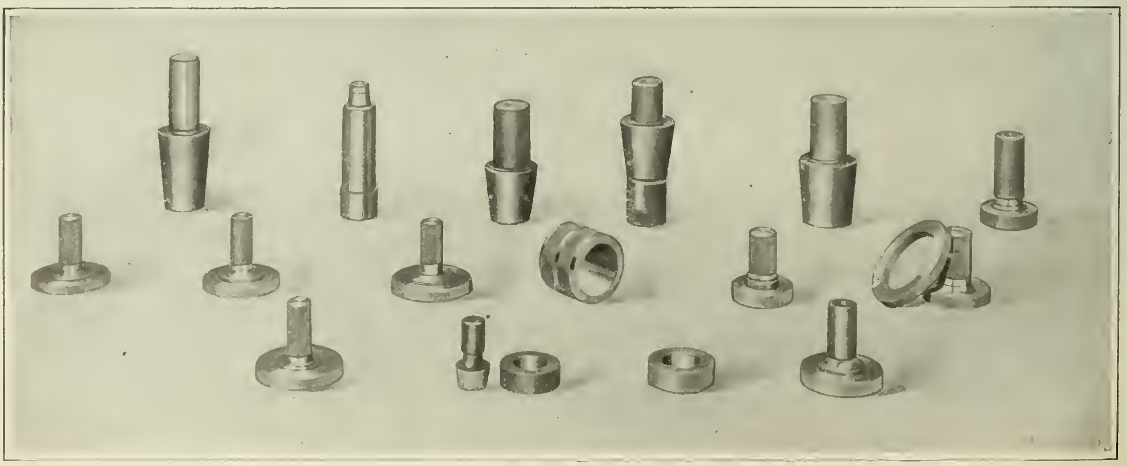


Fig. 16. Miscellaneous Collection of Plug and Ring Gages used in testing Parts of "Radical" Automatics

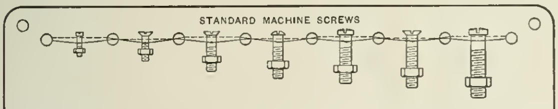
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

"MATERIALIZED" TABLES

In view of the fact that it is much easier to judge strength, size, etc., from the real article than from pictures or tables, it is convenient to have samples of all small articles, such as machine screws, cotters, taper pins, spring steel, sheet steel, small shafting and rods, wire, etc., conveniently mounted in some handy place in the drafting-room.

It has proved handy to mount them on cardboard in the manner shown in the illustration, which secures them in a definite position, and at the same time allows them to be handled if a little slack is left in the string. Metal eyelets should be used where the string passes through the cardboard, and in the corners for hanging it up. A string is put through the first eyelet, tied to the article to be fastened, through the next eyelet, across the back of the cardboard to the next eyelet, when it is again brought to the front of the board and tied to the article to be shown. This process is continued until the end of the cardboard is reached, when every alternate sample will have been fastened to the board. The string is then returned to the other end of the board in a similar manner and the remaining articles are fastened in place. Any information often made use of may be noted directly under the article to which it refers. For instance, the size and number of machine screws, diameter of screw, diameter of head, height of head, diameter of tap and free drills, etc.



SIZE	4-36	6-32	8-32	10-24	12-20	14-20	16-18	
DIAMETER								
DIAM. HEAD								
HEIGHT OF HEAD								
TAP DRILL								
FREE DRILL								

Machinery

Handy Chart for Drafting-rooms

Harvey, Ill. G. G. STEVENSON

FITTING TAPERS

I do not agree with the method of fitting tapers described by D. B. in the September issue of MACHINERY. It is all right for the lathe hand if the tapers are to be finished on a grinder, but I have used a method of fitting the finest taper fits that does not require the use of a special blue pencil or any marking material whatever. The majority of mechanics think they cannot get along without some kind of blue crayon, as it shows up well on brass and can be seen better on steel and cast iron than white chalk, but it is really unnecessary. My method of fitting tapers such as arbors and shafts to drill chucks and the endless category of machine tool spindles is as follows:

After the taper has been turned, leaving an allowance for filing, I take a piece of new emery cloth and make scratches lengthwise around the work. Then, when trying the fit, the bearing can be easily seen in the dull spots made by rubbing the internal and external surfaces together.

Winchester, N. H. WILBUR HATFIELD

With reference to the method of fitting tapers described in the September number of MACHINERY, the writer would say that rubbing Prussian blue or other color on the parts and wringing them together serves quite well when both surfaces are newly machined and true. But if one member has been used, or if a reamer used in the external member was not perfect, wringing gives misleading indications.

The writer has found the use of strips of paper satisfactory in all cases. The paper may be of almost any kind, but a thin grade of writing paper is preferable. As the strips should be used lengthwise of the work, they should have the same taper and should be about one-twentieth of the circumference in width. If there is just a trace of oil left on the taper member, the results are more easily read.

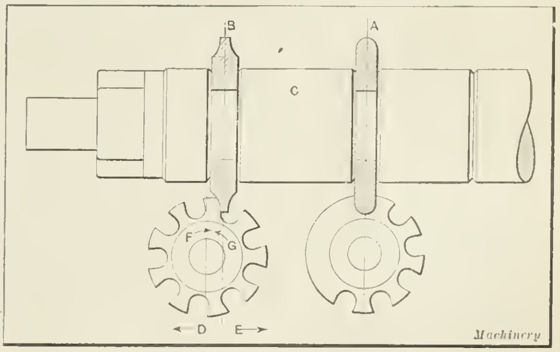
When the tapered members have been carefully put in their correct position, with the strips of paper between them, the strips being placed equal distances apart when more than one is used, the tapered parts are lightly tapped together. After they have been separated by tapping (not by wringing), a delicate and perfect record of both surfaces will appear on the surfaces of the paper. The objection to wringing such surfaces together is that any projection is likely to appear as a circular ridge, which it often is not, and a depression of the internal surface may not appear at all. Such paper prints of the condition of taper surfaces may be kept as permanent records.

Wilkinsburg, Pa. WILLIAM S. ROWELL

HOW WE CUT A FEW SPROCKET WHEELS

There were a number of nine-tooth sprockets for a half-inch roller chain to be cut. The tool-room did not contain a regular sprocket cutter, and the number of sprockets required was too small to warrant the expense of a cutter, so a 5/16-inch convex cutter *A* and a nine-pitch No. 8 gear-cutter *B* were mounted on a milling machine arbor, as shown in the accompanying illustration. By making the length of spacing collar *C* such that the distance between the centers of *A* and *B* was an even number of inches, the work of making the settings was greatly simplified, as it was then possible to move the cross-slide an even number of turns.

After the convex cutter *A* was set central with the dividing-head spindle and the cross-feed dial set at zero, the table was moved over and the gear-cutter *B* centered; its position was



Method of setting Milling Machine

then noted on the dial. The table was then set back so that the convex cutter *A* was in line with the dividing-head spindle, the sprocket blanks were placed between the centers, and the nine gashes cut to the proper depth.

When all the blanks were cut, the table was again moved so that the gear-cutter *B* was in line with the spindle. The corners of the teeth were then formed to the proper shape by setting the table slightly off center in direction *D* and rotating the blank in the direction shown by the arrow *F*, to bring one side of the tooth against the cutter. The amount of this offset was found by experiment. As soon as the complete cut had been

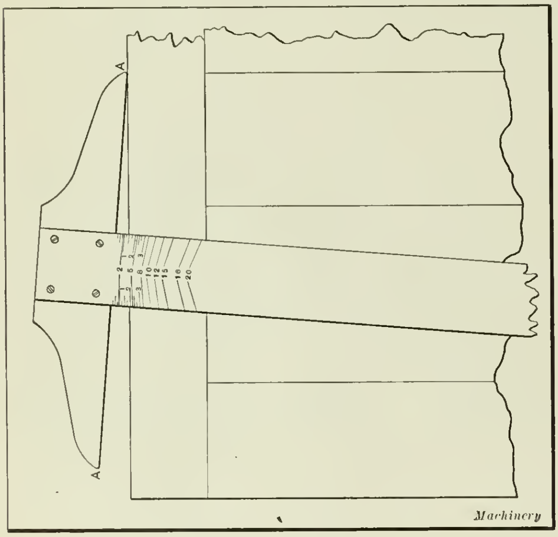
taken around the blank, the table was dropped so the blank would clear the cutter. The table was then offset a like amount in the direction E on the opposite side of the center, and the blank rotated in the direction of the arrow G to trim the opposite side of the tooth. The depth at which the gear-cutter was set was determined by experiment, as it depends on the amount the blank is set off center.

While this description may seem rather long and complicated, the process is simple and the settings are quickly made, and if a little care is exercised the work produced will equal that done by a regular sprocket cutter. If a record of the various settings is kept, it is possible to duplicate the work and make the settings very rapidly.

Brooklyn, N. Y. PHILIP H. KALLENBERG

HANDY T-SQUARE PROTRACTOR

In some lines of drafting a protractor is constantly required. The accompanying illustration shows one which is quite satisfactory in that it is always at hand, and is not conveniently "lendable." It is also sufficiently accurate if put on carefully. When used in combination with triangles, any desired angle can be obtained, either vertical or horizontal. The figures down the center of the blade and the lines running to them represent the angles, and the other figures and lines near the margin represent the tapers in inches and quarter inches per



Handy T-square Protractor

foot. The corners A of the head of the T-square should be rounded before the marks are put on, to avoid wearing and making the protractor inaccurate.

An accurate lay-out of the required angles and tapers is first made on drawing paper by the use of a good protractor or by trigonometry. Then while the lay-out is still fastened on the drawing-board, the T-square is set to the lines of the layout, and by means of a straightedge and a scratch-awl the angles and tapers are transferred to the blade, each mark coinciding with the edge of the drawing-board. After the marks are put on, the figures are stamped and inked.

Sarnia, Ontario, Canada. JOHN BURKAM

TOOLMAKER'S TEST INDICATOR

While there are a number of different styles of test indicators on the market, some of the best designs are in use only by the designers or their immediate acquaintances. The indicators shown in Fig. 1 at A and B were designed by Warren Dunbrack and have been used on the fine tool and die work at the factories of both the Waltham Watch Co. and the Howard Watch Works. The various points used on these instruments are contained in a boxwood holder shown at D.

While this indicator was designed for very small and accurate work, it can, of course, be used for any purpose for which

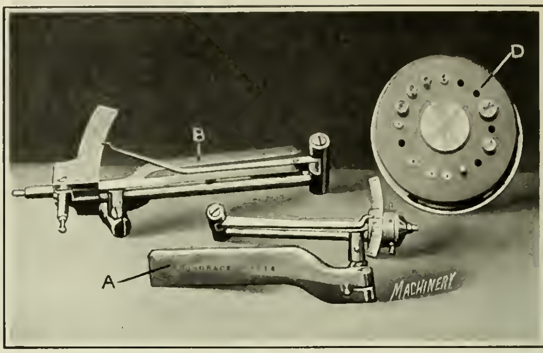


Fig. 1. Toolmaker's Test Indicators

an accurate indicator is adapted, but for average tool work an instrument of heavier construction is to be preferred, as it is stronger and more easily handled. Since the original was made, several others like it have been made, as well as some of twice the size, like that shown at B in Fig. 1, for heavier work. These indicators have all proved to be very satisfactory tools.

In the essential principle of multiplying levers, this indicator differs little from many others, but the construction which permits indicating a piece of work, both on its inside and outside diameters and also on its face without disturbing the setting of the tool, and the movable dial which allows its use in close corners, are well worth a description. The details, with the dimensions of the small sized tool, are given in Fig. 3, for the benefit of any who may wish to make up an indicator for personal use. For making the larger size it is only necessary to multiply the dimensions given by 2, except in the case of the pin which controls the multiplication of the levers. This is best placed farther away from the pivot so as to make the instrument less sensitive, as the extreme multiplication of levers is not needed on average work.

Referring to Fig. 2, A is the body of the tool, made in one piece from drill rod, B is the indicating dial segment, C the indicating pointer, and D the multiplying lever which swings on pivot E and carries the three indicating points F, G, and H. At J are shown two flat springs carried by a stud K which is a light drive fit in the body A. L is a screw having an eccentric pin turned on one end. This screw is used to adjust the normal position of the pointer C which is controlled by the pin M passing through it and the slot in the multiplying lever and between the two springs J. These springs are under constant tension, which keeps them in contact with the pin M and also with the eccentric pin on the end of screw L; so that turning the screw to the right or left will throw the pointer to either side of the dial, according to which side of a piece of work is being indicated when the full swing of the pointer is wanted in one direction. The pivot P which carries the

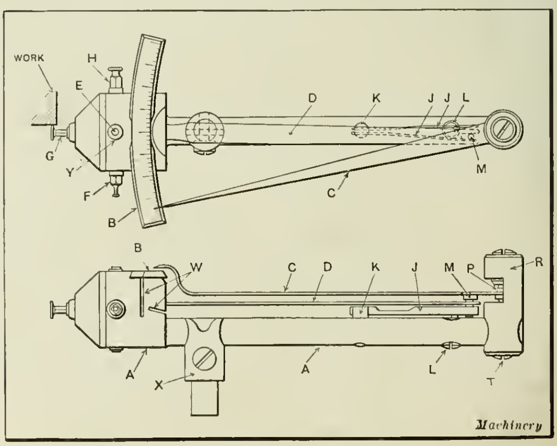


Fig. 2. Toolmaker's Test Indicator Assembled

pointer has a bearing in a bushing at one end and in a screw at the other, contained in the head *R*. The screw and bushing are made as shown in Fig. 3 at *Z* and *S*, respectively, being hardened and the edges nicely rounded over and given a high polish at the pivot bearing.

The head *R*, Fig. 2, is fastened securely to the body *A* by a pointed set-screw *T*. The dial *B* is a friction fit in the body of the tool, and to maintain this friction two cuts are made in the body as shown at *W*, the body afterward being hardened and drawn to a spring temper. *X* shows part of the holder which is merely a piece of drill rod bored out to slip on the body and then split and held to a proper friction fit by the screw shown. This, in combination with the holder *O* (see Fig. 3), allows the tool to be turned to any position when once set up in the lathe, and as all parts of the holder are a light friction fit there is little danger of the tool becoming damaged by an accidental blow or by undue pressure being applied to some part of it, as it would readily turn out of the way. Points of different kinds and sizes can be made up to suit different conditions, and as pressure may be brought to bear on either side of any of the three indicating points, there is hardly any position in which this indicator cannot be used.

For indicating center-punch marks in a piece of work swung on the lathe faceplate or otherwise, a spring center *V* (Fig. 3) is used. This differs from the usual spring center in having a disk *X*, which is a friction fit on the body *U*. This disk permits the indicator to be placed parallel with the body instead of having to be swung around at an angle, which is sometimes necessary, thus throwing the tool out of adjustment so that an exact reading cannot be obtained from the indicator dial.

Long Island City, N. Y. DONALD BAKER

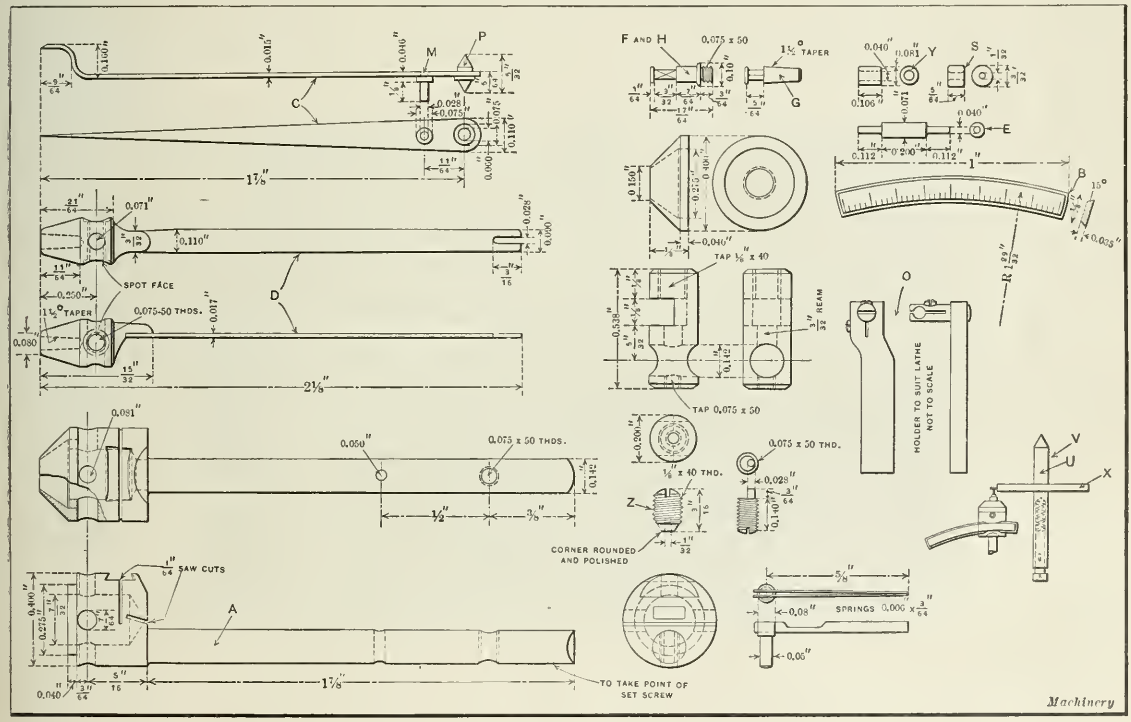


Fig. 3. Details of Toolmaker's Test Indicator

CARE OF THE EYES IN MECHANICAL WORK

There are a few points in connection with caring for the eyes of men engaged in mechanical work, which are of sufficient importance to warrant their being stated specifically. The man whose eyes are in first-class condition does not need glasses, of course; but one who has difficulty of any kind due to impaired eyesight, should always wear them. If the conditions of work are such that there are particles of emery or flying chips that might get in the eyes, glasses or goggles should be used as a protection.

If the eye becomes injured or a foreign body gets into it, it is not the part of wisdom to have a fellow workman attend to it, but it is far better to seek skilled aid at once. Many men who have some defect of vision neglect to secure suitable glasses on account of the bother of wearing them, or with the idea that they may outgrow the defect. It is undeniable that glasses are troublesome, but so are many things which we never think of doing without for that reason. The defects of vision that one outgrows or that tend to recover spontaneously are few in number. In the majority of cases the trouble either increases or the constant effort to see with impaired vision induces eye strain, with all its uncomfortable and sometimes serious consequences. It is far wiser to consult some reliable optician who may be recommended by your family physician, and get from him the lenses needed to correct your vision.

Some factories require the use of goggles, but even then many men foolishly omit this precaution. Let us suppose that a particle of steel or other foreign material enters a man's eye and he goes to a physician or to a skilled attendant in the hospital or first-aid room which many of the larger shops now provide for the care of injured employes. The foreign matter is extracted with a carefully sterilized instrument, and possibly a little mild antiseptic solution is dropped into the eye. These precautions make it certain that no infectious matter is carried into the eye by the instrument, and that anything of this kind accompanying the particle is rendered harmless.

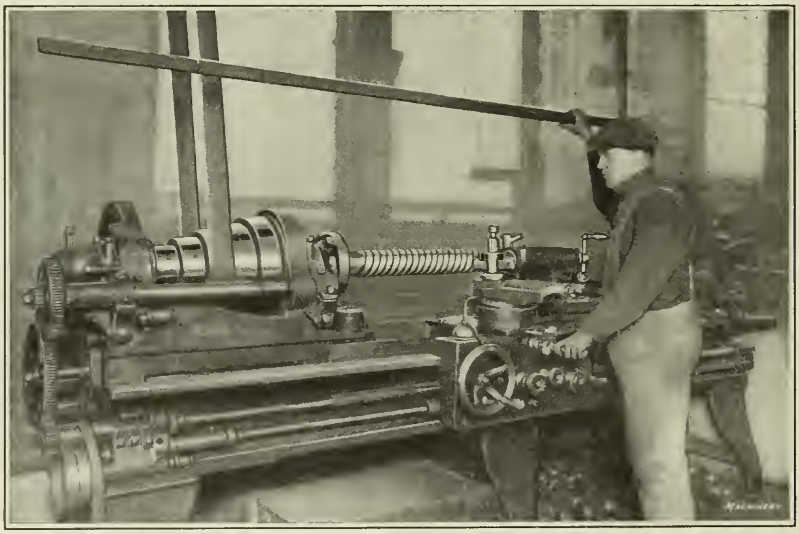
On the other hand, if a fellow shopman is called upon to remove the steel, emery or other matter, the chances are that he will whittle a bit of wood to a point with the same knife with which he cleans his finger nails and cuts his tobacco, not infrequently moistening with saliva the tool thus made. It is true that even this rude instrument may not affect the delicate covering of the eye ball, and yet there are frequent cases when it does so. I might quote startling statistics showing the average number of hours' work lost by the man whose eye has been infected by "toothpick treatment," but this is probably unnecessary, as everyone today knows something of the wonderful results in general surgery of antiseptic treatment and

can readily see the need of giving every possible chance to so delicate an organ as the eye.

In writing this article I wish to be understood as casting no aspersions on the skill of the man in the shop who enjoys the well-earned reputation as an extractor of chips from his friends' eyes. I have known more than one such man to whose manipulation I would submit my own eye with as much confidence as to any occulist *if the workman's instruments and hands were properly sterilized.* ANONYMOUS

LATHE EQUIPPED FOR HEAVY SCREW CUTTING

The Zeh & Hahnemann Co., Newark, N. J., uses Colonial "Red Star" steel for the screws used in its percussion type of power presses. These screws are cut on a lathe as shown in the accompanying illustration, and owing to the severe nature of this work a great deal of trouble was experienced through the breaking of teeth on the first pinion of the change-gears used to transmit motion to the feed-screw. To overcome this difficulty the lathe on which this work is done was equipped with a special drive shown in the illustration, which makes connection with the change-gears by means of a shaft extending across the front of the headstock. At the right-hand end of this shaft there is a pinion which meshes with the back-gear in front of the headstock, the teeth of which are of coarser pitch than those of the change-gears, and by having the pinion mesh with them, sufficient strength is provided to avoid trouble from breakage. At the left-hand end of this shaft connection is made with the change-gears, and as the gear at this point is of considerable size, the strain on the gear teeth is sufficiently reduced to avoid trouble from broken gears. Equipped in this way the lathe has been giving very satisfactory service without any of the trouble formerly experienced. E. K. H.



Lathe equipped for cutting Screws for Zeh & Hahnemann Percussion Power Presses

MAGNIFYING EYEGLASSES

Those whose work necessitates the use of a magnifying eyeglass, such as the familiar rubber-mounted glass, often known by its French name "loupe," are sadly aware of its most exasperating characteristic—the tendency of the inner surface of the lens to become clouded by moisture at the exact instant when unobscured vision is most needed. Various expedients have been tried to overcome this difficulty. Some persons have smeared the lens with glycerine, but it is doubtful if anyone did this more than once or twice. Some drill holes for ventilation in the rubber, which answers fairly well if the holes are sufficiently large and numerous.

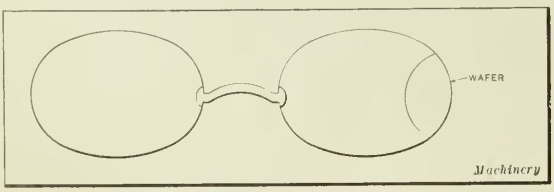


Fig. 1. Spectacles with Magnifying Wafer

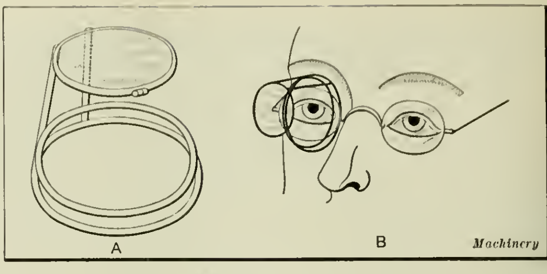
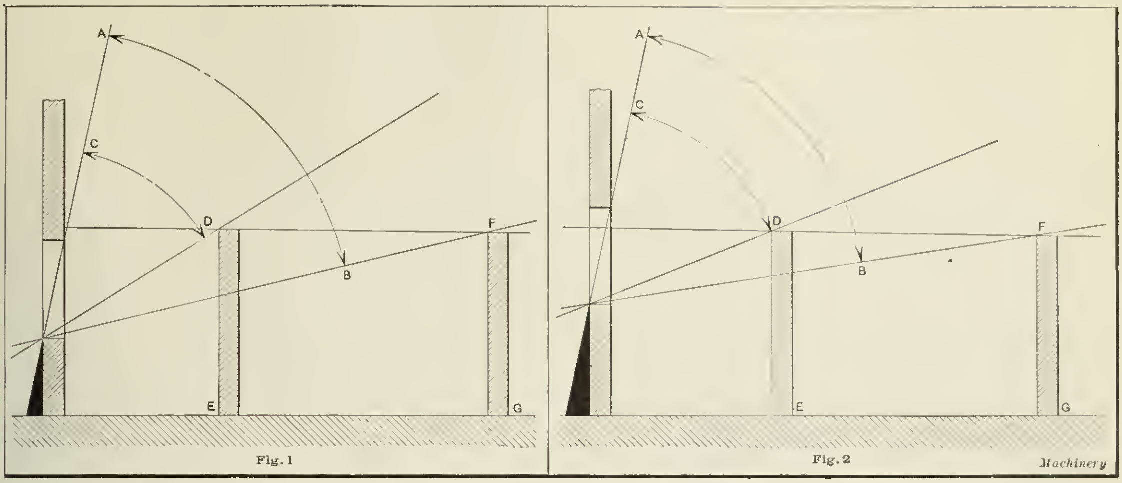


Fig. 2. Skeleton Loupes

Prominent among the memories of former days is that of a toolmaking friend who proudly wore an unsteamable glass of his own devising and construction. Its body was of No. 18 brass spring wire formed into a frustum of a cone by winding it around a taper-shank drill socket. To its base he attached a ring to be grasped by the muscles about the eye, and at its other end was placed a ring that encircled the lens. It was a success as far as non-steaming qualities went, but its weight compelled him to twist his face into a hideous shape, and the relaxation of the facial muscles caused by a moment's forgetfulness would send the glass careering along the floor, hotly pursued by its owner. He later cured the device of its wanderlust by tying to it a piece of stout twine, the other end of which he fastened to the shoulder strap of his apron.

Those who have normal eyesight can use a spectacle or "nose pincher" frame, one side of which is empty while the other carries a lens of four or five inches focal length. This is a very convenient arrangement, but manifestly unsuited to one who has to wear glasses for defective vision. These people have troubles of their own. Some of them use what the optical trade calls a "grab front"; that is, a frame holding a lens and having two prongs by which it is attached to the wearer's spectacles. Others mill or file a slot in the mounting of the ordinary loupe so that it can be hung on their glasses. They usually add a pair of small springs after a few loupes have fallen off and been broken. Still others have a "wafer," like those in bifocal glasses, cemented to the inner surface of one spectacle lens near its outer margin, as shown in Fig. 1, but this plan has the objection that it is possible to look through the wafer only by going through great contortions.

One man brought to the shop a contrivance which he confidently regarded as the acme of perfection. The lens was carried by a hinged arm attached by a ball-and-socket joint to a strap encircling the forehead, like the mirror with which the physician reflects light into a man's mouth when he desires to inspect the "department of the interior." This was very convenient, as the lens could be brought down to the line of vision when required and turned up above the front of the head when not in use. One of his shopmates, foreseeing the



Figs. 1 and 2. Diagrams showing Relative Conditions of Illumination obtained with Windows placed near Floor and Higher up in Wall

inevitable, advised the others to offer no criticisms, but patiently await results. One day, as summer advanced and the sun shone brightly on the bench where the proud owner of the "doodad" was at work, its genial rays were brought to a focus by the lens and ignited his hair. He worked placidly on, merely expressing wonder that some folks smoked such malodorous tobacco, until the process of combustion reached his scalp. Then a swift motion of his right arm sent the once fondly cherished "doodad" flying through the open window.

The writer does not know who devised the arrangement shown at *A*, Fig. 2. Though designed to hang on one's glasses, as at *B*, it can be held equally well in the usual manner. It is called a skeleton loupe and may be had in focal lengths from one to four inches from any watchmaker, as all wholesale jewelry houses have them in stock.

New London, N. H. GUY H. GARDNER

HEIGHT OF WINDOWS FROM FLOOR

Fig. 1 shows the conditions of illumination when a window is placed near the floor, and Fig. 2 shows the conditions when a window of the same size is placed at a greater height from the floor. In each case arc *AB* represents the total direct illumination which can come through the window; and *DE* and *FG* in each diagram represent walls of the same height which cut off a certain amount of light. It will be apparent that with a window placed high up the amount of light obstructed by both the nearby and the distant wall is less than where the window is placed near the floor. These diagrams also illustrate a fact which should be quite apparent, namely, that a nearby wall cuts off more light than one at some distance from the window.

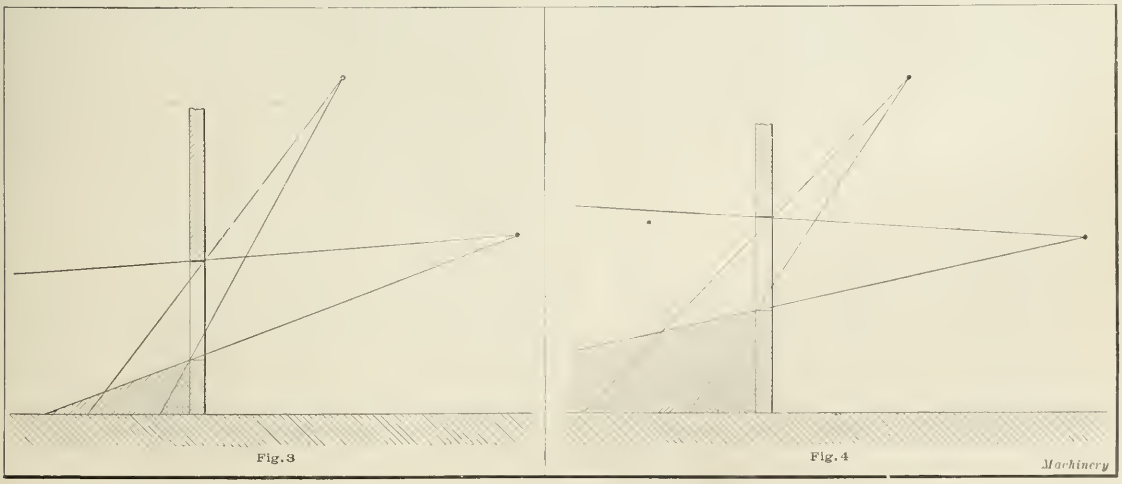
In placing windows in a factory building it naturally makes a great deal of difference where the light is needed. Thus, in Figs. 3 and 4, with unobstructed windows, we see that windows placed near the floor favor illumination on benches, etc., that are near the wall, while windows at a greater height from the floor give poor illumination at points near the wall, but improve the general illumination throughout the shop. In Figs. 3 and 4 the single cross-hatched areas obtain direct light from the sun during only a portion of the day, and the double cross-hatched areas never obtain direct illumination.

New York City. ROBERT GRIMSHAW

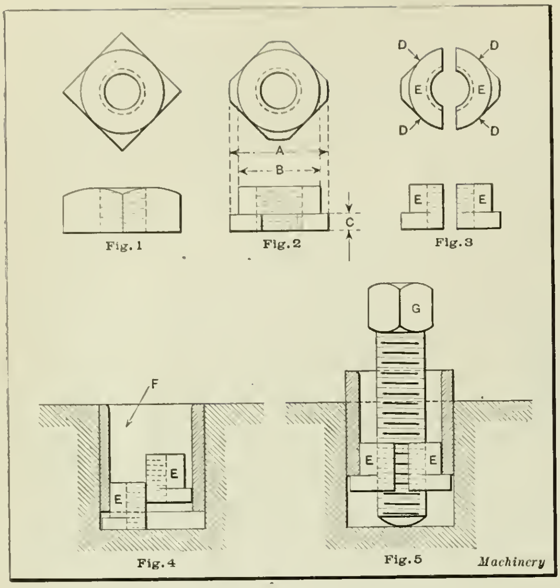
While the above deductions are correct, modern practice in factory construction favors the use of an abundance of windows extending for almost the height of the room, so that advantage is taken of the full amount of natural illumination which is available at any time of the day.—EDITOR

EXTRACTING A HARDENED BUSHING FROM A FIXTURE

Recently it was found necessary to extract a hardened bushing from a fixture, and, as there was no way of driving it from the back, the work was accomplished by using a common square nut and a cap-screw. The nut, shown in Fig. 1, was a little larger across diagonal corners than the diameter of the hole into which the bushing was driven. It was first turned down so that its diameter *A*, Fig. 2, was a little less than the



Figs. 3 and 4. Positions receiving Direct Light All Day, during Part of Day and at No Time with Low and High Windows



Method of extracting Rings or Bushings from Holes

outside diameter of the bushing. Then a part was turned down to the diameter *B* of the hole in the bushing. The thickness *C* of the lip thus formed was such that the lip could pass beneath the bushing, as shown in Fig. 4. The nut was cut in two by a tool that was a little wider than the width of one of the lips *C* and the two opposite lips were filed flush with the smaller part, as shown at *D* in Fig. 3. Both halves *E* were then placed in the bushing *F*, Fig. 4, and the insertion of a cap-screw *G*, Fig. 5, spread the halves of the nut apart, causing the lips to catch under the bushing; as the screw was turned, the bushing was forced out of the hole.

Troy, N. Y. A. M. Aldrich

DIEMAKER'S KINK

The device illustrated at *X* in Fig. 1 is a valuable addition to a diemaker's kit. It is used for locating the piercing holes in die-blocks and for locating the piercing plungers in the punch pad; it will also be found especially useful on that class of dies known as pillar sub-press dies, shown in outline at *Y*. The tool *X* consists of the body *A* made of hardened tool steel, in which a center hole is lapped, the bottom *B* and edge *C* being ground true and square with the hole. *E* is a hardened and ground pin, the ends of which must be ground true with the body and which should have an included angle of about 60 degrees. This pin should be an easy sliding fit in the body of the tool. To use the device for locating the centers of piercing holes in die-blocks, templets or other work, it is placed on the work, lightly clamped in the approximate position of the hole and then adjusted accurately by the use of a micrometer depth gage or other measuring tool of suitable nature, as indicated in Fig. 2. After being located in position, the center pin is put in place with the sharp pointed end down and lightly tapped with a hammer on the top to make a center in the work, which can afterward be used as a locating point.

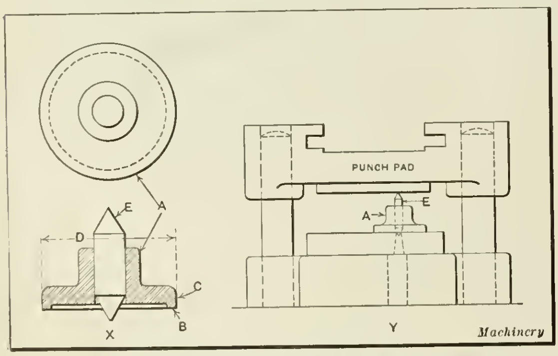


Fig. 1. (X) Centering Plug for transferring Holes; (Y) Application of Plug to a Punch and Die Job

A convenient form of parallel clamp for use with this tool is illustrated in Fig. 2. One end is forked to fit over the shoulder on the body of the tool, while the screws *K* for adjusting the clamps are placed well back from this end to allow plenty of room for the work to enter the clamp when center locations are some distance from the edge of the work. In locating centers for the piercing punches in the punch pad, the die and punch pad are first put in place in the sub-press or holder; then the tool is located in position over the piercing hole in the die by entering the center pin into the piercing hole, as shown at *Y* in Fig. 1. This method obviously locates the tool exactly central with the hole, as the tapered sides of the pin are self-centering, and the body of the tool, resting on the die face, holds the center pin square with it; it is only necessary then to lower the punch pad until it rests on the center pin, which will make a sufficient impression on the punch pad from which to work. Care must be taken, however, to see that the force used is not so great as to cause the hardened pin to damage the edges of the piercing hole in the die. This might easily occur if the punch pad and its holder were allowed to drop onto the pin. If anything more than a light impression

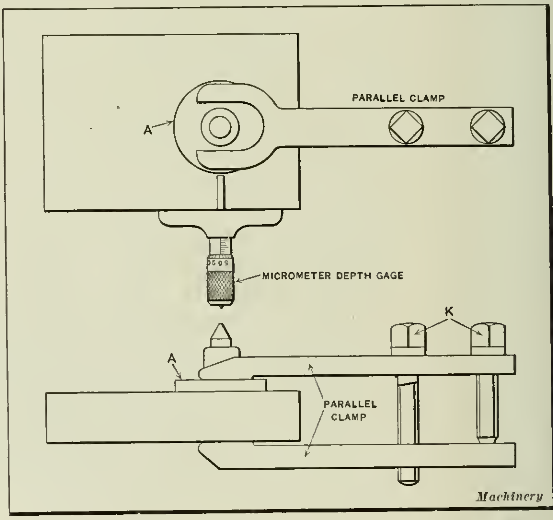


Fig. 2. Method of locating Hole by Use of Centering Plug, Parallel Clamp and Depth Gage

is desired, the best method is to let the punch pad down until it just holds the pin in place and then, working from the back of the die, a rod can be placed against the opposite end of the pin through the die clearance hole, after which a light tap of the hammer will do the work.

In making this tool, the body was first roughed out on the lathe, the center hole being reamed; it was hardened and then the hole was lapped out, after which it was ready to be ground on the face and diameter. To make sure that all the parts were square and accurate, we first took a piece of drill rod and placed it in the bench lathe chuck in which it was turned to within 0.002 of 3/8 inch; then it was finished by grinding until we could just wring the body onto it. In this position the body was ground, first on the bottom and then on the diameter, the diameter *D* being ground so that the dimensions came in even figures, in this case 1.500 inch, for ease in figuring when setting to given centers with the aid of micrometers. In making the center plug, a piece of drill rod was used with the ends turned to 60 degrees, after which the parts were hardened and tempered and the body lapped until it was a snug fit in the part *A*. Then with the plug in place in *A*, with one end projecting, it was strapped in placed on the faceplate of a bench lathe and the body *A* indicated until it ran true, after which the ends were ground, using the bench lathe

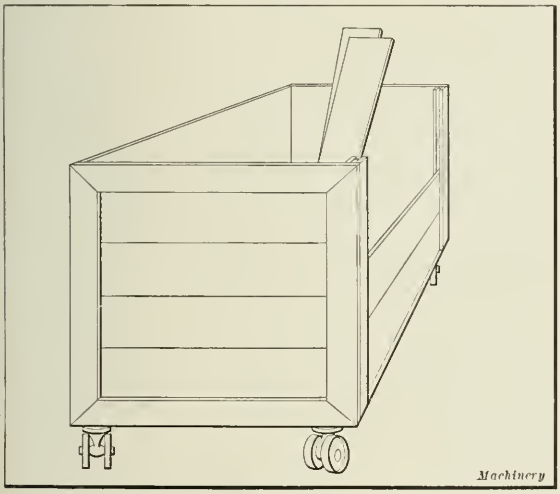
grinder. The other end was finished in a similar manner, but the extreme end or point was blunted off slightly so that a light hammer could be used on it when occasion required. After the ends were finished in the manner described, the pin was removed from the body and the outside lapped until it became an easy sliding fit on the body. The tool was then ready for use, and has been found most convenient.

Long Island City, N. Y. DONALD BAKER

BOX TRUCK

In the accompanying illustration is shown a box truck which is being adopted in many factories for transporting work step by step. This truck is easily made, light and durable, and allows of much faster work by machine operators; it is also a potent factor in the "safety first" movement, and does away with the necessity of looking here and there for boxes and barrels to put the work in, which are generally driven full of nails, wire and ragged-edged tin binders.

This box is made of 3/4-inch pine or other cheap lumber, planed on both sides, with a six-inch caster wheel at each corner; the boards on one side are removable, allowing the operator to reach the work conveniently when the box is not full. When necessity requires, these trucks can be picked up by the crane and stacked one on another in tiers. They are easily moved about the room even when heavily loaded. The



Box Truck for carrying Loose Material and Small Parts

illustration really needs no explanation, as manufacturers can quickly see its advantage over the box, barrel and pan system of transportation.

Pittsfield, Mass. G. R. SMITH

TOOL FOR RE-CENTERING AXLES

For use in re-centering axles I developed the tool shown in the accompanying illustrations, which enables this work to be done much more rapidly than by other methods in common use. Fig. 2 shows the tool in operation, and in Fig. 1 the cutting tool is illustrated and an enlarged view is shown of the point of the tool in order to give a clear idea of its form. It will be evident from the latter illustration that this tool drills the center out to a greater depth and countersinks it at a single operation; also, that the shank of the tool is made to fit an air motor by which it is driven.

The entire tool is supported by a clamp *A*, Fig. 2, which is secured to the axle journal; and this clamp is slightly rounded on the under side in order to have it fit properly on the work. The clamp is held in place by 3/4-inch bolts, and proper location of the feed-screw on the air motor is obtained by lining up the tool with the axle by means of a square *B*. By the use of this tool it is much easier to re-center an axle than to lift it up on a horizontal boring mill or drill press, where it is frequently necessary to center one end and then turn the

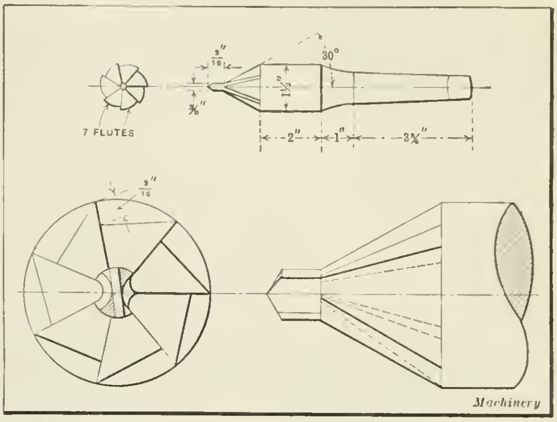


Fig. 1. Close View of Re-centering Tool and Enlarged View of Point

axle around to center the opposite end; and when the condition of the axles is such that about half of them have to be re-centered before they can be set up on the lathe, this tool is the means of saving a great deal of time. M. K.

FLOOR PLANS IN MACHINE CATALOGUES

A large manufacturing plant had a serious fire, and while most of the machines and equipment were destroyed, some were saved or repaired and placed in another building until the damaged buildings could be reconstructed. As all the plant lay-outs, drawings, etc., were destroyed, it was necessary to get out entirely new sets of floor plans, speed charts, etc. This was some work, for before any information could be obtained from the manufacturer, it was necessary to find where and when a machine was bought, its size, and its serial number, which was stamped in different places on different makes of machines.

This work would have been much easier if the machine tools and equipment were designated as are automobiles; for instance, Blank & Co. 16-inch engine lathe, "1906 Model," or Blank & Co. 16-inch engine lathe, "Model H." Then if the catalogue showing "Model H" contained a floor plan drawn to small scale, but giving all such data as feeds, speeds, sizes of pulleys, horsepower required, etc., that would be useful when moving the equipment, it would be of much more value than a catalogue containing the tables, etc., that are usually found therein.

South Orange, N. J. WILLIAM PHILIP

* * *

The United States Civil Service Commission will hold examinations November 14 for an electrical and mechanical engineer to fill a position in the Bureau of Yards and Docks, Navy Department, Washington, D. C., at $12.48 per day. The duties of the position cover the expert maintenance and supervision of the operation of all navy yard power plants, embracing the economical production, distribution and utilization of electric power for manufacturing, pumping dry docks, charging submarines, for ships undergoing repairs; compressed air for manufacturing; steam for power and central heating, etc. Technical education will have a weight of forty points and experience and fitness of sixty points.

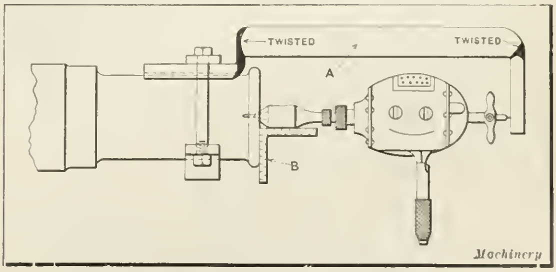


Fig. 2. Air-operated Tool for Use in re-centering Axles

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

WEIGHT OF THE GRAIN

A. C. G.—Will you kindly advise whether or not the unit of the grain is the same in apothecary as in avoirdupois weight?

A.—The grain was originally the weight of a plump kernel of wheat, and is the same in apothecary, avoirdupois and troy weights.

FORM OR FORMED MILLING CUTTER

G. T. Co.—Which is the preferable usage, "form" milling cutter or "formed" milling cutter?

A.—The consensus of opinion seems to favor "form" milling cutter, the reason being that the cutter is generally referred to with its product in mind, the same as a gear-cutter. Strictly speaking, the usage should depend upon whether the characteristic of the cutter itself is meant or that of its product, but in order to avoid confusion authorities seem to have agreed to use "form" instead of "formed."

PROBLEM IN ALGEBRA

J. G. K.—Given the two simultaneous equations, $x^2 + y = 7$, and $x + y^2 = 5$, can the values of x and y be found without solving an equation of a degree higher than the second?

A.—We do not know of any way of finding x and y without solving an equation of the fourth degree. The method used by the writer would be to find the value of x in the second equation, substitute it in the first equation, thus obtaining $y^4 - 10y^2 + y + 18 = 0$; solving this by Horner's method, $y = 1.6384 +$. Then $x = 5 - 1.6384^2 = 2.3157$. J. J.

ANNEALING GERMAN SILVER CUPS

P. J. Y.—I have been having trouble with "ten per cent" German silver drawn into cup shape and then redrawn. We undertook to anneal the cups in a Stewart muffle gas furnace, but the sides cracked. We have tried placing the cups in all positions and have mauled the sides before placing them in the furnace, but they always crack before they get black. The size of the cup is 6 inches diameter at the bottom, and the height of the sides is 2½ inches. The temperature of the furnace is kept between 1100 and 1300 degrees F. What is the proper temperature for annealing German silver, and what formula produces a German silver best suited for drawing purposes?

The questions are submitted to readers who have had experience in working German silver.

ANNEALING HARD CASTINGS

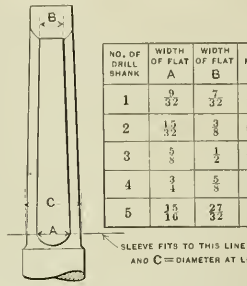
P. J. McK.—I would like to know of any methods that we could use to drill hard cast iron. We have tried drilling with turpentine as a lubricant, but without results, and have also tried heating the castings to a dark red, allowing them to cool in a dying fire.

A.—The best advice we can give you in regard to the treatment of hard castings is to throw them into the scrap heap. Usually the time and trouble taken to save a hard casting costs more than a new one. However, it is often possible to anneal hard castings so that they may be easily machined. Heat the castings to a temperature of 1500 to 1600 degrees F., pack in an iron box filled with air-slaked lime and let cool slowly. The time required for cooling will vary from twenty-four to forty-eight hours, depending on the size and mass of the castings. Sometimes very hard castings may be drilled successfully with a forged flat drill, using turpentine as a lubricant. The speed should be slow—not more than eight or ten feet peripheral speed per minute.

"USE-EM-UP" DRILL SOCKET DIMENSIONS

W. L. M.—Will you kindly give me the dimensions of the "Use-em-up" drill sockets? That is, the type with a flat milled on the side of the shank and with the socket made to fit.

A.—The dimensions of "Use-em-up" drill sockets made by the American Specialty Co. of Chicago, Ill., are given in the accompanying table for Nos. 1 to 5, inclusive. The data are given in terms of width of flat at the large and small ends, and the diameter of the shank at the large end where dimension A is measured. It should be understood that the flat is milled parallel to the axis of the drill. When the cutter has been sunk at A to give the required width of flat the width B is bound to be right, provided the taper of the shank is correct, and the index centers are set for parallel work.



NO. OF DRILL SHANK	WIDTH OF FLAT A	WIDTH OF FLAT B	DIAMETER C
1	$\frac{9}{32}$	$\frac{7}{32}$	0.475
2	$\frac{15}{32}$	$\frac{3}{8}$	0.700
3	$\frac{5}{8}$	$\frac{1}{2}$	0.938
4	$\frac{3}{4}$	$\frac{5}{8}$	1.231
5	$\frac{15}{16}$	$\frac{27}{32}$	1.748

Dimensions of "Use-em-up" Drill Sockets of Five Sizes

ODD OR EVEN REAMER FLUTING

P. J. V.—Kindly advise me whether or not it is a fact that odd lipped tools such as reamers of, say, five, seven or nine flutes, make smoother and truer finishes than those with six, eight or ten flutes. One of my toolmakers maintains that odd lipped tools of, say, five to seven cutting edges produce the best finishes, but I maintain that when the stock to be removed is not excessive and when a six-flute reamer does not give the desired smoothness of cut, then one of double the number of flutes, or more if necessary, will do the work, in all cases keeping an even number of flutes for grinding and measuring purposes. If odd lipped tools are superior, why are they?

A.—It is undoubtedly true that an odd number of teeth in a reamer favors smoother work than an even number. The reason for this is as follows: In a reamer having an even number of teeth, any ridge or hard spot in the work tends to push the tooth away at that point and the action is transmitted diametrically across the reamer to the opposite side of the hole. Now, if the reamer has an odd number of teeth the effect is transmitted across the hole to two teeth instead of one and is, therefore, less than if concentrated on one tooth. In other words, the irregularities are not see-sawed back and forth across the hole by the action of the teeth as much with an uneven number of teeth as with an even number. The average manufacturer, however, prefers reamers with an even number of teeth because of the difficulty of measuring those with an odd number of teeth. Reamers which have an even number of teeth, but in which the spacing is broken up so that it is irregular, can be made to ream a hole as true as an odd-toothed reamer. The difficulties met with in grinding can be overcome by applying a method like that shown in the April number of MACHINERY on page 694, under the heading, "Calipering Five-Flute Reamers."

POSITIVE CHARACTERISTICS OF LOGARITHMS

C. P. W.—Why do tables giving the logarithms of trigonometric functions always print 8 or 9 for the characteristics of the functions, with the exception of the cotangents, secants, and cosecants?

A.—When logarithms were first invented (about 1614), they were applied to the trigonometric functions. Computers at that time were rather shy about using negative numbers, and to avoid these, 10 was added to the negative characteristics, thus making them positive for practically every case that would ordinarily arise. The tables first computed contained many errors, which were gradually eliminated by the publica-

tion of other tables based on the first set, and which copied the preceding ones closely. This practice (together with a slightly increased difficulty in setting up negative characteristics) probably accounts for the present appearance of most tables. In many of the tables and textbooks, positive characteristics are used even in ordinary logarithmic computation, when decimals are involved, although in most American works, they are used only in connection with trigonometric functions. The practice of adding 10 (or even 20, in some cases) is very awkward and clumsy, and is one that the writer does not recommend. The writer (in common with many authors and computers) always changes the positive characteristic to its negative equivalent before using the logaritum. There are a few tables in which negative characteristics are printed in connection with the logarithms of the trigonometric functions, and it is to be hoped that this practice will become universal. It may be remarked that the negative characteristic can always be found by subtracting the positive characteristic from 10; thus, log sin 1 degree, 20 minutes = 8.36689 = $\bar{2}.36689$. Since the cotangents of angles less than 45 degrees and the secants and cosecants of all angles are greater than 1, the characteristics of the logarithms of these functions are positive or are 0. J. J.

ILLUSTRATION OF THE FIRST LAW OF MOTION

T. M. Y.—Referring to the illustration, which represents a wagon, suppose a cord to be attached to one of the wheel spokes at A; a pull on the cord will make the wagon move in the direction indicated by the arrow. Suppose, however, the cord had been attached to one of the lower spokes at B and pulled in the direction indicated by the arrow; in what direction would the wagon move, and why?

A.—The wagon will move in the same direction in either case; that is, in the direction of the pull. It is rather surprising, when the experiment is tried with a bicycle or wagon and the cord is attached as shown at B, to see the end of the cord at B apparently moving backward instead of forward, as most persons expect it to do. This is a good example of the correctness of the first law of motion, which may be stated as follows: Every body continues in a state of rest or of uniform motion in a straight line, unless acted upon by some external force that compels a change. Note particularly that the acting force must be external. In this case, the pull is an external force; hence, if it is sufficiently great to overcome the resistance to motion, the wagon must move, and (in accordance with the second law of motion) it must move in the direction in which the force acts. Consequently, it makes no difference where the cord is attached, whether to the hub, the rim, a spoke, or to the wagon body, the wagon must move in the direction of the pull. Moreover, the end B of the cord does not move backward. It appears to move backward on account of its circular motion; but, if the end P moves six inches the end B will also move six inches in the same direction, provided the cord is not stretched. In the case of a locomotive, the force exerted by the steam is an internal force, so that there is apparently a violation of the first law of motion. However, it will be noted that the only reason that a locomotive moves is because of the friction between the drivers and the rails. If there is not sufficient friction, the wheels will simply revolve and the locomotive will remain stationary. J. J.

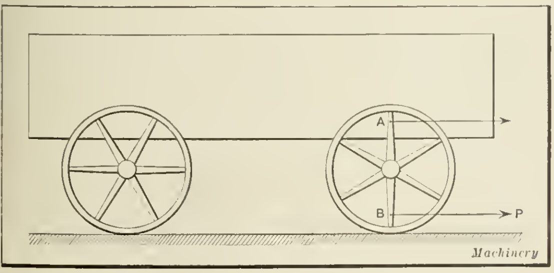
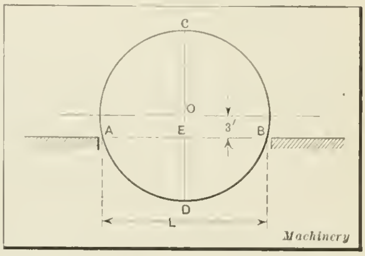


Diagram illustrating First Law of Motion

LENGTH OF HOLE IN FLOOR FOR FLYWHEEL

C. A. F.—A flywheel is 16 feet in diameter (outside measurement) and the center of its shaft is 3 feet above the floor; how long must the hole in the floor be to let the flywheel turn? Please show how this may be found.



Method of finding Length of Hole in Floor for a Flywheel

A.—The conditions are as represented in the illustration. The line AB is the floor level and is a chord of the arc ADB; it is parallel to the horizontal diameter through the center O. CD is a vertical diameter and is perpendicular to AB. It is shown in geometry that the diameter CD bisects the chord AB at the point of intersection E. Now, one of the most useful theorems of geometry is that when a diameter bisects a chord, the product of the two parts of the diameter is equal to the square of one-half the chord; in other words, $AE^2 = ED \times EC$. If AB is represented by L and OE by a, $ED = r - a$ and $EC = r + a$, in which $r =$ the radius OC; hence, $\left(\frac{L}{2}\right)^2 = (r - a)(r + a) = r^2 - a^2$, and $L = 2\sqrt{r^2 - a^2}$. Substituting the values given, $L = 2\sqrt{8^2 - 3^2} = 14.8324$ feet = 14 feet, 10 inches. The length of the hole should be at least 15 feet, to allow for clearance. J. J.

EXPRESSING ANGLES IN CIRCULAR MEASURE

P. P. C.—Please explain what is meant by the term "radian" and why angles are sometimes measured with this unit instead of in degrees, minutes, and seconds.

A.—In geometry, the measuring unit for angles is the right angle; in practical trigonometry, angles are measured in degrees, minutes, and seconds; in what is called analytical trigonometry, the measuring unit is the radian. The first two of these measures are concerned only with the angle itself or with a part of a revolution; as a consequence, no linear unit can be used in comparing one angle with another, and both measures are called angular measures. In certain formulas and in mathematical investigations, it is advisable to have a linear measure for comparing or denoting angles, and in such cases the arc is used instead of the angle. Now, a semicircle of a radius r has a length equal to πr; but since this line is rather long to use as a unit of arc measurements, it is customary to use that part of the semicircle which is equal in length to the radius. It will readily be perceived that the angle which this arc subtends is constant; in other words, the angle will be the same whatever the radius. The value of this angle in angular measure is readily found. Thus, since the semicircumference subtends two right angles, or 180 degrees, and its length is πr, we have the proportion $\frac{180}{\pi r} = \frac{x}{r}$, from which $x = 57.29577951 +$ degrees = 57 degrees, 17 minutes, 44.8 seconds, very nearly. Hence, if an angle is given in degrees, minutes, and seconds and it is desired to find its value in radians, reduce the minutes and seconds to a decimal of a degree, and divide the angle by 57.29578 or multiply it by $\frac{\pi}{180} = 0.0174532925 +$. As an example showing the use of circular measure in a formula, the area of a sector is equal to the product of one-half the arc by the radius; if the central angle is V radians, the length of the arc is rV; the area of the sector is $A = \frac{1}{2} rV \times r = \frac{1}{2} r^2 V$. By substituting $v = \frac{1}{2} V$, $A = r^2 v$, a very convenient and simple form. When angular measure is used, $A = 0.0174532925 + r^2 v$, when v is in degrees. J. J.

DRAWING A CIRCULAR ARC THROUGH TWO GIVEN POINTS

T. S. B.—Will you please show me how to draw a circular arc through two given points when the radius of the arc is known and the center falls without the drawing?

A.—There are a number of ways in which this may be done, but the writer prefers the following construction. Let A and B be the given points and let r be the given radius. Calculate the height CH of the arc, using the formula $h = r - \sqrt{r^2 - c^2}$, in which r = the radius and c = one-half the distance between the two points, or AC in the illustration. Draw AB and bisect

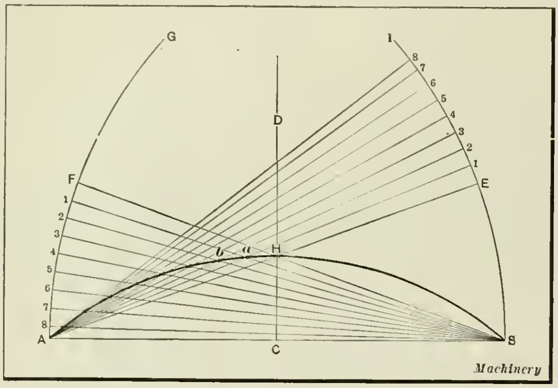


Diagram showing how Circular Arc may be drawn through Two Given Points

it at C; draw the perpendicular CD and lay off $CH = h$. With A and B as centers and a radius equal to AB, describe the arcs BI and AG. Draw AHE and BHF, intersecting the arcs BI and AG in E and F, respectively. Using the spacing dividers, lay off $F1$ toward A and its equal $E1$ toward I; draw $A1$ and $B1$, and mark the point of intersection a. Lay off $F2$ and $E2$, draw $A2$ and $B2$, and mark the point of intersection b. Proceed in this manner until a sufficient number of points have been located; these points are all situated on the required arc, which may be drawn through the points by means of an irregular or adjustable curve. The distances F–1, 1–2, 2–3, etc., may be equal or unequal, but the corresponding arcs on AG and BI must be equal; for example, $E5$ must equal $F5$, etc.

J. J.

DISCHARGE OF WATER THROUGH PIPE

A. C. T.—About one-half mile from our shop is a large spring; we wish to tap this spring and lead the water to the shop through a 1½-inch pipe; how many gallons of water per minute will be obtained? The difference of level between the spring and the tank is about 60 feet.

A.—There are many formulas for calculating the discharge of water through a pipe; some of them are quite complicated, and all are, and must of necessity be, approximate. It is impossible to derive a formula that will fit any case. The pipe, or conduit, is made of various materials, and the friction of the moving water varies greatly with the material of which the pipe is composed. Even for a particular material, the discharge will not be the same for a pipe that has been in use a long while as for a new pipe. The impurities carried by the water stick to the pipe, causing it to become foul; this reduces the diameter and discharge, and also alters the resistance due to friction. If the slope is not gradual and even, air will accumulate at different points; this also reduces the discharge, since the area of the cross-section at those points is less. Bends, especially those of short radius, reduce the velocity and, consequently, the discharge. Contractions and enlargements, likewise, exert a deterrent effect. As a result of the examination and comparison of a large number of experiments, the following formula has been derived; it is simple in form, is said to give good results, and is admirably adapted to logarithmic computation: $v = 0.0757cd^{\frac{5}{8}}\left(\frac{h}{l}\right)^{\frac{1}{2}}$, in which v = velocity, in feet per second; d = diameter of pipe, in inches; h = head, in feet; l = length of pipe, in feet; and c = a constant the value of which depends on the material of which the pipe is composed. For new, smooth, wrought-iron pipe, laid straight and without bends, c may be taken as 160. Since the actual internal diameter of a 1½-inch pipe is 1.61 inch, the velocity of discharge in the pipe is

$$v = 0.0757 \times 160 \times 1.61^{\frac{5}{8}} \times \left(\frac{60}{2640}\right)^{\frac{1}{2}} = 2.508 \text{ feet per second.}$$

The number of cubic feet per minute discharged is

$$\frac{60 \times 2.508 \times 0.7854 \times 1.61^2}{144} = 2.127;\quad 2.127 \times 7.48 = 16 \text{ gallons}$$

per minute.

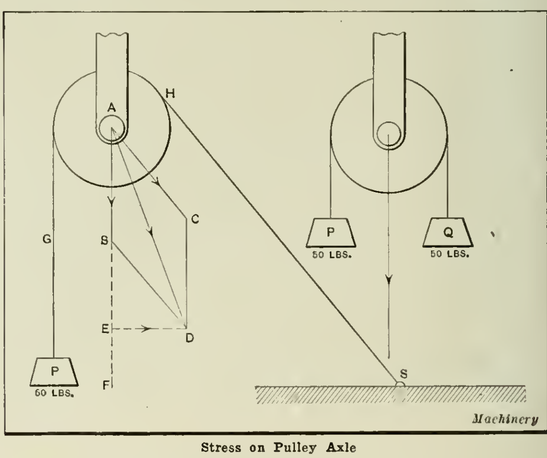
J. J.

STRESS ON PULLEY AXLE

S. J. C.—In the accompanying diagram a pulley is shown rigidly fastened to a support at a height AF = 9 feet from the floor. A rope passing over the pulley has one end attached to a staple S at a distance of 8 feet from F, and to the other end is attached a weight P of 50 pounds. What is the total force acting on the pulley axle? I claim that it is 50 pounds, the same as the weight, but a friend says that it is more than that; which of us is right?

A.—Your friend is right, as a little consideration will show. Referring to the view at the right, one weight Q of 50 pounds exactly balances the other weight P of 50 pounds; and since the pulley supports both weights, the total force (or stress) on the axle is $50 + 50 = 100$ pounds. Suppose, now, that one of the weights were removed and that the free end of the rope were fastened; then, in so far as the stress on the axle is concerned, the conditions would be exactly the same as before, provided the two parts of the rope were parallel. Thus, suppose the weight Q were removed; the weight P tends to fall and pull the rope along with it. But this is resisted by fastening the free end of the rope. As a result, P acts downward and the reaction acts upward; on the other side, P acts upward and the reaction acts downward. The reaction in the second case corresponds in every respect to the force Q; hence, the total stress on the axle is 100 pounds, as before.

Under the conditions shown in the left-hand view, a part of the reaction of the staple tends to pull the pulley away from the perpendicular, and the stress on the axle is less than the sum of the stresses in the two parts of the rope. To find what this stress is, draw a line, as AB, parallel to



Stress on Pulley Axle

the part G of the rope, and make it of a length that will represent 50 pounds; draw AC parallel to HS, the other part of the rope, and make it of the same length, also representing 50 pounds; complete parallelogram $ACDB$, and draw diagonal AD; this measured to the same scale as AB gives the stress on the axle and shows the direction in which it acts. By producing AB and drawing DE perpendicular to it, ED represents the force tending to pull the pulley from the perpendicular, and AE represents the downward force on the axle. Assuming the pulley to be 1 foot in diameter, the writer obtained in this manner the following values: AD = 94.25 pounds; AE = 88.75 pounds; and ED = 31.75 pounds. By calculation, AD = 94.19, AE = 88.72, and ED = 31.64.

J. J.

MESTA HERRINGBONE GEAR PLANER

MACHINE DEVELOPED FOR CUTTING HEAVY GEARS AND PINIONS

THE well-known advantages possessed by properly cut herringbone gears as compared with the standard type of cut spur gears or cut spur gears with staggered teeth, have led to an increasing demand for herringbone gears. In order to secure the full benefit resulting from the use of this type of gear, however, it is absolutely necessary for the cutting to be done on a machine capable of producing accurate work. For rolling mill equipment it is often desirable to use herringbone gears of very coarse pitch because slight inaccuracies in alignment, which are unavoidable in mill practice, do not exert such a detrimental effect upon their operation and life. In cutting coarse pitch gears of this kind excellent results are obtained by planing the teeth, and there is no limit to the pitch of gear that can be cut in this way. To meet the requirements of this work the Mesta Machine Co., Pittsburg, Pa., has developed a planer type of herringbone gear cutter which it is the purpose of the following article to describe.

In comparing the design of this machine with that of other herringbone gear planers, the most noticeable features are: (1) That the position of the gear blank remains fixed while the tools are made to follow helical paths required to finish elements of the tooth faces. (2) That the carriages which support the cutting tools occupy a fixed transverse position on the machine, while the headstock and tailstock that support the work are moved transversely to obtain the required setting for planing teeth in gears of various sizes. It is claimed that greater accuracy can be obtained by holding the work stationary and having the tools follow helical paths determined by the angles of the teeth, because the gears cut on this machine are large and heavy, and would gather considerable momentum if it were attempted to rotate them for cutting herringbone teeth while the cutters were following paths parallel to the axis of the gear.

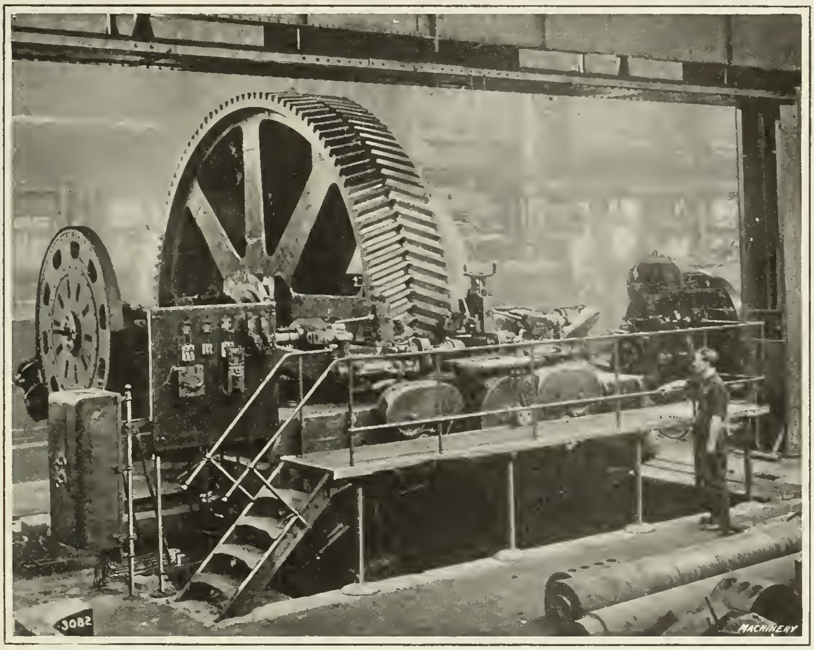


Fig. 1. Herringbone Gear Tooth Planer developed by Mesta Machine Co. for Heavy Work

In the operation of this machine one side of a tooth is planed, after which the machine is stopped and the tools are backed out to the starting position by hand; the work is next indexed so as to bring the corresponding side of the next tooth into proper relation with the tools, after which the work is locked in place and the tools started cutting. This procedure is continued until all of the teeth have been cut on one side, and in this connection it may be mentioned that either the upper or lower sides of the teeth may be cut first. After the work has been indexed through one complete revolution, *i. e.*, after all the teeth have been cut on one side, it is necessary to adjust the setting to bring the opposite side of the first tooth into proper relation with the cutting tools. In securing this result, the work is brought into approximately the desired position, after which a very light cut is taken and the tooth tested with a gage to ascertain the amount of metal which must still be removed in order to reduce it to the desired thickness. Several trial settings will be made in this way and light cuts will be taken, gaging the tooth after each cut, until the desired setting of the work has been obtained; then cutting and indexing operations will take place alternately—as in the case already explained for cutting the first side of the teeth—until the gear has been indexed through another complete revolution, which finishes the cutting of the teeth.

In order to describe just how the machine operates, it will probably be best to explain the conditions which must be fulfilled in cutting the side of one tooth and the mechanical means provided for this purpose. The conditions imposed in planing herringbone gear teeth on the Mesta machine are as follows: (1) The tools must follow paths which conform to the helix angles of corresponding teeth at each side of the gear. (2) The position of the tools must be kept in constant relation to the faces of the teeth, *i. e.*, the tools must be held normal to the tooth profiles at all times. (3) Compensation must be provided for curvature of the teeth due to their angularity. (4) After completing each stroke the tools must be fed in toward the axis of the gear. (5) The position of the tools must be constantly adjusted so that the desired involute profile is obtained for the teeth.

The way that a reciprocating motion is imparted to the tool carriages, and the manner in which the tools are made to follow paths corresponding with the helix angles of the teeth are clearly shown in Fig. 2. Referring to this illustration, a thirty-five horsepower Westinghouse electric motor which drives the machine is shown at *A*. This motor is of the reversing type and transmits power through bevel pinions *B* to lead-screw *C*, reversal of the drive taking place at such intervals that the desired length of stroke is imparted to the cutting tools. It will be seen that the tool carriages run on inclined ways *D* which are set at angles to correspond with the required helix angles for the gear teeth. In making this setting the stand which supports the driving motor is raised by elevating screws, which results in raising the inner ends of the inclined ways *D* on which the tool carriages reciprocate. When this setting has been obtained, screws *E* are manipulated in order that supports *F* under the outer ends of the tool carriage ways may be moved sufficiently to obtain

the required angular setting, which is ascertained through the use of a bevel protractor and spirit level. Teeth with helix angles ranging from 12 to 23 degrees can be cut.

In referring to conditions that must be fulfilled in planing herringbone gear teeth, mention was made of the necessity of maintaining a constant relation between the position of the cutters and the tooth profiles, *i. e.*, the tools must be kept normal to the tooth faces. Provision is made for securing this result by rocking the tool-holders on shafts *G* so that a constant relation is maintained as each tool passes over the gear tooth that it is cutting. Fastened to each of the inclined ways over which the tool carriages run there is a rack; and secured to each of the carriages there is a cross shaft with a pinion at its outer end that meshes with one of these racks. At the opposite end of the shaft there is a worm which meshes with a worm-wheel segment on the tool-holder, as shown in Fig. 3; and it will be evident that as the carriage moves back and forth, engagement of the pinion *H* with the rack results in rotating the cross shaft, worm and worm-wheel segment, and thus rocking the tool-holder about shaft *G*. In this way compensation is provided for the "wind" of the gear teeth due to their angularity, and a constant relation is maintained between the planing tools and tooth profiles. The tool-holders are rocked through an angle shown at *DEF* in Fig. 4.

In planing herringbone gear teeth it is also necessary to make compensation for curvature due to angularity of the gear teeth, *i. e.*, in passing across the gear face, center *A* of each tooth, Fig. 4, is higher than either end by an amount *BC*. In setting up the machine each tool is located at a central point *A* and it will be evident that means must be provided to make the tool follow the curved path of the teeth, the amount of adjustment necessary varying according to the diameter, helix angle and face width of the gear which is being planed. The method by which this compensation is secured is illustrated in Fig. 3. Referring to this illustration it will be seen that arm *I* carries link *J*, and as arm *K* rocks up and down, link *L*, which connects arm *K* and shaft *M* with link *J*, swings in and out relative to arm *K* due to the comparatively short

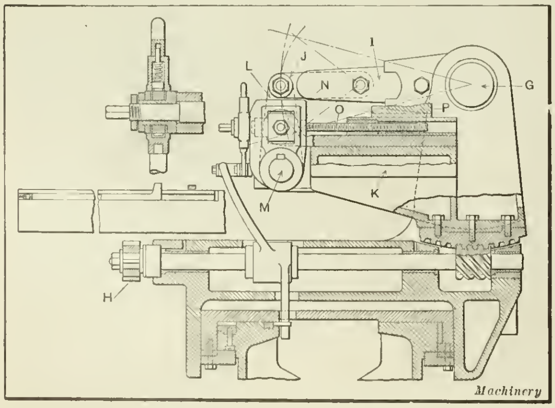


Fig. 3. Mechanism provided to keep Tools Normal to Tooth Profiles and to compensate for Curvature of Teeth due to Angularity

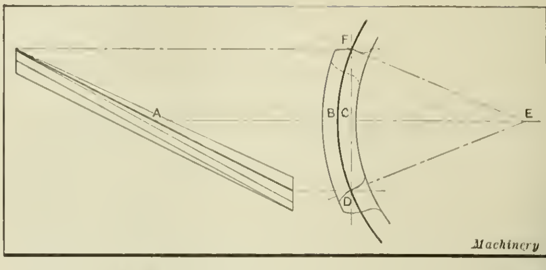


Fig. 4. Diagram showing Conditions that must be fulfilled in planing Herringbone Gear Teeth

length of link *J*. This relative motion is transmitted by means of block *N* and screw *O* to tool-holder *P*. The tool is at the center of shaft *G* when in the central position so that the working of arm *K* does not affect the position of the tool.

On each of the tool carriages there is a compound tool-block *Q* fitted with horizontal and vertical slides. The horizontal slides are used for feeding the tools in toward the axis of the gear, this feed motion being actuated at the end of each return stroke of the tool carriages. The manner in which this result is obtained is shown in Fig. 2; lever *R* is of bell-crank form, the lower portion not being shown. When the carriage approaches the limit of its return motion, this lever comes into contact with block *S*, which is secured to the feed-rod. Further movement of the carriage results in lever *R* pushing block *S* and the feed-rod over, thus turning a feed-screw that operates the horizontal slide of tool-block *Q* by means of a ratchet and pawl mechanism shown at *T*. Adjustment is provided to vary the amount of feed according to the requirements of the work. In addition to the horizontal slide, each tool-block *Q* is furnished with a vertical slide to which is secured roller *U* which runs in contact with templet *V*. As ratchet mechanism *T* feeds the tool in toward the axis of the gear, roller *U* rides over templet *V* and causes the tool to be raised by movement of the vertical slide; and as templet *V* corresponds to an involute tooth curve of the required pitch, it will be evident that this results in securing the desired contour for the gear teeth.

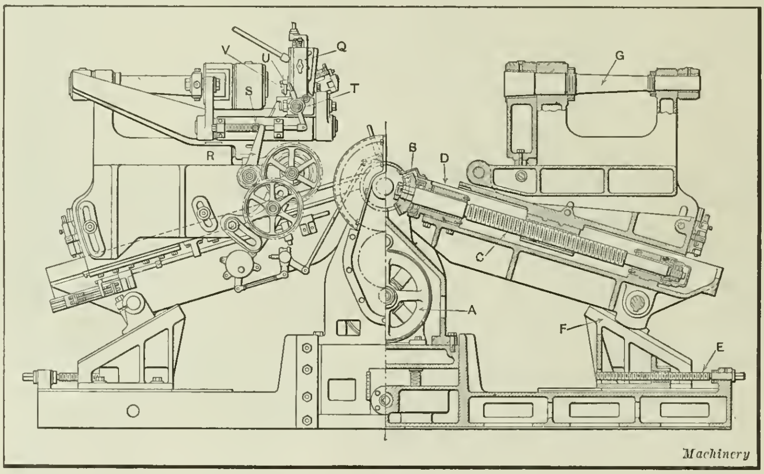


Fig. 2. Mechanism for securing Reciprocating Movement of Carriages on Paths corresponding to Helix Angle of Teeth; also Means of obtaining Cross-feed and Involute Tooth Profile

Indexing of the work is done by means of the large worm-wheel shown at the left-hand end of the machine, this wheel being driven by a worm that receives power from an independent five-horsepower motor. The design of the index mechanism is essentially the same as that used on other forms of gear tooth planers, so that a detailed description is not called for; but in this connection it may be mentioned that indexing is effected through the familiar arrangement of differential gears and a locking bolt which drops into place to secure the work against further movement when it has been brought into the desired position ready for cutting a tooth. After indexing has been completed the operator starts main driving motor *A*, Fig. 2, to set the machine in operation, and when the cutting of the tooth has been completed and the tool-heads have been backed out to the starting point, the first step is to release the lock bolt on the index mechanism, which is done by pulling a pendant cord which hangs down at the front of the switchboard at the left-hand end of the machine.

Then the switch governing the indexing motor is closed in order to start this motor running to index the work.

The gear blanks in which teeth are cut on this machine are steel castings in which the teeth are cast to approximately the desired form so that it is merely necessary to finish them on the machine. Those experienced in the production of steel castings know that particular attention must be paid to provision of means to take up shrinkage. Gear blanks are usually cast in halves and unusually large shrink heads are provided so that there will be ample metal to drop down into the mold as the metal shrinks in cooling. These castings are planed on the joint between the two halves, and the halves are then secured together with bolts and shrink keys, after which the work is ready to be set up on the machine. The first operation consists of taking a roughing cut with a square nose tool, which removes excess metal from the tooth spaces. After this has been done a finishing cut is taken according to the method already described, and in taking this cut a pointed tool is employed, guided in the same manner.

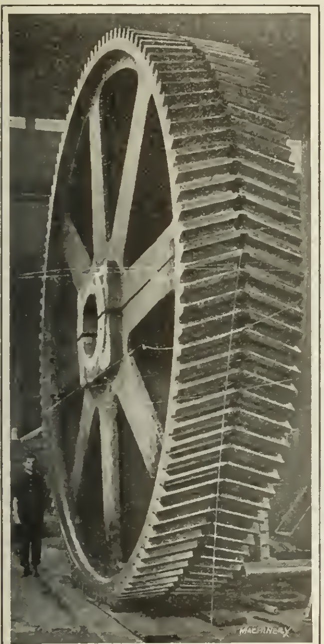


Fig. 5. Large Herringbone Gear which had Teeth planed on Machine

The diameter of gears which can be cut is limited only by the pit capacity; and at present the machine is so arranged that gears up to 22 feet in diameter can be accommodated, but this could easily be increased should the necessity arise. The maximum face width of gears which can be cut is 5 feet, 6 inches. An idea of the accuracy obtained may be gathered from the fact that during each cutting stroke the tool follows a true helix within limits of 0.0005 and 0.001 inch. Errors due to deformation of the tool and support, and to wear of working surfaces are exceedingly small because all parts of the machine were so designed that they are of ample size. The machine occupies a floor space of 26 feet by 26 feet, and weighs approximately 150,000 pounds. E. K. H.

* * *

The Ford Motor Co. of Detroit made $59,994,118 profit for the year ending July 31; it built upwards of 500,000 cars, the selling price of which was $206,867,347. The company employs 49,870 men in all its plants, and of these, 36,626 receive $5 or more a day. More than 27,000 are employed in Detroit.

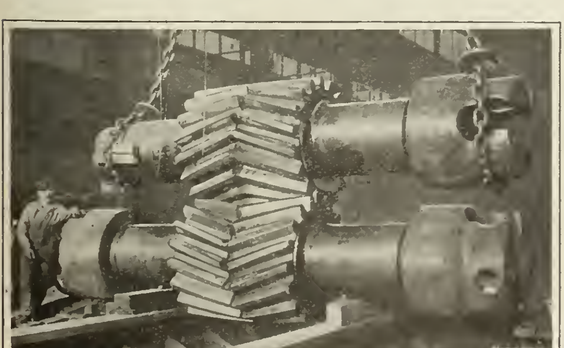


Fig. 6. Herringbone Pinions for Rolling Mill Service

MODERN POWER DEVELOPMENTS

In an interesting address delivered before the American Society of Swedish Engineers, 271 Hicks St., Brooklyn, on "Power and Its Application in Modern Industries," Dr. C. P. Steinmetz, chief consulting engineer of the General Electric Co., Schenectady, N. Y., pointed out that the main difference between our present civilization and that of a hundred or a thousand years ago is that in those days man depended entirely upon his immediate surroundings, whereas today, through the facilities of transportation, he can command the energy and the materials of the whole world at any point within the reach of the systems of transportation. Apart from passenger traffic, the speaker pointed out that the means of transportation served two purposes: (1) that of transporting materials—that is, the things actually used by mankind for comfort and pleasure; and (2) the transportation of potential energy. Coal, peat, etc., is not transported as a material, but simply because of its potential energy. Coal is transported not because it is wanted in itself, but simply that it may be burned as soon as possible upon its arrival, thereby liberating the potential energy tied up in it and producing power. With the progress of engineering, still simpler means of transporting energy than carrying coal have been invented, the electric current making it possible to cheaply transmit energy.

Not only is electrical energy more easily transported than any other known form of energy, but one of the greatest advantages of electricity is that it can be used in small quantities with almost the same efficiency as when used in large quantities. A motor of one-eighth horsepower is, practically speaking, as efficient as one of 10,000 horsepower. It is true that, expressed as a percentage, the larger motor is more efficient; but comparatively speaking, the difference is slight. With steam, gas or oil engines there is no such comparison. The large steam or gas engine is highly efficient, but an engine of one-eighth horsepower would be exceedingly inefficient. Imagine, if you can, a little boiler with its furnace placed on the office desk, and pipes leading to a small engine with a flywheel belted to a pulley mounted on the shaft of an ordinary desk fan. The arrangement would, of course, be impossible, but with the electric motor it is a simple matter to transmit power efficiently to drive a desk fan.

It was also pointed out that in the modern development of electric power the country is covered with a power-distributing network, which, on a map, might be likened to the network of railroads some fifty years ago—isolated systems that were only here and there connected to complete trunk lines; so, today, the electric systems are not yet connected into one complete network, and just as the railroads in the early days had different gages, so these systems are now of different cycles and the power from one is not directly interchangeable with the power from another. In the near future, however, sixty cycles will predominate for electric power transmission systems. The systems can then be linked up, and, in the case of the temporary failure of one system, power from other systems can be turned into it and the industries dependent upon the electric power will not be inconvenienced. There are hydro-electric power stations today that are able to produce electric power at the source as cheaply as 0.15 cent per kilowatt-hour, and power is being sold to consumers as cheaply as 0.62 cent per kilowatt-hour. The reason why power in cities is so much more expensive than power near hydro-electric plants in the country is that the distributing systems in the cities require an outlay of capital so much greater in proportion to the power actually consumed that the charges for interest and depreciation are much higher than the cost of the power itself. Hence, it is difficult to compare kilowatt rates in cities with those in the country near power plants.

* * *

An indication of the widespread interest in engineering circles as to our future commercial and engineering relations with South American countries is given by the fact that 180 out of 231 students entering Stevens Institute of Technology this fall have elected to study Spanish instead of French or German. This is a most remarkable increase in proportion over other years at Stevens in favor of Spanish.

SEMI-AUTOMATIC SHELL MAKING MACHINES

EQUIPMENT FOR MACHINING BRITISH 18-POUNDER HIGH-EXPLOSIVE SHELLS

A SHELL making equipment, consisting of two semi-automatic machines capable of turning out a completed 18-pounder British high-explosive shell in six minutes, has been built by the Manitoba Shell Co., St. Boniface, Manitoba. One of the machines performs the operations on the interior of the shell, and the other, the operations on the exterior. In other words, when the shell leaves these two machines it is completed and ready to have the band pressed on. It requires only two operators to attend to the two machines, and their production is equal to that of eleven ordinary machines equipped with special attachments for handling the various operations. All lubricating pipes and stop-cocks are opened and closed automatically as required. Every tool-holder has an adjusting mechanism graduated to 0.001 inch for adjusting the tools to depth. The "internal" machine is provided with eight work-holding spindles and the required number of opposed tool spindles for boring, reaming, facing, threading, etc., whereas the "external" machine is provided with six spindles for performing all the operations on the exterior of the shell.

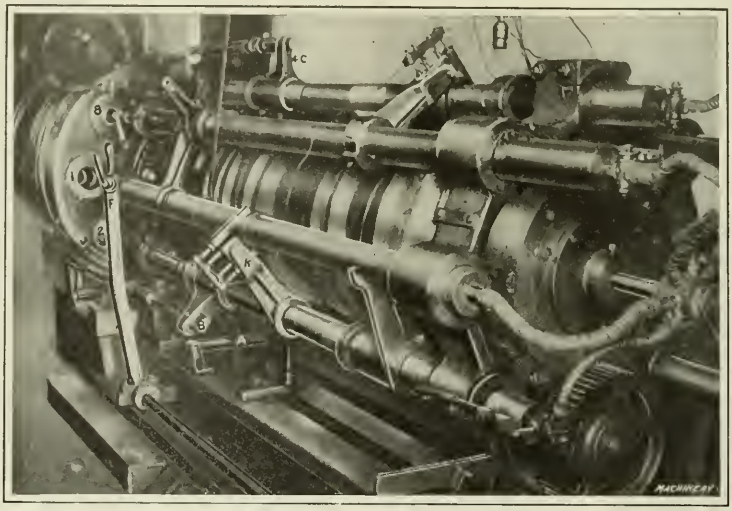


Fig. 1. Semi-automatic Shell Making Machine for performing Operations on Interior of British 18-pounder High-explosive Shells

Construction and Operation of Semi-automatic Machine for Performing Interior Operations

A front view of the machine for performing the operations on the interior of the shell is shown in Fig. 1, and a longitudinal section of the machine is shown in Fig. 2. All the movements of this machine receive power from a twenty-seven-horsepower motor located at the left-hand end on a bracket. This motor, through suitable gearing, rotates and indexes the head carrying the eight work-holding chucks for the shell, and at the same time operates a cam drum for controlling the longitudinal movement of the various boring, reaming, facing, tapping and recessing bars or spindles. The chucks, of course, are independently rotated by gearing in a somewhat similar manner to the spindles of a multiple-spindle automatic screw machine and are provided with two speed changes, for drilling and tapping, respectively, which are effected by means of a pin clutch. The speed of the work can be varied, depending on the hardness of the material, three changes in the driving motor being available, and is controlled electrically, as will be subsequently explained. The rotating head has one idle position, which is indicated in Fig. 1 as No. 1, for loading the work. When in this position, the chuck, of course, does not rotate.

Referring to the diagram Fig. 3, the sequence of operations accomplished on this machine is clearly outlined. After the shell has been located in the chuck, the set-screws shown in Figs. 1 and 2 are tightened, centering the shell and at the same time holding it rigidly in position. A stop (not shown in the illustrations) is used to push the shell up against and locate it so as to distribute the amount of material to be removed from each end. The machine is started and stopped by operating handle *F*, Fig. 1. The first position, as indicated, is the loading and unloading position, the work-holding chuck remaining idle so that the operator can insert and remove the work without stopping the other movements of the machine. In the second position, the blank is operated on from both ends, the work rotating at 139 R. P. M. The first opera-

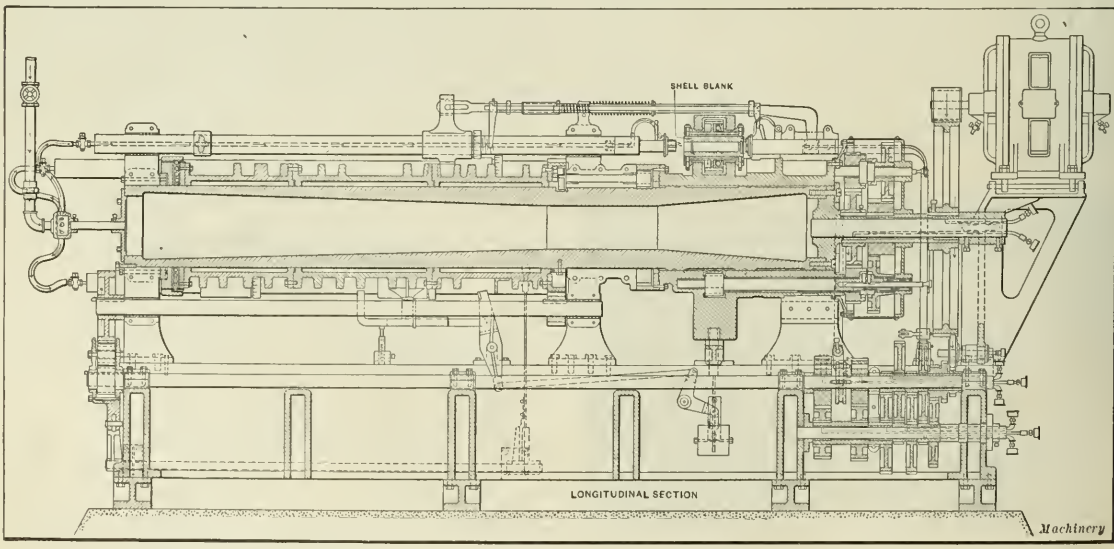


Fig. 2. Longitudinal Section of Machine shown in Fig. 1, illustrating Method of driving, etc.

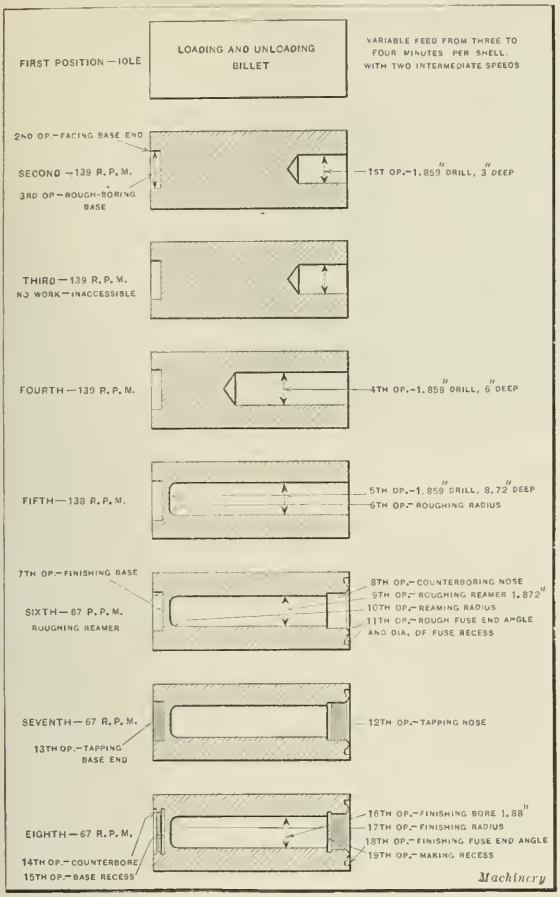


Fig. 3. Diagram showing Sequence of Operations performed on Machine shown in Fig. 1

Hence the third position is not used for any of the machining operations.

In the fourth position, the work is still rotating at 139 R. P. M., and it is operated upon at one end only by a drill 1.859 inch diameter, which advances 3 inches farther than the first drill, thus extending the hole in the nose end of the shell to 6 inches. In the fifth position, the work is still rotating at the same speed, and all the operations are performed from

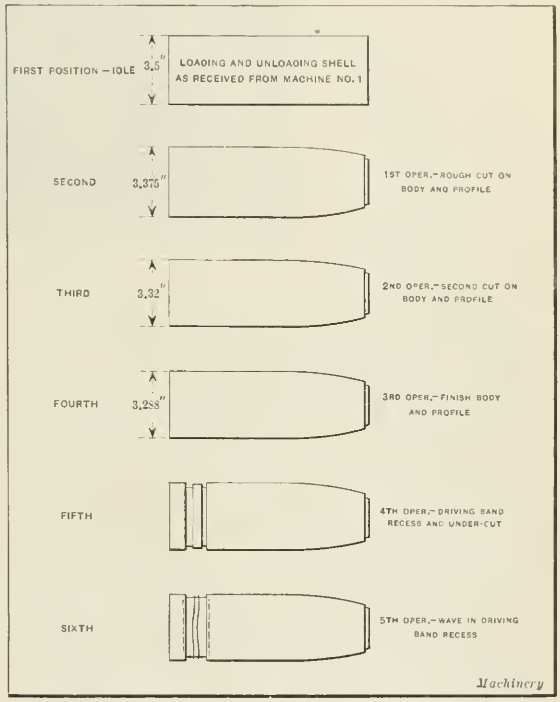


Fig. 4. Diagram illustrating Sequence of Operations performed on Machine shown in Fig. 7

tion consists in drilling a hole 1.895 inch diameter, 3 inches deep in the nose end; and the second and third operations consist in facing off the base end and rough-boring the pocket for the base plug. In the third position, no operations are accomplished for the reason that this position is inaccessible.

the open end. The fifth operation consists in finishing the 1.859-inch hole, which is now extended to a depth of 8.72 inches; and the sixth operation consists in roughing the radius at the bottom of the pocket. In the sixth position, the seventh operation consists in finishing the base end with a roughing

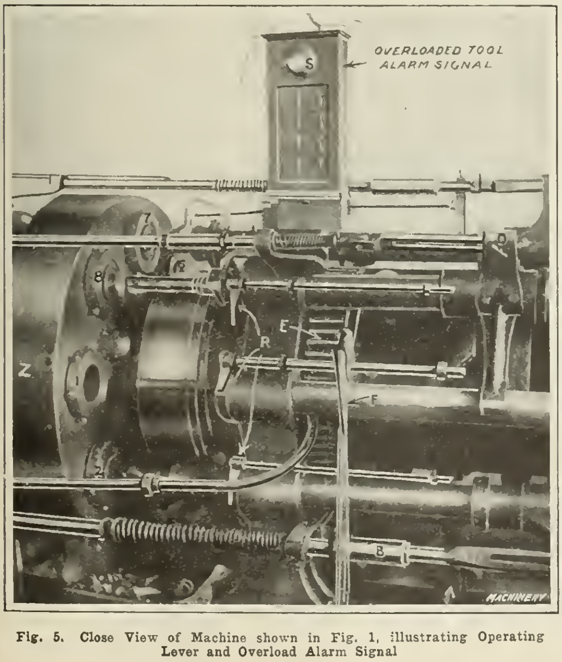


Fig. 5. Close View of Machine shown in Fig. 1, illustrating Operating Lever and Overload Alarm Signal

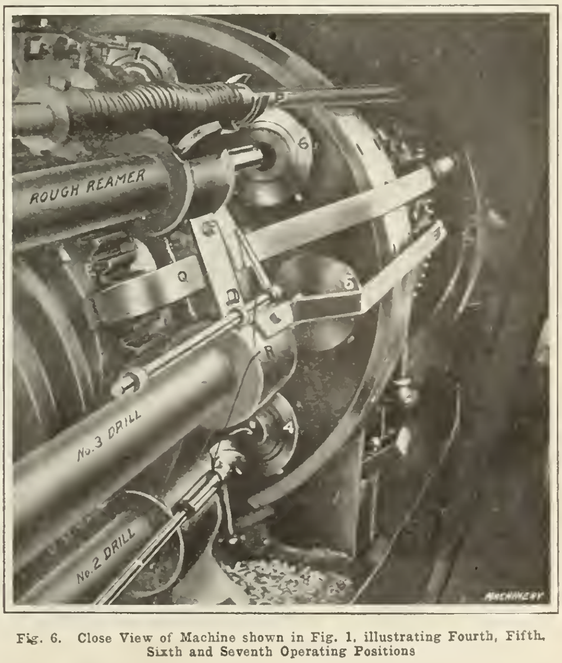


Fig. 6. Close View of Machine shown in Fig. 1, illustrating Fourth, Fifth, Sixth and Seventh Operating Positions

reamer, the work being rotated at 67 R. P. M. On the opposite end of the shell, the eighth operation consists in counterboring the nose; the ninth in rough-reaming to 1.872 inch diameter; the tenth, in finishing the radius on the nose; and the eleventh in roughing the fuse end angle and diameter of the fuse recess. In the seventh position, the work is still rotating at 67 R. P. M. and the thread is cut in both ends. Reference to Fig. 2 will show that the two collapsible taps are operated by opposed spindles, which are in line with each other. The twelfth operation, therefore, consists in tapping the nose, and the thirteenth, in tapping the hole in the base end for the base plug. In the eighth position, the work is still rotating at 67 R. P. M., and the fourteenth operation consists in counterboring the seat for the base plug; while the fifteenth operation is recessing the base seat. The sixteenth operation consists in finishing the bore with a reamer 1.885 inch diameter; the seventeenth in finishing the radius at the bottom of the pocket; the eighteenth in finishing the fuse end angle; and the nineteenth in making the recess in the open end. This finishes the operations on the shell and brings it to the unloading position. It should be understood, of course, that it requires one complete revolution of the work-spindle head to finish all the operations on the ends and interior of one shell, and during this time nineteen drilling, facing, chamfering, reaming and threading operations are performed upon it.

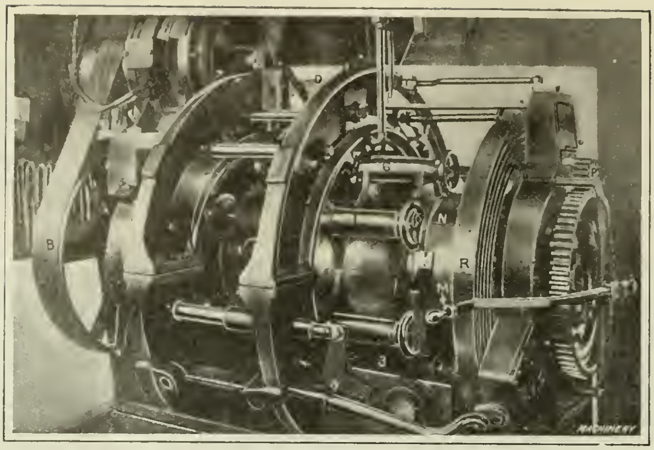


Fig. 7. Front View of Semi-automatic Machine for machining Exterior of British 18-pounder High-explosive Shell

Owing to the impracticability of using the third position, it is necessary in several positions to use two tools working from the same end. In the second position the hole for the base plug is both drilled and counterbored. In order to accomplish this, adjustable arm B is provided, as shown in Fig. 5, which brings the boring tool into position after the drill has cleared. Reference to Fig. 3, of course, will show that the hole in the nose of the shell is over four times as deep as the one in the base, so that sufficient time is allowed both to drill and counterbore the hole in the base. It should also be noted that in the sixth position it is necessary to use two tools, which cannot be operated at the same time. Therefore, an adjustable feed-rod P is provided for bringing the base facing tool into operation whenever the roughing reamer is clear of the hole. It is also necessary to use two tools in both the seventh and eighth positions. As shown in Fig. 6, an adjustable arm is provided in the seventh position for bringing the base tap into operation whenever the nose tap is clear. It is evident, of course, that both taps cannot work at the same time, because both are right-handed. The adjustable arm D is used to bring the base recessing tool into operation in the eighth position when the base reamer is clear of the hole.

As shown in Fig. 5, the lever A is the locking and unlocking device for the spindle carrier drum, the latter being rotated by the gear E, which indexes the head Z one-eighth revolution upon the completion of each operation. Fig. 5 also shows the devices used at R for setting the various tools to depth. The rod carrying these levers is provided with an adjustable collar so that the different tools can be set by these stops in the desired position. Another point that has not been mentioned is the automatic electric alarm S. Should the cutting tools strike a hard shell so that the power necessary to force the tools into the work is greater than that required under ordinary conditions, this alarm electrically operates the rheostat on the motor and reduces its speed. The machine can also be so set that it automatically reverts to the previous speed when softer material is encountered. The construction of the electric alarm device for controlling the machine when hard spots are encountered is shown at K in Fig. 1. This device, as will be noticed, is connected with the various spindles, the successful operation of which would be affected by the tools striking hard spots in the material. The application of electrical means for controlling the movements and working capacities of machines is being more generally adopted as the advantages to be derived from this method of control are becoming recognized. In this case the machine automatically accommodates itself to the hardness of the stock. Lubrication is pumped into all the tools, as illustrated in Fig. 2, so that they are kept cool.

Semi-automatic Machine for Performing Operations on Exterior of Shell

The machine for performing the operations on the exterior of the British 18-pounder high-explosive shell is shown in Figs. 7 and 8. This machine differs in principle from that illustrated in Fig. 1 in that it is not of the double-end type, as all the work is done on the exterior and not on the ends and interior of the shell. Also, it is only provided with six spindles or "lathes" instead of eight work-holding positions.

In principle, the machine consists of a large central drum carrying six tailstocks and six headstocks. The work to be finished is held on special arbors located by the headstock and tailstock. The cutting tools are carried by operating slides that receive motion from a drum cam which brings the various cutting tools into action on the work. These tool-holders are also moved longitudinally, the work remaining stationary, except for rotating and being indexed around to the various tool positions. The machine is driven by a fifteen-horsepower motor by a single belt. Gears were at first used for driving the machine from the motor, but it was found that the belt worked much better. All the mechanism of the machine is uncovered and is operated from cams and rockers as described in a preceding part of the article.

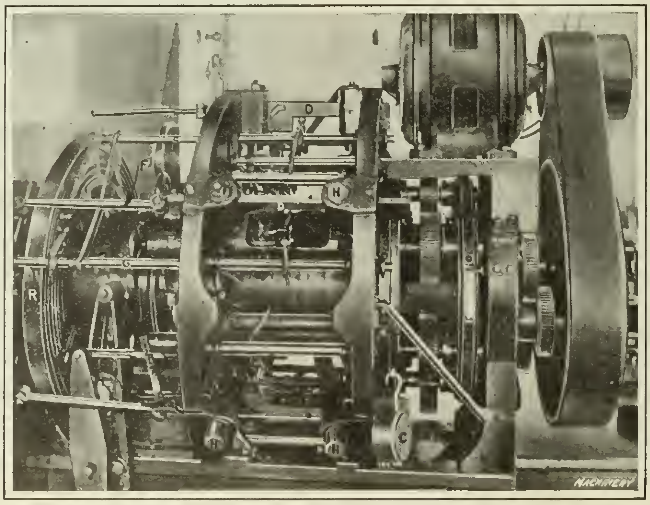


Fig. 8. Rear View of Machine shown in Fig. 7, illustrating Operating Cams, Tool-holders, etc.

The first two cuts, as outlined in the diagram Fig. 4, are made with four cutters on each "lathe"; the third has one tool and finishes the entire length. Reference to Figs. 7 and 8, which show front and rear views of the machine, will give an idea of its construction. The machine is driven from the main driving pulley *B* through a friction gear (not shown), which stops the rotation of the "lathe" at the loading point. *C* is a counterweight for the locking device which is used when the head is indexed into the various positions; the indexing is accomplished by the pinion *P*, which transmits motion to the large gear just beneath it and is operated by a cam sleeve to rotate the drum carrying the lathe heads one-sixth revolution at the completion of each cut. The machine is started and stopped by operating the lever *M* located directly in front of the machine. The various tools are brought into and out of contact with the work by means of sliding wedges *D*, as shown, which, in turn, receive power from the large drum *R* carrying cams for operating the various tools.

Rod *E* governs the depth of travel of the driving band recessing tool, and it will be noticed that it also receives motion from drum *R*. The shaft *F*, on the other hand, is a rocker for the under-cutting tool for the band groove, and as shown in Fig. 8, also receives power from cam *R*. *G* is a feed-rod for the wave cutting tool and is operated in the same way as the other tools. *H* is a raising rod for the wedge bar *D*, and *J* is a rocker acting on the final finish cutting tool, the result of which is shown diagrammatically in Fig. 4. Most of the other details of the machine do not differ materially from the standard type of automatic screw machine or chucking lathe. The principle, of course, as a whole is quite unique. The production on this machine is one shell every three minutes, so that with material of the correct physical properties it is possible to turn out a complete shell, finishing both the interior and exterior on the machines shown in Figs. 1 and 7, respectively, in six minutes, or at the rate of ten an hour. D. T. H.

* * *

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION CONVENTION

The fifteenth annual convention of the National Machine Tool Builders' Association was held in New York City, October 24 and 25, at the Hotel Astor. The meeting was called to order by J. B. Doan, president, following which was the usual routine business, including reports of committees. J. H. Drury, chairman of the Membership Committee, reported that the following concerns had applied for membership: Fitchburg Grinding Machine Co., Fitchburg, Mass.; Sipp Machine Co., Paterson, N. J.; W. W. & C. F. Tucker, Hartford, Conn.; Simplex Machine Tool Co., Hamilton, Ohio; Nutter & Barnes Co., Hinsdale, N. H.; Cincinnati Grinding Co., Cincinnati, Ohio. Mr. Doan, in his presidential address, discussed the machine tool trade and the probable condition of business following the European war as follows:

A special feature of this association is the good fellowship of its members. Good fellowship, in the deeper sense of binding men together by the powerful ties of mutual self-interest and profound friendship, is a most valuable element in the development of every industry. Men have learned that cooperation is one of the necessities of business success. By combining our wisdom we learn better methods of manufacture; we learn that there is some better system of business than merely trying to cut the throat of a competitor, and we find that the concentrated rays of business friendship, like concentrated sunbeams, will melt the coldest and hardest markets. In other words, cooperation and the exchange of business ideas teach us to manufacture more scientifically, to keep costs more accurately, and to market our product more successfully. So let this membership get together, abandon business suspicion, and build up business confidence.

There never was a time when these fundamental laws of success were so essential to business men. We are living in the most momentous days of history, and are witnesses of the results which follow when national suspicion becomes national fear, and national fear turns to national hatred, leading to international destruction. We in America, enjoying as we do the privilege of living as a people without internal hatreds, without internal suspicions, without deep internal antagonisms, do not yet realize the greatness of these privileges. Such associations as ours keep alive in our country the great spirit of national trust and national cooperation. We come from coast to coast, from North to South, and meet with a common language and a common purpose. Let this unity increase and grow, and in the midst of this unity, do not fail to observe the horror that overwhelms nations and peoples who do not enjoy it.

As far-seeing business men living in these historic days, there are three elements of profound influence on the future which I would suggest that we consider deeply. First, the effect of the international war in Europe on our future, both at home and abroad. Second, the effect of the enormous business expansion which has come about in this country as a result of the war, both in the enlargement of old machine tool factories and the addition of new ones; and third, the effect of whatever changes in national laws may be made after the forthcoming election.

None but those who are blind and deaf can fail to comprehend that there will be terrific effects following the ending of the European war. Those effects follow all wars, as they follow floods, hurricanes and earthquakes. Even small wars leave an aftermath of physical and financial upheaval and distress. There will be debts to stagger the imagination, and there will be an instantaneous disappearance of certain business demands created by war. Peace will return to the industries of Europe approximately 20,000,000 men, supplemented by many women workers. The man who does not realize these conditions is, in my opinion, due for a rude shock. It will be a time for wise heads to acquire and use greater wisdom than they ever before possessed. No one can accurately forecast that future. It is all in the second act of the great tragedy.

We do know that after the Civil War, much as the South had need of everything under heaven, the South staggered on in poverty, unable to buy freely for more than a quarter of a century. Europe will be in need of everything; but the wherewith to buy, what about that? For Europe is blowing up its capital at the rate of the cost of a Panama Canal every week.

In the United States there has been immense business development during the last two years. Old machinery has been put in shape for work and new machinery has been built with break-neck speed. New buildings have been erected and expansion has been the order of the day in the machine tool industry along with others. Our demand has been due to the enormous call for machinery and supplies of every kind from Europe. We might picture business in America as a great forge made white hot, as the demand from Europe has blown upon it like a mighty bellows. The anvils have rung, the workers have toiled, and still the cry has been for more, more. But this Hercules of war will grow weary. The giant bellows will lose their force. Will there then be a sufficient demand to keep all busy? America wants and needs all the prosperity it can get; so in the midst of unprecedented prosperity let us not forget to prepare for other days.

In the days that are to come we need to enlarge our vision and build up the friendliest possible relations with other nations. In building up that business, the fundamental principle still holds. Tell exactly what your machine is when you try to sell it, and make it exactly as you have agreed to make it before you ship it. We want no soft spots in machine tools, no matter where they go. We are going to meet these different nations in the future, not merely on foreign soil, but perhaps on ours. It may be surprising to those who have not followed the statistics to know that, notwithstanding that practically all Europe is at war, we imported from the world during the fiscal year ending in 1916 goods valued at the astounding total of $2,197,000,000. This would have had a tremendous effect upon American industries and workmen if it were not offset in a measure by war orders. It will tax the ingenuity of Americans to meet that competition of the future. America is in a condition of the fat and well favored today. The old adage was "a lean hound for a long race." We will have to race with a lean and hungry hound after this war, so let us prepare for it.

We represent an industry that is fundamental in the world, more fundamental today than ever before. The struggle of the world has become one of machinery against machinery. If we did not know it before, the European war has taught us this fact. The nation with the largest and most powerful machinery, and the most of it, wins. It is still true, as Napoleon said, that "God fights on the side of the heaviest artillery." Our lathes, our turret machines, our planers, our milling machines, our fine mechanical devices of every nature are the war weapons of civilization. We represent a great industry. We manufacture the mechanism which keeps men always at the topmost point of civilized development. It is an honor to be a machine tool builder. It is a great honor to be a builder of good machine tools. It is more than an honor; it is a national responsibility, as it never was before, that the machine tool builders of America should be the builders of the best machine tools. Let us be worthy of that responsibility.

Concluded on page 275.

RUSSIA, THE AWAKENED LAND

During the past two years Russia has attracted more attention commercially than any other nation, largely because of its immense purchases of all kinds. Suddenly cut off from its accustomed sources of supply, this nation, which owns one-seventh of the land surface of the earth, found itself confronted with the problem of finding new markets in which it could buy, and to avoid a recurrence of this condition Russia began preparations for the development of its natural resources.

While the empire has an area of 8,505,957 square miles, or two and a half times the area of the United States with all its possessions, it is sparsely inhabited; the people for the most part till the soil, raise live stock, or are nomads. Only 13 per cent of the population of Eastern Russia live in cities; 23 per cent of that of Russian Poland; 12.9 per cent of that of the Caucasus; 11 per cent of that of Siberia; 13.5 per cent of that of Central Asia; and 14.6 per cent of that of Finland. In natural resources Russia is perhaps one of the richest countries in the world. The Ural Mountains are said to contain about every known metal; while the Altai and Caucasian Mountains, as well as other parts of the empire, are veritable storehouses of minerals. Though the metallurgical industry has been carried on with such indifference that at the beginning of the present century many blast furnaces and factories were torn down to avoid payment of the zemstvo taxes, so great is the mineral wealth of the country that in 1911 Russia ranked first in the production of platinum; second in the production of petroleum, asbestos, and manganese ores; fifth in the production of gold; seventh in the production of copper and asphalt; and eighth in the production of iron. It produced nearly all of the world's supply of platinum and approximately one-fifth of the supply of petroleum. The iron ores from South Russia are said to be the finest in Europe, some of the ore analyzing 70 per cent iron. The gold ores found in the Urals also supply much of the wolfram, osmium, tantalum and iridium used in the manufacture of electric lamps.

Several reasons have been given for the poor development of the nation's resources. Among the first is the sparsely settled condition of the country and the poor transportation systems. Owing to the marshy character of a large part of Eastern Russia and the lack of road-building materials, good roads are almost unknown; in fact, much of the marketing is done when the ground is frozen and sleds can be used. Yet so extensive a waterways system was developed early in the last century that by means of canalized rivers and the 1225 miles of artificial canals, the Baltic and Black Seas, and the Caspian, Baltic and White Seas were connected. Concessions have been granted for the building of many other canal systems. The Ob-Yenisei waterway system, in Siberia, is nearly 3650 miles long. In proportion to its population and area the railway mileage of Russia is small. The first railroads were built very slowly and were located so as to augment the transportation systems in existence and not as competing lines, with the result that they were not placed in many cases where they aided in the development of the country. About two-thirds of the lines, and those most of the important ones, are owned by the government.

Because most of the people follow agricultural pursuits, and also because of the inadequate systems of transportation, the buying and selling has been done at long intervals. This has caused the holding of fairs at which the people gathered in immense numbers. It has been estimated that 16,000 of these fairs are held annually, and that their sales exceed $500,000,000. Of course many of these are small and only of local interest, but some are of national importance and are known throughout the world. From 30 to 50 per cent of the furs found in the London and Leipsic markets were formerly bought at the Irbit fair.

The greatest factor in this tardy growth of the nation is now said to be the Germanic influence, which has dominated the Russian government since the days of Peter the Great. The Germans have secured the greater part of Russian trade through this influence and through their willingness to adapt their methods to Russian conditions. In a recent issue, *Engineering* of London told of two brothers who bought and quietly worked a small farm in Siberia until they had gained the confidence of those living in the surrounding region. Then they offered to teach better farming methods to all who would pay them a certain percentage of the increase in the crops, and the machinery necessary for the success of their methods they sold on three yearly installments. With the extra depth of soil turned over by the machine plow, the risk incurred by the brothers was small and the profits were so large that they were able to retire to Germany at the end of a few years.

Germany's dominance in the year 1913 is shown by the fact that of the $18,747,730 worth of machinery bought by Russia, Germany sold $14,626,050, while the United States sold only $211,342; of cast-iron products Germany sold $1,366,837, and the United States $20,553; of manufactures of copper alloys Germany sold $4,708,065, the United States $15,136; of tin-plate manufactures, Germany sold $2,653,491, the United States $15,631; of metal-working machinery, Germany sold $5,488,934, the United States $244,405; of dynamos and electrical motors, Germany sold $4,431,762, the United States $14,180; of parts of machinery and apparatus, Germany sold $6,966,330, the United States $601,254; of electrical appliances, Germany sold $3,196,215, the United States $51,576; of motor cars and trucks, Germany sold $7,102,264, the United States $300,760.

It has been estimated that German firms sold to Russia about two and one-half times as much American machinery and machine tools as was imported direct from the United States. A good part of this was sold at the Nizhni Novgorod fair and paid for at the fair the following year; the American firms, however, were paid cash in New York. So well developed was the German credit information service that the losses of one firm in the last twenty years are said to have been less than two per cent. English firms usually require a one-third payment with the order, one-third when the goods are shipped, and one-third when the goods are received.

The true reason for the slow growth of Russia seems to have been a lack of fuel and of capital. While the country has many large coal deposits, some of it is of an inferior quality and much that is of good quality has been inaccessible. Railroads are being built to these deposits, so that it is thought the fuel supply will be sufficient for a long time to come. Plans are being made for the conservation of this supply by making as wide a use as possible of the water power, of which there is an abundant supply.

The Russian markets are increasing in size and importance and are demanding better articles than two years ago. During the war several ports have been developed and new ones have been built, necessitating the construction of new railroads, some through territory that heretofore has been inaccessible. Existing roads have also been extended and in some cases rebuilt, and with the increase in the manufacturing plants of all kinds the people have more ready money than ever before. Wages have been increased in some cases nearly a hundred per cent, and in consequence the people are adopting a higher plane of living. Factories of many kinds are being planned and built, some under the direct supervision of American, English, Swedish and other engineers. The choice of these men, who will largely determine the equipment that will be adopted, is often dependent on the source of the capital furnished for the factory.

One mistake that is being made in the published descriptions of the Russian conditions is to speak of the changes that are taking place as "rapid." Nothing with which the people of Russia have to do is rapid—quite the reverse. The introduction of modern methods of manufacture, the use of labor-saving machinery, the adoption of comforts such as we have in America and a voice in their own government will all be matters of education, and they will be slow; but they are all coming. D. E. J.

* * *

The smoother the point of the diamond used for truing diamond wheels, the smoother will be the finish on the work. Don't think of the diamond as a means of sharpening the wheel, but rather as a means for correcting inequalities of the surface.—*Grits and Grinds.*

WESTINGHOUSE RIFLE BARREL DRILLING AND REAMING MACHINES

Both the drilling and reaming machine have capacity for handling twelve rifle barrels simultaneously and the work is held in a vertical position on both machines. This is the means of securing several important advantages, among which particular attention is called to economy of floor space. One of these twelve-spindle machines occupies the same amount of room as an ordinary rifle barrel drilling or reaming machine which works on two barrels simultaneously. Each spindle on the drilling machine is driven by an independent variable-speed motor, and an automatic electric switch provides for stopping the spindle should a drill stick or become dull. On the reaming machine feed is provided by counterweights, so that the rate of feed may be automatically adjusted to accommodate varying conditions in the size of bore, hardness of material, etc.

A radical departure from the conventional method of drilling and reaming rifle barrels has been made in the machines shown in Figs. 1 and 2, which have been designed by the New England Westinghouse Co., and are now at work in its East Springfield. Mass., plant. These machines differ from standard rifle barrel drilling and reaming machines in several important respects: First, they are designed to handle the barrels vertically instead of horizontally; second, twelve instead of two barrels are handled by each machine; third, each spindle on the barrel drilling machine is driven by a separate variable-speed motor; fourth, one machine occupies exactly the same floor space as the standard machine, which has a capacity for only two instead of twelve barrels; fifth, on the drilling machine an automatic electric switch instead of a mechanically operated clutch is provided for stopping the machine should a drill stick or become dull; and sixth, on the barrel reaming machine, the feed is by counterweights instead of a positive screw, thus automatically adjusting the rate of feed to suit varying conditions in the size of bore and hardness of metal.

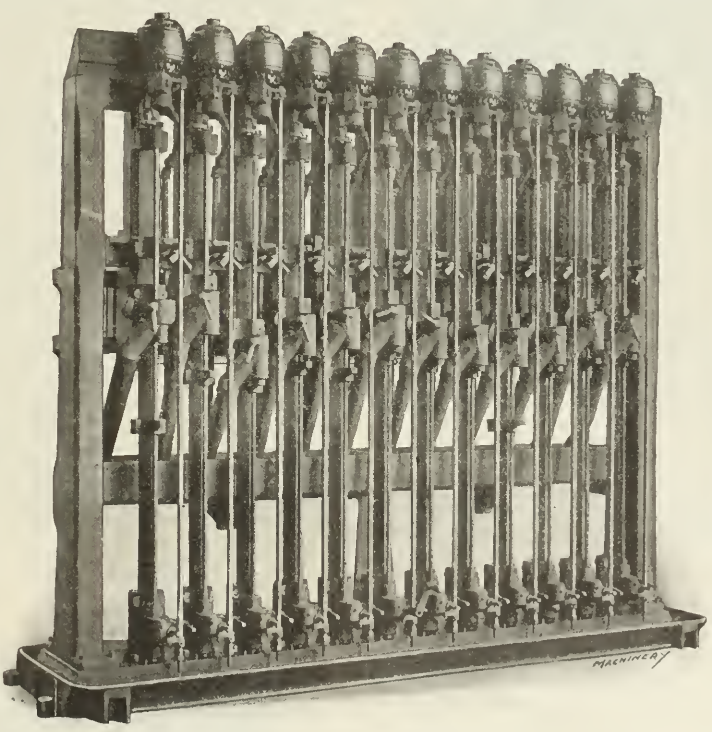


Fig. 1. Westinghouse Rifle Barrel Drilling Machine that works on Twelve Barrels simultaneously

Rifle Barrel Drilling Machine

Reference to Fig. 1 will show that the rifle barrel drilling machine consists of an upright frame standing on a base of rectangular section and carrying twelve individual units, comprising a variable speed motor, headstock, tailstock, drill guide, carriage and controller, the controller being located at the rear of the machine. All these members, with the exception of the motor and headstock, are carried on twelve uprights. In the machine shown, these uprights are of square section, which in the later models now being built will be changed to circular section to facilitate machining and assembling.

In operation, the rifle barrel to be drilled is held in and rotated by the headstock, a female driving chuck or center with sharp projections contacting with the machined taper on the muzzle end of the barrel. This chuck is connected directly to the motor shaft. The lower center in the tailstock is held upward by a stiff spring, thus insuring that the barrel is always held up in the chuck with the same pressure, and at the same time providing for linear expansion of the barrel due to heating while it is being drilled. The carriage is furnished with the standard type of oil-tube barrel drill and is fed upward by a lead-screw that receives power from the motor through a train of gears, worms and worm-wheels.

The oil is pumped up through the drill from an oil "line" in which the pressure registers about 800 pounds per square inch. The oil and chips pass down through the exterior flute in the drill and shank, and are carried off through a "by-pass" pipe which is part of the tailstock casting. This pipe extends to the rear of the machine and empties into a trough in which the chips are separated from the oil, which returns to the pump.

Each spindle is automatically stopped when the drill breaks through at the muzzle end of the barrel by a dog which operates the starting and stopping handle. An interesting feature in connection with this machine, which eliminates the splashing of oil when the drill breaks through, is a "by-pass" arrangement consisting of angular holes in the lower section of the headstock casting. This "by-pass" conveys oil from the drill to a pipe, which, in turn, carries it to a trough behind the machine. In this way, the machine is kept clean and free from oil.

Another feature, which relates more particularly to the electrical equipment, is the provision made for stopping the machine automatically, should the drill become dull or stick and thus consume more power than would ordinarily be required. This consists of an electric switch, comprising an overload coil which is connected in series with the armature, and is so arranged that any excess current passing through the armature will operate the coil and through it the switch, thus automatically stopping the machine. This overload coil can be very accurately adjusted to suit conditions of steel, etc. A starting rheostat is also provided which enables work speeds varying from 1200 to 2400 revolutions per minute to be obtained.

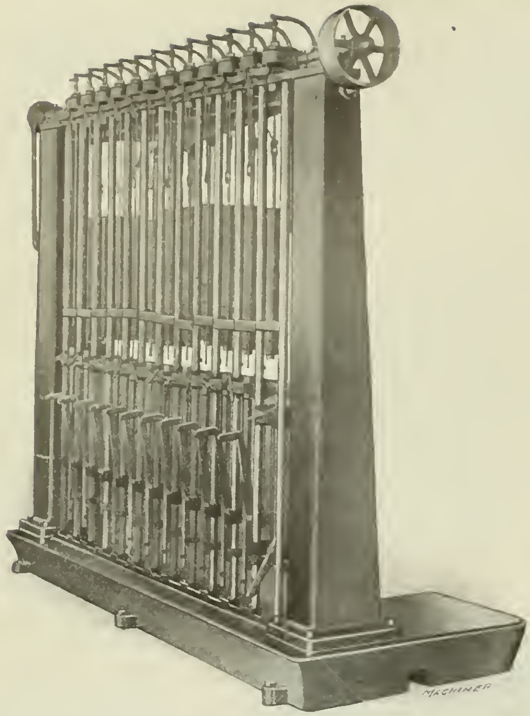


Fig. 2. Westinghouse Twelve-spindle Rifle Barrel Reaming Machine

This vertical rifle barrel drilling machine has been found to combine a number of valuable features. In the first place, it brings the line of action of gravity parallel with the axis of the drill, which tends to produce a truer hole and also helps to keep the drill clear of chips. In addition, it permits of the arrangement of a greater number of spindles in such a position that one man can easily attend to twelve spindles, enabling him to secure a very high rate of production. The other advantages previously enumerated clearly prove that this machine represents a considerable advance in the art of deep-hole drilling.

Rifle Barrel Reaming Machine

In the rifle barrel reaming machine shown in Fig. 2, advantage is also taken of the vertical principle of handling the work. Reaming on vertical machines comprises several important advantages over the horizontal method. In the first place, twelve spindles occupy exactly the same floor space as two spindles of a horizontal machine, and present the spindles in compact form, so that they can be attended to by one operator. In the second place, lubrication of the reamer is more easily accomplished, resulting in the production of holes free from rings and other defects.

There are several other advantages incorporated in this machine, among which are the following: First, the barrels are swung from universal joints, enabling the reamers to follow the drilled holes accurately. Second, the feed is by counterweights—not positive—so that it automatically adjusts itself to agree with the amount of work being done by the reamers. For instance, if there is more material to be reamed out of a hole than is normally the case, the machine will feed more slowly; and if the reamer strikes a hard spot in the barrel, the feed will slow up to accommodate itself to this condition. Third, the machine can be used either for push or pull reaming. This is accomplished by changing the direction of driving rotation of the belt on the cone pulley at the left-hand end of the machine, and by changing the location of the counterweights.

The feed for the reamers, as previously mentioned, is obtained by means of counterweights which are placed on crossheads or at opposite ends of the cables, depending upon whether the push or pull method is being used. These cables run over pulleys that are mounted on friction clutches so arranged that they can be made to work in either direction. The weights can also be adjusted to give any rate of feed that is found most satisfactory for the steel being machined and the amount of material being removed. All twelve spindles are driven from one longitudinal shaft running the entire length of the machine, which, in turn, is operated from a countershaft located on the floor.

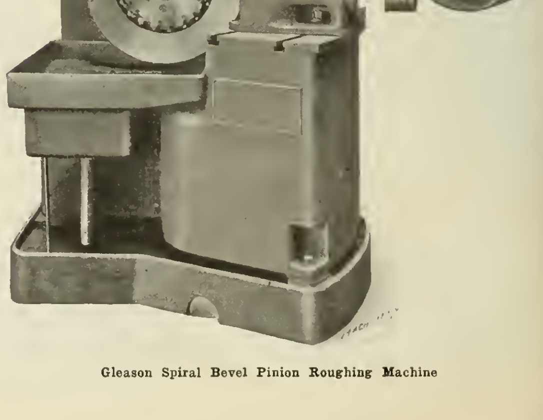
GLEASON SPIRAL BEVEL PINION ROUGHER

The standard Gleason spiral bevel gear generator is adapted for roughing and finishing gears of this type; but manufacturers of spiral bevel gears in quantity found need for a machine to rough out their pinions cheaper and faster than could be done on the regular finishing machine; and to meet this requirement the Gleason Works, Rochester, N. Y., have brought out the spiral type bevel pinion rougher which is illustrated and described herewith. Pinions roughed out on this machine are finished on the standard spiral bevel gear generator illustrated and described in the April, 1914, number of MACHINERY.

This pinion roughing machine is universal, *i. e.*, it is adapted for roughing either right- or left-hand spiral work, and it is fully automatic in operation. The construction is simple, making it easy to oil and adjust all parts. The positive index mechanism is actuated by the generating roll of the work-spindle; and for spacing teeth a notched dial is used, which has the required number of divisions. A cam mounted directly on the cutter sleeve drives the positive feed. The cutter is driven through a pair of internal gears, the driving pinion being integral with the pulley shaft. All other drives, including the pump drive, are taken from this shaft; all bearings are furnished with ample oiling facilities and the gears are thoroughly guarded.

The cutters used on the machine are of the same type as those used on the finishing machine and are interchangeable from one machine to the other. Adjustments for setting to the required spiral angle can be easily and quickly made, and the cutter is set permanently to the root angle and needs to be adjusted only as it wears or when a new cutter is required. The same mandrels are used on both roughing and finishing machines and, like the cutters, they are interchangeable. Attachments furnished with the machine include one index dial, one set of feed change-gears, one cutter gage, one oil pump and connections, one countershaft and the necessary wrenches for making all adjustments.

The principal dimensions of this machine are as follows:



Gleason Spiral Bevel Pinion Roughing Machine

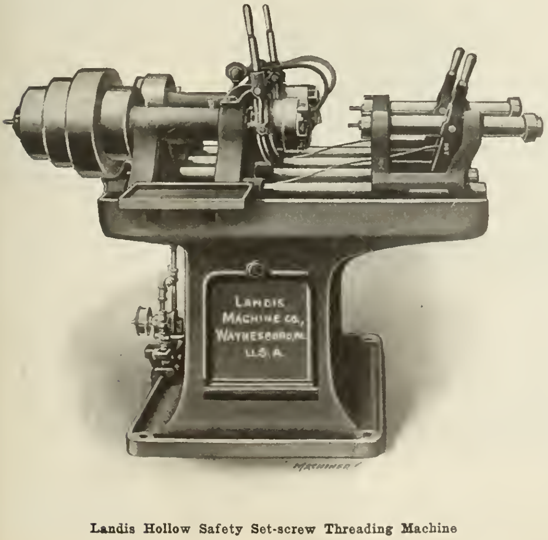
longest cone distance of any gear that can be cut, 7⅝ inches; shortest cone distance of any gear that can be cut, 0; extreme ratio of any bevel pinion, 8 to 1; maximum pitch angle, 26 degrees, 34 minutes; minimum pitch angle, 7 degrees, 7 minutes; greatest pitch diameter of 8 to 1 ratio, 1⅞ inch; greatest pitch diameter of 2 to 1 ratio, 6½ inches; maximum diametral pitch, 2½; longest face, 1/3 cone distance; cutter speed, 130 feet per minute; fastest time in which one tooth can be cut, 19 seconds; slowest time in which one tooth can be cut, 90 seconds; diameter of driving pulley, 16 inches; width of driving belt, 4 inches; diameter of tight and loose pulleys, 12 inches; speed of countershaft, 300 R. P. M.; taper hole in spindle, No. 14 B. & S.; horsepower required to drive machine, 5; floor space occupied, 53 by 58 inches; height of machine, 60¾ inches; and net weight, approximately 5000 pounds.

OLIVER SAWING, FILING AND LAPPING MACHINE

In the December, 1915, number of MACHINERY, a description was published of a sawing, filing and lapping machine which had just been placed on the market by the Oliver Instrument Co., 1168 Cass Ave., Detroit, Mich. Recently the same company has introduced an improved type of the same machine which provides for releasing the collet in the lower ram by means of a wrench similar to that used in the Jacobs drill chuck, instead of requiring the use of a spanner wrench, as was formerly the case. The design of the over-arm has also been improved by providing means for holding a saw in the upper ram, this being accomplished by the use of a clamp instead of a collet. A holder for files and oilstones has been devised in which any standard file can be used by cutting it off to suitable length. This makes it possible to use up the entire file, instead of merely working at one spot. This same holder can be adapted for receiving oilstones which are made in various shapes and sizes. An extra hold-down is furnished for use when the over-arm is not in place. Other features of the machine are the same as those described in the December, 1915, number of MACHINERY.

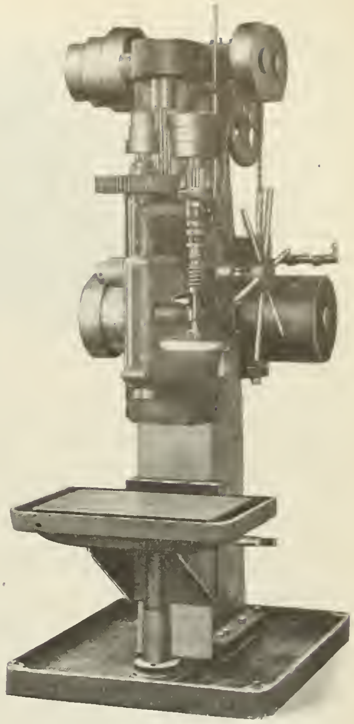
LANDIS SET-SCREW THREADING MACHINE

The Landis Machine Co., Waynesboro, Pa., has recently placed on the market threading machines equipped with special carriages for threading hollow safety set-screws. While these machines were primarily designed for this purpose, they may be employed for threading stock where there is a continuous thread and a similar method of holding. The carriages proper are stationary and support two spindles which have a free horizontal movement. These spindles are brought to the threading die-heads by means of weights which are attached by chains to levers operating the spindles. These weights exercise a continuous force upon the spindles in the direction of the die-heads, making it unnecessary for the operator to feed the stock forward for the threading operation.



Landis Hollow Safety Set-screw Threading Machine

The heads of the spindles are bored and fitted with mandrels for holding the set-screws, and a collar is placed on the rear of each spindle, making it adjustable for cutting any desired length of thread. For the threading operation, the set-screw is placed on the mandrel and the spindle automatically forces it into the die-head. When the screw is threaded, it remains in a tube which extends through the spindle from the face of the threading die-head to the rear of the machine. The subsequent threading of screws forces the finished pieces through the tube, where they drop into a receptacle placed at the rear of the machine.



Moline Traversing-head Drilling Machine

These machines may also be used for threading standard bolts by attaching automatic opening and closing attachments for the die-heads. When standard bolts are threaded, the heads of the spindles on the carriages are fitted with bolt sockets for the various diameters within the range of the machine. These machines are equipped with Landis all-steel die-heads, which employ long-life chasers.

MOLINE TRAVERSING-HEAD DRILLING MACHINE

The accompanying illustration shows a single-spindle traversing-head drilling machine which has recently been added to the line of machines built by the Moline Tool Co., Moline, Ill. Instead of mounting the spindle in a quill which is fed by a rack and pinion, the entire head is traversed by a double rack and pinion, the spindle running in long bronze bushings with means of compensating for wear. Attention is also called to the fact that, instead of drawing the spindle through the gear and subjecting the keys to considerable strain while traversing, the spindle driving gear is mounted directly on the spindle and traversed along a wide faced pinion which is supported on a shaft that runs in bronze-bushed bearings. This long pinion is driven by steel and bronze spiral gearing.

Between the spiral pinion and cone pulley shaft there are change-gears by which practically any range of speeds can be obtained. As shown, the machine is equipped with belt feed; but gear-box feed can be provided if desired. The spindle may be furnished with a short nose and a hollow to accommodate a knock-out rod; or it may be provided with the nose extending far enough out from the bearings to afford space for a knock-out slot. The spindle nose may also be threaded for a chuck if desired. The countershaft is mounted on the column; and the machine is equipped with a pump and lubricant pipe as part of the regular equipment.

The principal dimensions of this drilling machine are as follows: distance from center of spindle to face of column,

10 inches; maximum distance from table to spindle, 34 inches; maximum distance from spindle to floor plate (when provided), 46 inches; working face of table, 15 by 24 inches; number of T-slots in table, 3; maximum vertical adjustment of table, 15 inches; maximum travel of head, 18 inches; diameter of spindle in lower bearing, 2 15/16 inches; size of tight and loose pulleys, 12 inches diameter by 5 inches face width; size of steps on cone pulley, 8, 10 and 12 inches diameter by 3 inches face width; countershaft speed, 500 R. P. M.; available speeds with two sets of change-gears, from 20 to 200 revolutions per minute.

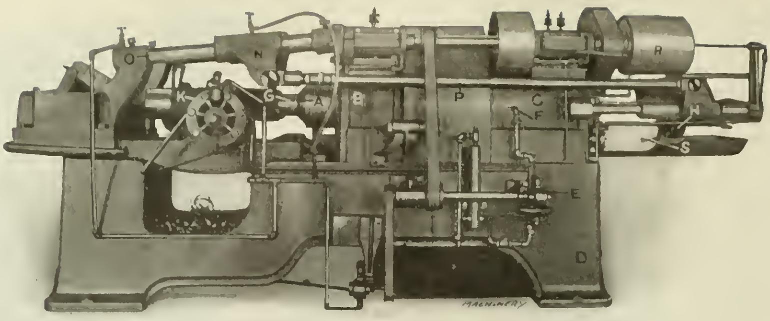


Fig. 1. Warren Hydraulic Lathe for External Machining Operations on Shell Forgings

WARREN HYDRAULIC LATHE

This machine is a rather interesting modification of the hydraulic lathes already built by the Lombard Governor Co., Ashland, Mass., for the rapid production of 3-, 5- and 9-inch high-explosive shells. As is the case with previous machines, spindle *A*, that is 9 inches in diameter and about 4 feet long, is mounted in two long bearings *B* and *C*, which are cast integral with frame *D* of the machine. The rear end of spindle *A* is enlarged to 10 inches in diameter and forms a revolving piston in rear bearing *C*.

Oil under pressure is supplied by small pump *E*, through pipe *F*, to act against the revolving piston at the end of spindle *A* in such a way as to hold the spindle rigidly as regards axial motion without interfering in any way with its rotation; and this body of oil at all times takes the whole thrust of the spindle. A needle valve provides convenient means for permitting oil to enter slowly behind the end of spindle *A*, and this moves the whole spindle forward; in this way an accurate and infinitely adjustable axial feed for the spindle is provided. A tool steel arbor *G* extends from the front end of the spindle into the shell forging; and expanding pins in the arbor, which are set out by the hydraulic diaphragm *H*, provide a satisfactory method of clamping the forging firmly on the arbor.

Two hydraulic turning tool-holders on opposite sides of the arbor, one of which is shown at *K*, carry tools 1 inch wide and 2 inches deep, which are used for roughing out the cylindrical portion of the shell. Drill *L* and facing tools *M* are mounted in a heavy swinging arm (see Fig. 2), which can be thrown down and locked central with the main spindle of the machine. These tools are used in this particular shell, which is the Italian, for perforating the closed end with a 2¼-inch hole and facing this end to length. For the purpose of cutting off excess metal at the open end of the forging, a traveling cutting-off tool-holder *N* is provided, that moves on inclined ways *O*, being driven from the main spindle of the machine by heavy connecting rods *P*. In carriage *N* is mounted a heavy parting tool. It is evident that as main spindle *A* moves forward, carriage *N* will move at the same rate, but on account of inclined ways *O* the cutting-off tool will have a component motion downward which will force the tool into the forging and finally result in cutting off the excess metal.

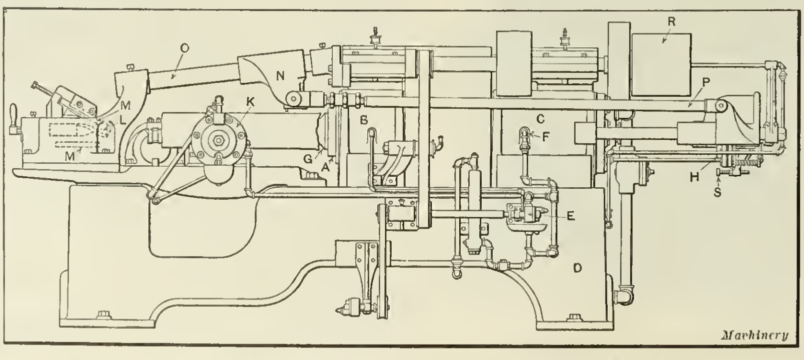


Fig. 2. Warren Hydraulic Lathe, showing Drill and End Facing Tools

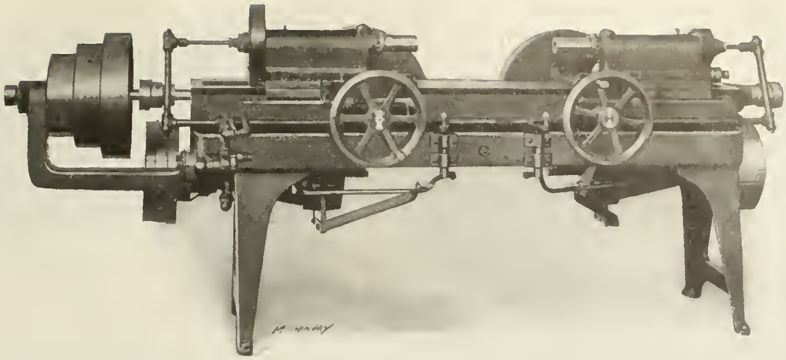
In operating the machine, spindle *A* is started in its backward position, the shell forging having been firmly clamped on the arbor — an operation requiring less than ten seconds. The spindle is started into rotation by a powerful hydraulic clutch *R*, which is operated instantly by a small valve, and then by opening another valve the turning tools mounted in holders *K* are fed into the work. As soon as this has been accomplished, the forward axial movement of spindle *A* begins; then the turning tools which divide the length of the shell into halves begin to remove metal from the outside. Very soon the cutting-off tool begins to penetrate the forging, and these three tools continue to work until the front end of the forging strikes drill *L*. Then the rate of feed is slightly reduced as the drill cuts through the closed end and the facing tools *M* finish this surface, which is 6 inches in diameter, to the correct length. When spindle *A* reaches its extreme forward position an adjustable stop *S* strikes an automatic reversing valve and the spindle immediately returns to its initial position, having finished the following operations on the forging: (1) Rough-turning the outside 22 inches long; (2) cutting off the open end to length; (3) perforating the closed end with a 2¼-inch hole; (4) facing the closed end to dimensions.

It will be observed that all these operations are taking place continuously, and at one time six tools are cutting simultaneously. The metal in Italian shell forgings is exceedingly tough and hard, and only the very best high-speed steel or stellite tool points will stand up for more than one or two shells without resharpening, but the economy of production of this hydraulic lathe is said to be most remarkable. In a test, all of the operations described were performed within a time interval of ten minutes and forty seconds, which is one-third of the shortest time required on ordinary power feed machines, such as heavy lathes, drills and cutting-off machines, for doing the same work. About thirty horsepower is required to drive one of these lathes. The operating oil pressure is in the neighborhood of 200 pounds per square inch. Cutting compound is supplied to all the tools, and the machine as a whole, including the extended arbor *G*, is so stiff that it operates almost without vibration and does not require any special foundation. Four of these lathes have been furnished to the Driggs, Seabury Ordnance Co., Sharon, Pa.

MOLINE DUPLEX DRILLING MACHINE

One of the latest additions to the line of machinery built by the Moline Tool Co., Moline, Ill., is the duplex drilling machine shown in the accompanying illustration. This machine has a capacity for driving drills up to 1 inch in diameter, and when so desired, gears on the machine can be changed to provide for running one spindle faster

than the other when it is desired to use two drills of different sizes. Both heads are driven from a central driving shaft; and the bed is cast in such a way that the top is solid at the center to protect the mechanism from chips; an oil tank is also cast integral with the bed. Each spindle is provided with three changes of feed which are independent of each other, and three changes of speed are available. The machine is equipped complete with a pump and piping for connection with the oil tank in the bed.



Duplex Drilling Machine built by Moline Tool Co.

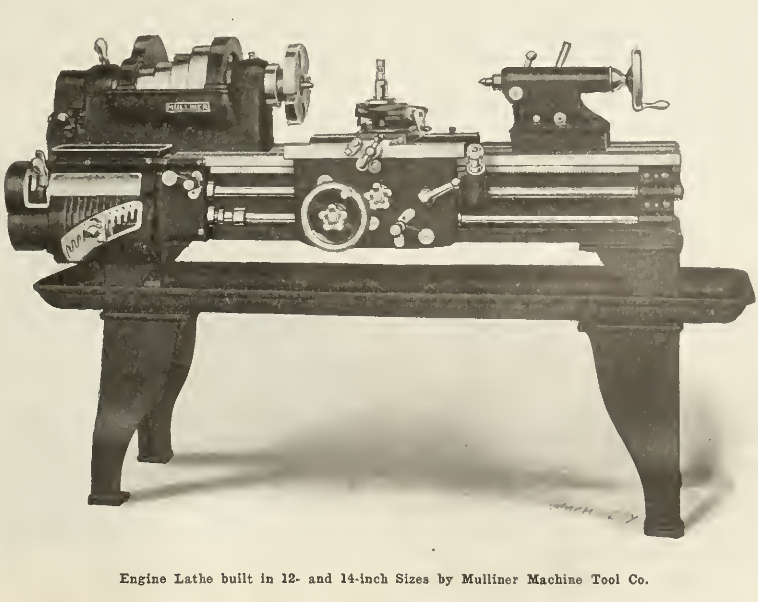
The principal dimensions of this machine are as follows: length of bed, 7 feet; minimum distance between spindles, 4 inches; maximum distance between spindles, 30 inches; bore of spindles, No. 4 Morse taper; distance from spindles to bed, 6 inches; width of bed, 10 inches; and capacity, for driving drills up to 1 inch in diameter.

MULLINER ENGINE LATHE

The Mulliner Machine Tool Co., Inc., 541 S. Clinton St., Syracuse, N. Y., is now manufacturing 12- and 14-inch sizes of the quick-change gear lathe shown in the accompanying illustration. The bed is ribbed transversely with heavy double-walled cross girths, and the bed castings are made in a way which produces a hard, close-grained metal. This provides a harder metal on the shears than in the carriage bearings, so that wear is largely confined to the carriage where compensation can be made.

The headstock spindle bearings are provided with means of compensating for wear; and the front and rear journals are adjustable independently of each other. These bearings are of the ring-oiling type and receive lubricant from large oil reservoirs. The spindle is made from a crucible steel forging and is accurately ground to size. The double-walled construction has been adopted for the apron in order to take advantage of the outboard bearings provided for all studs and shafts. Full surface contact is provided between the swivel and bottom slide of the compound rest; and the rest is clamped to the cross-slide by two bolts. Full length tapered gibs with end screw adjustment are furnished for slides of both the cross and compound rests.

Cone gears of the quick-change gear mechanism are cut with improved Brown & Sharpe 20-degree involute cutters, which form a pointed tooth that is slightly rounded at the top. This is a very satisfactory form of tooth to use in a tumbler gear mechanism, as it permits of instantaneous engagement of gears without clashing. The quick-change gear mechanism gives thirty-seven changes of threads and feeds, which are shown on an index chart mounted on the quick-change gear-box. In addition, provision is made for applying extra change-gears by means of an auxiliary quadrant located at the end of the bed, which carries gears connecting the head with the quick-change gear mechanism. This arrangement permits the use of such extra change-gears as are necessary to cut all special or metric threads.



Engine Lathe built in 12- and 14-inch Sizes by Mulliner Machine Tool Co.

The regular equipment furnished with these lathes includes compound rest, steadyrest, thread chasing dial, large and small faceplates, a countershaft and the necessary wrenches for making all adjustments. The principal dimensions of the 12-inch lathe are: swing over bed, 12¾ inches; swing over carriage, 7½ inches; ratio of gearing in head, 10 to 1; cone pulley steps, 2⅞, 4½, 6⅛ and 7¾ inches in diameter by 1¾ inch face width; diameter of hole through spindle, 15/16 inch; range for screw cutting, 1½ to 80 threads per inch; range of feeds, 6 to 320 per inch; capacity between centers for 6-foot bed, 40 inches; and net weight of machine with 5-foot bed, 1990 pounds. The dimensions of the 14-inch lathe which differ from those of the 12-inch machine are as follows: swing over bed, 14¼ inches; swing over carriage, 8¾ inches; ratio of gearing in head, 8½ to 1; cone pulley steps, 3⅝, 5¼, 6⅞ and 8½ inches in diameter by 2 inches face width; diameter of hole through spindle, 1 inch; capacity between centers for 6-foot bed, 36 inches; and net weight of machine with 5-foot bed, 2100 pounds.

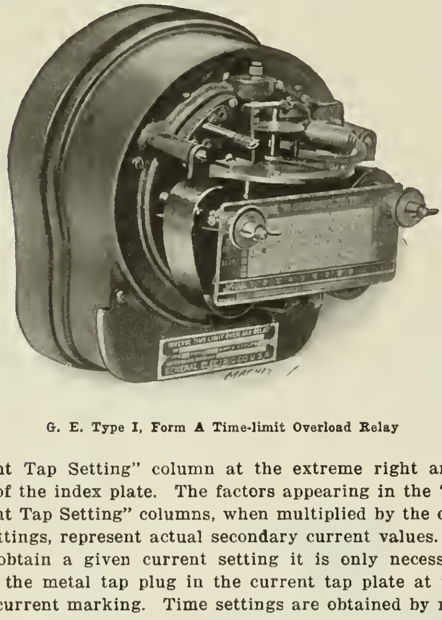
G. E. TIME-LIMIT OVERLOAD RELAY

The single-pole time-limit circuit closing overload relay illustrated and described herewith is of simple and rugged construction. It is particularly applicable to those systems where extreme accuracy in timing is required for tripping two or more air or oil circuit breakers selectively. Operating or characteristic curves for the various time-current settings are entirely separate and distinct at even the heaviest overloads and never become instantaneous; and heaviest overloads do not disturb the form of curve nor cause vibration of the moving parts. The relay operates within a period of time which varies inversely with the lower current values and approaches a definite minimum time for the higher current values. Consequently, the relay will do the work ordinarily required of time-limit relays

that operate within a definite time and those that operate in a time that is reduced as the current values increase.

The relay is designed for use in the secondary of current transformers. The normal load rating is five amperes; but by means of a current tap plate and a metal tap plug portions of the relay winding are cut out so that the relay may be set to operate at four, five, six, eight and ten amperes. Positive operation is obtained at any setting throughout this range. The contacts are closed on overload by rotation of a disk actuated by a U-shaped driving magnet with shading coils on the pole pieces. No tripping current is carried through the revolving parts. When the contacts have been closed they are firmly held in that position, until tripping occurs, by the armature of a holding coil connected in series with the contacts, the trip coil of the air or oil circuit breaker and an auxiliary switch which opens when the breaker is tripped. This insures current on the trip coil continuously until the circuit breaker opens, and prevents flashing at the contacts, which, as an additional precaution, are of high heat-resisting metal and non-corrosive, making them practically indestructible. The current closing capacity is extremely high for a relay of this type and ample for directly tripping any one circuit breaker made by the General Electric Co.

Temperature errors are minimized by a compensating device which is part of the relay; and bearings are of the jewel type used in G. E. watthour meters, so that the friction is small and will not vary. The values given in vertical columns 1 to 10 on the index plate are the time delays which will be obtained with different degrees of overload represented in the "Times Current Tap Setting" column at the extreme right and left sides of the index plate. The factors appearing in the "Times Current Tap Setting" columns, when multiplied by the current tap settings, represent actual secondary current values.



G. E. Type I, Form A Time-limit Overload Relay

To obtain a given current setting it is only necessary to insert the metal tap plug in the current tap plate at the desired current marking. Time settings are obtained by moving a small lever in front and near the top of the relay, to the graduation mark representing the column in which the desired time appears. The relay is being furnished in two styles, for 25- and 60-cycle circuits, respectively. The principle of operation and inherent characteristics are the same in both, and the relays themselves differ only in slight details of construction. This relay is known as Type I, Form A and is being manufactured by the General Electric Co., Schenectady, N. Y.

GLOBE COLLET CHUCK

The collet chuck shown in the accompanying illustrations takes the place of the usual type of draw-in collet chucks made for use on engine lathes. Fig. 1 shows the parts of this chuck, and in Fig. 2 the headstock of an engine lathe is shown with the collet chuck in place in the spindle. It will be evident from these illustrations that instead of the operator's having to go to the rear of the lathe to tighten or release the collet, he is able to do this at the nose of the spindle, making it unnecessary to leave the regular operating position. This saves a considerable amount of time. It will be seen that this chuck takes the place of a center in the spindle; on small lathes a No. 3 Morse taper center is usually furnished, and on lathes swinging from 16 to 20 inches a No. 4 Morse taper is furnished. The body of the chuck, as well as the nose-piece, is made of steel which is heat-treated and ground; and the collet is made of tool steel that is tempered in oil, and it is split back about three-quarters of the way from both ends, so that when tightened on a bar by means of the handwheel the chuck grips for the full length of the collet.

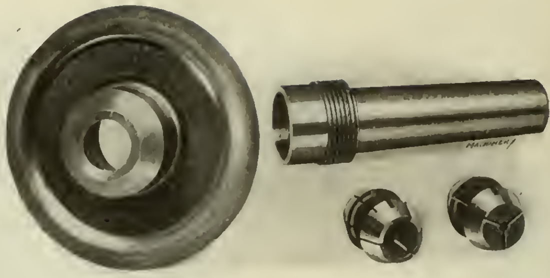


Fig. 1. Parts of Collet Chuck made by Globe Engineering Co.

In order to attach this collet chuck to the lathe it is necessary to remove the spindle center and substitute the taper end of the chuck. Next remove the nose-piece on which the handwheel is mounted and place the collet in the body of the chuck, and after this has been done, screw the nose-piece back into place. These collet chucks are made in two sizes by the Globe Engineering Co., 412 Traction Bldg., Cincinnati, Ohio. The principal dimensions of the No. 0 chuck are: taper of shank, No. 3 Morse; capacity for round stock, up to 5/8 inch in diameter; capacity for hexagonal stock, up to 1/2 inch; capacity for square stock, up to 7/16 inch; diameter of handwheel, 5 inches; and distance chuck projects beyond spindle, 2 1/4 inches. The principal dimensions of the No. 1 collet chuck are: taper of shank, No. 4 Morse; capacity for round stock, up to 3/4 inch in diameter; capacity for hexagonal stock, up to 5/8 inch; capacity for square stock, up to 9/16 inch; diameter of handwheel, 6 inches; and distance chuck projects beyond lathe spindle, 2 1/2 inches.

PORTER-CABLE TAPER ATTACHMENT

The Porter-Cable Machine Co., Syracuse, N. Y., has developed the taper attachment illustrated and described herewith, for use on its manufacturing lathe. Like the machine for use on which it was developed, this attachment is essentially a manufacturing device, and consists of a double cross-slide with the upper tool-rest *H* controlled by a hand screw, and the lower auxiliary slide *E* controlled by the taper form or wedge *A*.

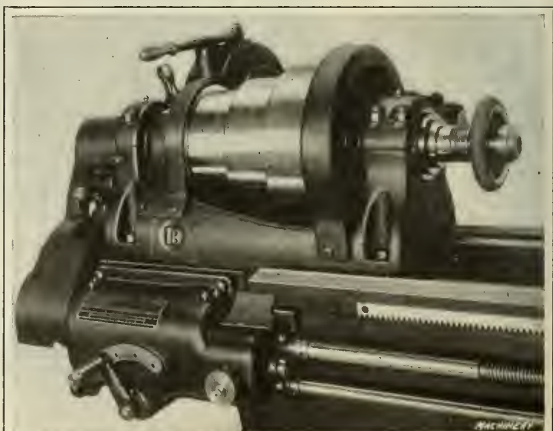


Fig. 2. Globe Collet Chuck in Use on Lathe

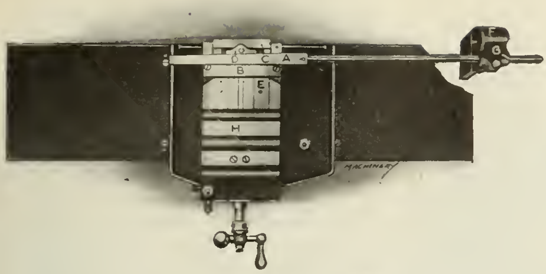


Fig. 1. Taper Attachment for Porter-Cable Manufacturing Lathe

\uxiliary slide *E* has a projecting portion *C* which is ma- :hined to form a seat for swivel shoe *D* that bears against the nclined surface of wedge *A*. The straight side or base of this vedge bears against block *B*, which is rigidly fastened to he carriage; and there is a concealed compression spring vhich tends to force slide *E* toward the operator so that swivel block *D* is always in contact with wedge *A*. It will ›e noted that this is the same direction as the thrust of the vork against the tool, so that a smooth, uniform cut and true aper is obtained on the work; and duplicate pieces can be ›roduced indefinitely.

A bracket *F* is provided, which is bolted to the end of the athe and forms a clamp for adjustable rod *G*. Wedge *A* .nd bearing blocks *B* and *D* are hardened and ground; and he substitution of one wedge for another of different taper ›nly takes a moment, as the taper block *A* is attached to od *G* by a single cross-pin. This taper attachment is self- ontained in the carriage and is very rigid, all possibility of pring being eliminated. Wedges may be made of any desired aper for the work; and in making these wedges advantage hould be taken of the simple expedient of milling a groove cross the small end of the wedge, as shown in Fig. 2, to form . point which can be measured with the same accuracy as the arge end of the wedge.

NEW BRITAIN STACKING TOTE BOXES

Numerous improved features have been incorporated in the Yew Britain stacking tote boxes which are made from No. 16 age steel and electrically welded throughout, no rivets being sed. Handles are made of No. 14 gage stock, folded double nd punched to afford hook hold for dragging the boxes along ле floor. It is believed the size adopted (20 by 12 by 6 inches) rill best meet average requirements, being in length and ca- acity about the limit for comfortable one-man handling. 'he sides slope inward just enough to provide support for the ox above and are folded onto the ends. Yet the deviation f the sides from square is so small that rectangular work can e packed in as conveniently as irregular pieces. A ¾-inch elvage around the edge of the box increases its stiffness.

The ends extend 1 inch above the sides and are folded over nto the selvaged edge of the sides where the latter lap onto ле ends; these raised ends are bent outward sufficiently to ermit the box above to slip between. Spot-welded to the bot- ›m and slightly shorter than the box are two half-round runners. These are carefully beveled on the ends and so placed that, when the box is in the stacking position, they are in contact with the edges of the box below, thus opposing any tendency of the sides to spring in under heavy weights. The upper corners of the ends are cut off at a 45-degree angle, and embossed pieces are spot-welded to the lower corners of the ends parallel with the upper corners and in such a position as to act as guides in bringing the box to the stacking position. These guides, in conjunction with the runners, also serve to prevent any sidewise shifting of the boxes while being trucked.

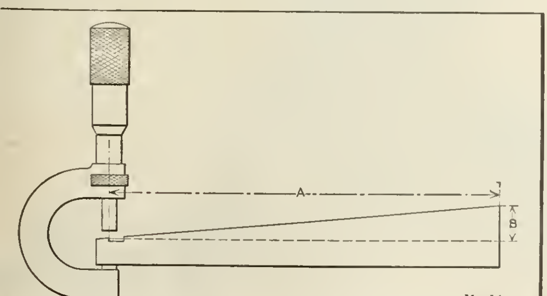


Fig. 2. Method of milling Slot in Small End of Wedge to facilitate measuring

In dragging a box over the floor these runners present only line friction and remove wear and tear from the bottom of the box, thus making for longer life. As a result of this feature, the New Britain stacking box lends itself to storage in racks better than the average, because it will slip into and out of the rack with greater ease. Owing to the small bearing surface and the firmness of the stacking feature, it has been found that a stack of five or six loaded boxes can be dragged along the floor with remarkably slight effort. By reason of the raised ends generous space is provided above the handle for a card holder, in which position it more readily indicates the contents of the box and is less likely to become soiled.

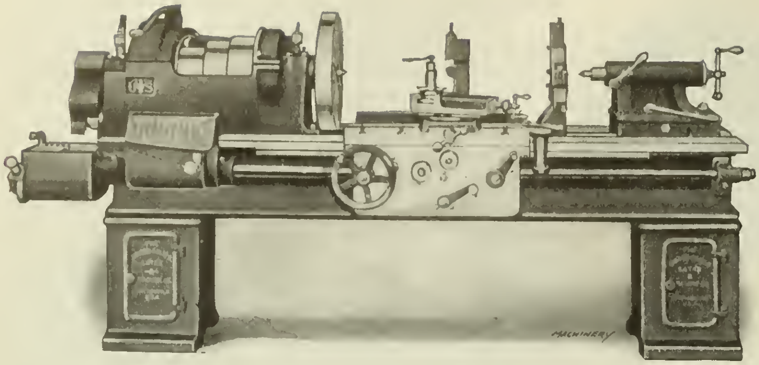
No more care is required to stack these boxes than to nest ordinary nesting boxes, since it is only necessary to bring one box approximately over another and let it drop. The raised

New Britain Stacking Tote Boxes

ends and embossed guides automatically bring it to its proper position. The boxes, when stacked, are securely held and can be trucked any distance over uneven floors without danger. In fact, in order to become unstacked, a box must be jarred or raised up 1 inch; otherwise, it will settle back to its stacking position automatically. As further indicating the security of the stacking feature, a stack of ten boxes can be tilted to an angle of almost 45 degrees before buckling. These boxes are made by the New Britain Machine Co., New Britain, Conn.

UNITED STATES LATHE

In the September number of MACHINERY a description was published of the 20-inch lathe which had just been placed on the market by the United States Lathe & Machine Co., Cincinnati, Ohio. The machine referred to is equipped with a five-step cone pulley and single back-gears. Recently the same firm has brought out the machine shown in the accompanying illustration, which is of similar design except that it is driven by a three-step cone pulley and double back-gears. It will be seen that simplicity of design and strength of all parts are predominant features of this machine, which insure ease of operation and long life. The feature of having the quick-change gears locking downward, which was described in connection with the previous article, has also been applied on the present machine. The general features of construction are the same for both single and double back-geared lathes.

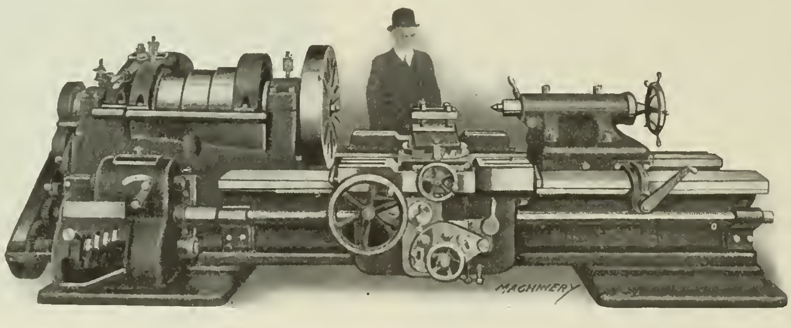


United States Double Back-geared Lathe

The principal dimensions are as follows: swing over bed, 20¾ inches; swing over rest, 12¼ inches; swing over carriage, 14¼ inches; maximum capacity between centers, 56 inches; hole through spindle, 1 9/16 inch diameter; diameter of tailstock spindle, 2⅜ inches; traverse of tailstock spindle, 9 inches; compound rest travel, 4¾ inches; capacity for thread cutting, from 1 to 32 threads per inch; and weight of lathe with eight-foot bed, 4600 pounds.

HOUSTON, STANWOOD & GAMBLE HEAVY-DUTY LATHE

The Houston, Stanwood & Gamble Co., Cincinnati, Ohio, is now building a 30-inch heavy-duty standard engine lathe which is illustrated and described herewith. This machine is driven by a three-step cone pulley and double back-gears which have ratios of 3.55 to 1 and 12.5 to 1. The cone pulley steps are 16.4, 18.2 and 20 inches in diameter by 6⅜ inches wide, and under the usual countershaft speeds of 243 and 129 revolutions per minute, eighteen changes of speed are obtained. These speeds are as follows: 8.3, 10.2, 12.7, 15.7, 19.4, 24, 29.5, 36.3, 45, 55.5, 68.7, 84.6, 105, 129, 159, 196, 243 and 300 revolutions per minute. The range for thread cutting is as follows: 14, 12, 11, 10, 9, 8, 7, 6, 5½, 5, 4½, 4, 3½, 3, 2¾, 2½, 2¼, 2, 1¾, 1½, 1⅜, 1¼, 1⅛ and 1 per inch. The available feeds are as follows: 56, 48, 44, 40, 36, 32, 28, 24, 22, 20, 18, 16, 14, 12, 11, 10, 9, 8, 7, 6, 5½, 5, 4½ and 4 per inch.



Heavy-duty Standard Engine Lathe built by Houston, Stanwood & Gamble

All gears used in this lathe are made of steel and the important bearings are bronze bushed. The front spindle bearing is 8 by 10 inches in size and the rear spindle bearing 4½ by 8 inches in size; a hole 2½ inches in diameter extends through the spindle, and a faceplate 30 inches in diameter is screwed onto the spindle nose. Centers used on this machine are No. 6 Morse taper. The tailstock is of the set-over type to provide for the performance of taper turning operations, and the tailstock spindle is 4¼ inches in diameter and it has a travel of 12 inches. Four bolts provide for clamping the tailstock, and attention is called to the fact that the rear bolts are as accessible as the front bolts. In addition to this method of clamping, the tailstock is held in position by a pawl fitting a rack cast in the bed midway between the vees. The front vee-bearing is of a broad, low-angle type, permitting the use of a gib at the front edge on the under side and affording a guide to the carriage of the same width as the vee. Both headstock and tailstock are carried on the rear vee.

The lead-screw is splined to act as a feed-rod, and the friction is liberally proportioned and controlled by a large handwheel. Double wall construction has been adopted for the apron. In addition to the type illustrated, this lathe can be furnished with a housing covering the entire top of the headstock to support a motor, where individual motor drive is employed; and owing to the increased power provided and the elimination of belt trouble, the use of motor drive is recommended. This lathe swings 30½ inches over the vees and 18¼ inches over the bridge; it is built with any length of bed up to 30 feet, and with a minimum length of bed the machine weighs approximately 18,000 pounds.

LIQUID RHEOSTATIC CONTROL FOR A. C. WOUND-ROTOR MOTORS

The extensive use of electric motor drive for hoists, dredges, and similar applications brought to the fore the necessity for a controller for large wound-rotor induction motors which would give wide and accurate speed variation, positive time limit acceleration, and allow the motor to run at reduced speeds for long periods. To meet these conditions the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., designed the liquid type of control which is illustrated in the accompanying halftone, Fig. 1.

A liquid controller consists essentially of a primary panel and a liquid rheostat. The primary panel is made up of mechanically interlocked magnetic contactors for starting, stopping, and reversing the motor; oil circuit breakers which entirely disconnect the motor from the line in the event of an overload; a fuse knife switch for pump motor; and a low-voltage relay for the protection of the operator and apparatus against voltage failure. The secondary control consists of a

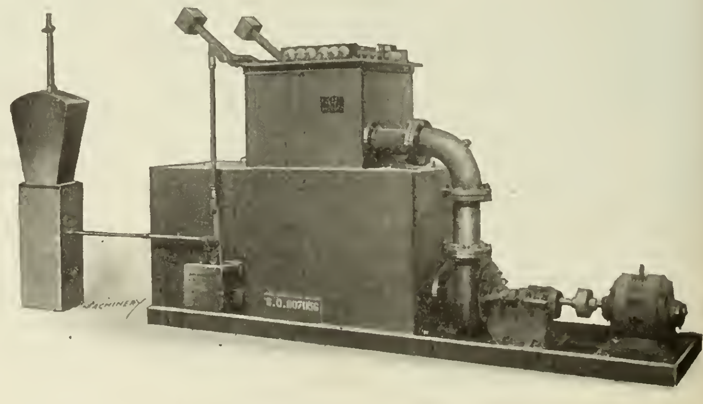


Fig. 1. Westinghouse Liquid Rheostatic Controller for A. C. Wound-rotor Motors

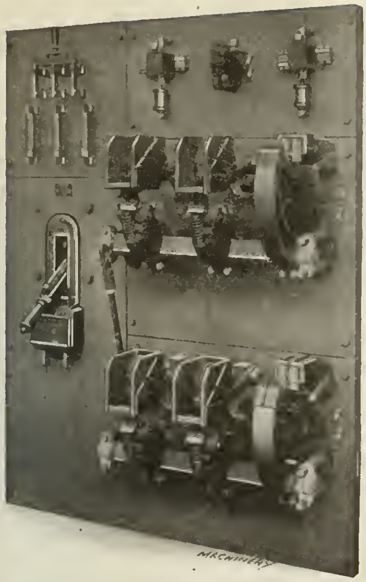


Fig. 2. Switchboard Panel used with Liquid Rheostat

liquid rheostat complete with brass or wrought-iron cooling coils for varying the resistance in the motor secondary, a pump and pump motor switch for the circulation of the electrolyte, and a master switch for the control of the equipment. For plugging service a single lever H-slot device and two overload relays are used. The two overload relays are mounted on the primary panel and protect the motor from overloads when running, but are short-circuited when plugging the motor. When operating under these conditions the circuit breaker is set to protect the motor against exceptional overloads and short circuits on the motor, but too high to trip out in ordinary plugging service.

In the type of control shown, the depth of the liquid in which the electrodes are immersed is varied. This principle insures smooth acceleration and close speed regulation of the motor, as an infinite number of steps can be obtained by gradually varying the depth of the liquid. It eliminates objectionable jerks and sudden strains in both the cable and equipment when starting loads of great inertia. The construction and operation of the control is so simple that even an inexperienced operator can obtain good results, and maintenance costs are low, since the electrodes are practically the only parts requiring renewal, and these infrequently. It is of especial value for heavy-duty reversing service when starting is frequent and the motor is run at reduced speeds. It is furnished for any primary voltage and frequency, and for either two- or three-phase.

As shown in Fig. 3, the three secondary phases of the motor are each connected to a set of electrodes suspended in the electrode tank. The operating lever is attached to an arm just above the master switch; and when the lever is in the "off" position the electrolyte, which is a solution of sodium carbonate (sal soda), is at its lowest level. When the operating lever is moved from the "off" position the contactors in the primary circuit are operated by the master switch and the weir raised. The electrolyte, which is circulated continuously by the pump, rises as the weir is raised; and this immerses the electrodes more, decreases the resistance in the rotor circuit, and speeds up the motor. By adjusting the position of the weir the resistance in the rotor circuit is changed and the speed of the motor regulated.

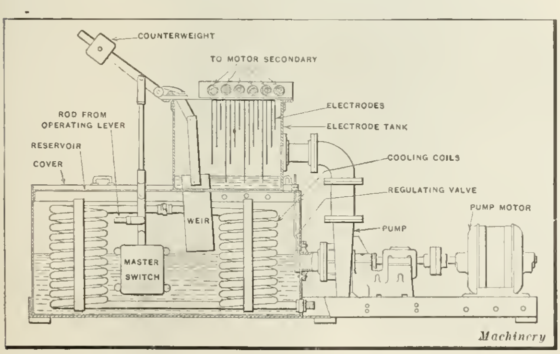


Fig. 3. Arrangement of Component Parts in Westinghouse Rheostatic Control for A. C. Wound-rotor Motors

A regulating valve in the pump discharge or intake pipe prevents the liquid from rising in the electrode tank at a rate greater than that for which the valve is adjusted. So the lever may be moved directly to the "full on" position while the liquid will rise at the rate determined by the valve setting. The weir, however, is of such a size and design that the electrolyte will flow through the lower compartment speedily enough to take care of plugging when that is practiced.

For plugging service the single lever H-slot device and the two overload relays afford a positive protection against the wrong operation of the lever. To prevent over-travel in hoist work, either single- or double-pole limit switches can be furnished; and when the hoists are used for lowering, an over-speed device is desirable. Cam limit switches form another means of protection, safeguarding against accidents due to carelessness on the part of the operator. These consist of a number of switches operated by means of cams mounted on a hexagonal shaft connected to the driving motor or the driven mechanism through a chain and sprocket or through a worm-gear.

MARTIN HAND MARKING MACHINE

The Martin Machine Co., Greenfield, Mass., has recently added to its line of marking machines the No. 6 hand-operated machine shown in the accompanying illustration. This is particularly adapted for use in marking trade names, sizes or patent marks on round or flat surfaces of such tools as drills, taps, dies, etc., and will mark any material in which an impression can be made. Attention is called to the simplicity of the design, which reduces probability of the machine getting out of order. Particular attention has been paid to providing ample strength in the handle and foot-treadle parts to avoid trouble from breakage. The pinion which moves the slide is made of steel and is exceptionally wide to insure strength and durability. Both table and slide are furnished with gibs to afford compensation for wear, and roller bearings are provided on the slide to reduce friction. The travel of the slide is regulated by a stop and screw, and the height of the table is adjusted by means of a screw and nut in order to increase or decrease the depth of marking.

Martin Hand Marking Machine for Drills, Taps, Dies, etc.

If the product to be marked has a flat surface, it is held in a suitable fixture mounted on the table, and by depressing the foot-treadle the table is raised to the desired height. The die held in a holder attached to the slide is then brought into contact with the work by means of a lever which forces the slide across to permit the die to roll the desired impression in the work. After completion of its stroke, the die is returned to the starting point by a spring in back of the holder. When marking round surfaces on taps, drills, etc., a flat die is attached to the slide and the work is allowed to roll on the table as the die comes into contact with it. Adjustments are provided when using round or flat dies so that the proper character on the die comes into contact with the work at a stated point; and screw stops govern the amount of travel after contact has been made, giving a clear cut from beginning

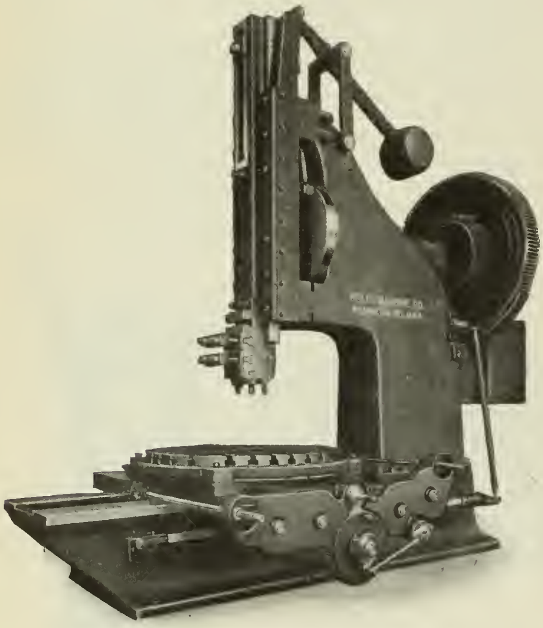
to end of the work. The principal dimensions of this machine are as follows: maximum travel of slide, 6 inches; maximum adjustment of table, 6 inches; floor space occupied, 20 by 20 inches; and weight of machine, 370 pounds.

BETTS CRANK SLOTTER

The Betts Machine Co., Wilmington, Del., has recently completed what is believed to be one of the largest crank-driven slotters ever built in this country, the machine having a maximum stroke of 30¾ inches. This slotter was built for installation at the plant of the Pennsylvania Steel Co., Steelton, Pa., which is a subsidiary of the Bethlehem Steel Co.

The fifteen-horsepower driving motor is bolted to the side of the frame, and in addition to the three to one variable-speed motor drive there are two geared speed changes. The cutter-bar has ten changes of speed and the return stroke is made at an increase of speed of 2¾ to 1. The bar is furnished with a vertically adjusted guide and relief tool apron.

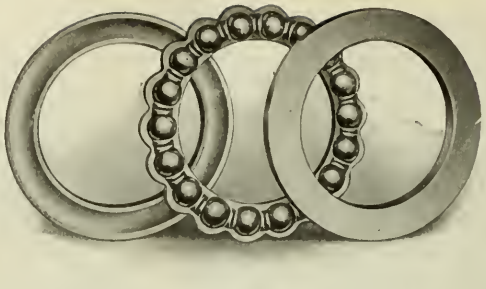
The feeds are positive and self-acting in all directions, the feed motion taking place at the upper end of each stroke. Attention is called to the simplicity of the design and the convenience of operation, all handles, etc., being located so that the operator has full control of the machine from one position where he is able to watch the action of the cutting tool. The compound table has adjustment longitudinally and vertically and supports a revolving table which may be secured in any position by corner clamps. This table is graduated and so arranged that the worm may be disengaged for ready adjustment of the work. The principal dimensions of the machine are as follows: distance from frame to front of cutter-bar, 48 inches; capacity for slotting, to center of 100-inch circle; distance from table to under side of frame, 42 inches; diameter of round table, 54 inches; maximum longitudinal traverse, 64 inches; and maximum transverse traverse, 52 inches.



Crank Slotter with 30¾-inch Stroke built by Betts Machine Co.

ROCHESTER BALL THRUST BEARING

The Rochester Ball Bearing Co., Inc., 203 State St., Rochester, N. Y., has recently placed on the market a line of ball thrust bearings which possess certain individual features of design. Among these may be mentioned the fact that solid brass ball retainers are used, as this company's experience has led to the belief that the greatest strength and durability are obtained with this form of construction. These Rochester ball bearings are usually made with round race grooves, although V-groove bearings are regularly made for use on installations where the speed is high and the service required of bearings relatively light. Thrust bearings for heavy duty are made with the familiar form of self-aligning spherical seat washers. The accompanying illustration shows medium-weight bearings of large size, and in this connection it may be mentioned that retainers of small bearings are not scalloped.



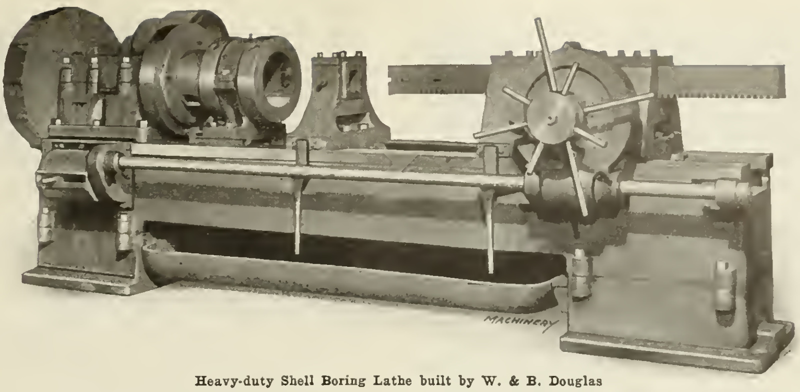
Medium-weight Rochester Ball Thrust Bearing

OTT NO. 1 UNIVERSAL GRINDER

In the February, 1912, number of MACHINERY, mention was made of a No. 1 universal grinding machine which had just been placed on the market at that time by the Modern Tool Co., Erie, Pa. Recently, the Ott Grinder Co., 32 N. Clinton St., Chicago, Ill., has taken over the manufacturing rights on this machine, and before placing it on the market several noteworthy improvements have been made in the design. Among these the following may be mentioned: The swivel table adjusting mechanism has been simplified, allowing the table to be swung around at right angles to handle work for which such a setting is necessary. The design of the tailstock spindle clamping device and the headstock spindle bushing have also been improved. The internal fixture has been somewhat changed, and the work-rests are now provided with both vertical and horizontal adjustment and set-collars for maintaining constant dimensions on duplicate work. The design of the countershaft has also been somewhat simplified.

The principal dimensions of this machine are as follows: normal range, 5 by 16 inches; swing over table without water guards, 4 inches; swing over table water trough, 5½ inches; swivel table graduated to 6 degrees; capacity for grinding

No. 1 Universal Grinding Machine built by Ott Grinder Co.



Heavy-duty Shell Boring Lathe built by W. & B. Douglas

tapers, up to 2½ inches per foot; diameter of wheel spindle, 1 inch; diameter of grinding wheel, 8 inches; face width of grinding wheels, ⅜ and ¾ inch; minimum reduction by power cross-feed, 0.0002 inch; maximum reduction by power cross-feed, 0.004 inch; available work speeds, 133, 178, 254 and 363 revolutions per minute; range of table speeds, from 34.5 to 121 inches per minute; horsepower required to drive machine, 2; floor space occupied, 31 by 68 inches; and net weight, 1400 pounds.

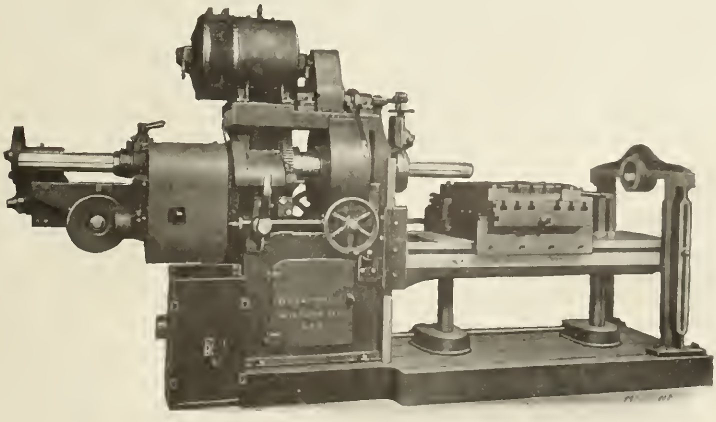
DOUGLAS HEAVY BORING LATHE

In the April number of MACHINERY mention was made of a heavy-duty lathe which had just been placed on the market by W. & B. Douglas, Middletown, Conn. This was a manufacturing machine primarily adapted for turning high-carbon steel forgings at maximum speed. Recently the same firm has introduced a heavy boring lathe for performing internal operations on shells from 8 to 12 inches in diameter. The bed, headstock and change-gear mechanism of both machines are similar, but the boring lathe is equipped with a pot chuck, special tailstock for operating a traversing boring-bar, and a steadyrest for supporting this bar, the arrangement being shown in the accompanying illustration.

The principal dimensions of the Douglas boring lathe are as follows: length of bed, 13 feet; swing over ways, 26½ inches; diameter of spindle, 6 inches; diameter of hole through spindle, 2 inches; dimensions of boring-bar, 5½ inches square by 74 inches long; maximum travel of boring-bar, 58 inches; maximum distance from faceplate to face of tailstock, 90 inches; maximum distance from faceplate to face of steadyrest, 81 inches; available feeds per revolution of spindle, 1/64, 1/32, 1/16 and 1/8 inch; ratio of gearing, 20 to 1; and size of cone pulley steps, 15 and 18 inches in diameter by 8 inches face width.

BETTS HORIZONTAL BORING, DRILLING AND THREADING MACHINE

The Betts Machine Co., Wilmington, Del., has recently completed a combination horizontal boring, drilling and threading machine for use on the U. S. S. *Dixie*. The machine is arranged with General Electric variable-speed motor drive, giving speeds from 7 to 260 revolutions per minute. The spindle is made of steel and is 3½ inches in diameter; it has a regular movement of 24 inches, and provision may be made for a traverse of 48 inches when required. Quick movement by hand is provided through a rack and pinion. The spindle may be driven in either direction and has a full bearing at all times through the cast-iron sleeve. The feeds are automatic, and six changes of feed are provided through gearing, covering a range from 1/128 to 9/32 inch per revolution; the spindle may be fed in either direction without reversing its rotation. It will be seen that the machine is equipped with a compound table, the bottom table being 6 feet long and elevated by two screws, worm-wheels and worms which are driven by power. This table carries a saddle which has a movement parallel to the main spindle. The saddle carries a cross table 24 by 36 inches in size, which also has a horizontal movement at right angles to the spindle. These tables can be lowered until the top table is 25 inches from the center of the spindle, and by removing the upper tables, which are 6¼ inches thick, this distance is increased to 31¼ inches. In addition, a circular table may be provided, as shown in the illustration, for handling work where it is necessary to bore holes at different angles without resetting. The circular table is graduated through a full circle and may be moved by hand to any required angle. This table rests on top of the rectangular table, to which it is secured by corner clamps.


Combination Boring, Drilling and Threading Machine built by Betts Machine Co.

For machining both ends of a casting at one time, an extra or right-hand facing head may be provided which can be arranged to clamp on a boring-bar or to fit a hole in the steadyrest yoke. The illustration shows a machine which is equipped with a threading attachment arranged to give suitable feeds to the boring spindle so that threads of different pitch can be cut in pump valve seats and similar work after it has been bored. Threading is done with a tool of the chaser type. For milling, a power feed mechanism can be provided for the top rectangular table and also for the circular table. The illustration shows a machine equipped with electric motor drive, but the same type of machine is also built for cone pulley drive.

READY ELECTRICALLY WELDED TOOLS

The Ready Tool Co., 550 Iranistan Ave., Bridgeport, Conn., is now manufacturing a line of arc- and butt-welded tools in which a cutter of either stellite or high-speed steel is electrically welded to a machine steel shank. This enables all of the cutter to be used up—a condition of exceptional importance at this time when the cost of these materials is so far above normal. In Fig. 1 the tools have stellite cutters, and in the case of the upper tool shown in this illustration particular attention is called to the fact that the stellite is welded onto the shank at such an angle that both front and side clearance is provided. This is an important matter, because stellite is made as a casting, and in sharpening the tool it is merely necessary to grind

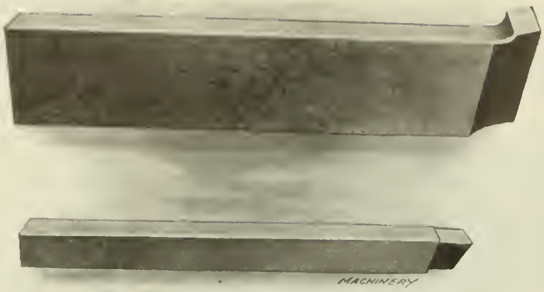


Fig. 1. Ready Tools with Stellite Cutters arc- and butt-welded to Machine Steel Shanks

the top face, thus leaving the surface metal intact on the sides, experience having shown this to be considerably harder than the interior metal. Also the cut is made with the grain of the stellite, which is an important feature, because the material is stronger with than across the grain. The shank is machined with a projection at the front that forms a base upon which the stellite cutter is supported in addition to being welded to the shank, thus insuring a full support right under the nose of the tool. The lower tool shown in Fig. 1 has the stellite butt-welded to the shank.

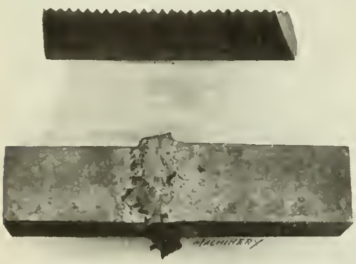


Fig. 2. Tool-holder Cutter with High-speed Steel butt-welded to Machine Steel

Fig. 2 illustrates the way in which high-speed steel is butt-welded to machine steel in order to form a tool-holder cutter that will allow all the high-speed steel or stellite to be utilized. Stellite could not be used in this butt-welded form, and if it is desired to use it, a section must be arc-welded to the front of the cutter by the new process. In all cases, the welding of either high-speed steel or stellite is so perfectly done that the joint shows a complete fusion; and the welding is done so rapidly that it is claimed the high-speed steel cutters are not heated sufficiently to affect the results obtained by the heat-treatment. In addition to the straight forms of tools shown, off-sets of all shapes, and also—what is very desirable—cutting-off blades with stellite tips are being made by the company for handling work on lathes, boring mills and screw machines.

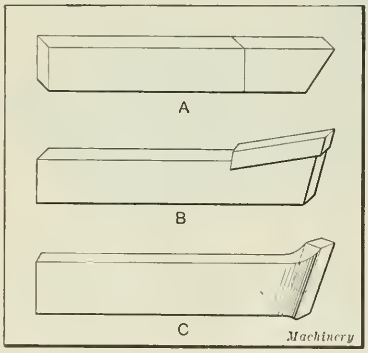


Fig. 3. A, Butt-welded Tool; B and C, Arc-welded Tools

"NASITRA" MARKING FLUID

The Artisan Chemical Supply Co., Box 395, Detroit, Mich., is now manufacturing a fluid compound known as "Nasitra" for use in marking metal products. "Nasitra" is especially adapted for marking products made of those grades of steel commonly used in the manufacture of tape measures, gages, scales, etc. It is used without requiring the metal to be first coated with paraffin, wax or soap, the only requirement being that the surface of the metal to be marked must be perfectly clean. Then the fluid is applied with a pen or sharpened piece of wood. Manufacturers who have a large number of carbon or high-speed steel products to mark should find this compound very useful.

Tool marked with "Nasitra"

CORRECTION OF WEIGHT, BAKER DRILLING MACHINE

A misleading statement appeared at the conclusion of the description of the Baker heavy-duty drilling and boring machine in the October number, as regards the weight. The weight of the three assembled machines with a common floor plate, as illustrated, is 66,000 pounds. The weight of 18,000 pounds given was the estimated weight of a single-spindle machine.

NEW MACHINERY AND TOOLS NOTES

Adjustable Male Gage: Nils E. Larson, Chicago, Ill. An adjustable male gage which has the body made of steel and adjustment of the measuring points provided by means of a wedge actuated by a knurled nut.

Sine Bar: Model Tool & Gage Co., 187 John St., Bridgeport, Conn. A tool known as the "Simplex" sine bar which can be used in conjunction with a table of natural sines and cosines for the accurate determination of angles. It measures 5 inches from center to center of the disks and forms a useful addition to the toolmaker's kit.

Combination Drawing Tool: Two Rivers Drawing Tools Co., Two Rivers, Wis. A combination drawing instrument designed to save time in laying out hexagonal and other forms in the use of the isometric system. The instrument can be quickly handled and covers a wider range than would be thought to be the case before the draftsman has had experience in its use.

File Handle: Strong-Hold Mfg. Co., 307 Arch St., Philadelphia, Pa. A wooden handle of ordinary form which is drilled to receive the file tang. Two saw slots crossing each other at right angles pass axially through the tang hole. The ferrule is in the shape of a helical spring; and when it is driven into the handle, it closes the slots and gives an elastic grip on the file tang.

Precision Square: Simplex Tool Co., Woonsocket, R. I. A square made of hardened steel and accurately ground to a fine edge on two sides and flat on opposite sides. The fine edges in contact with the work are claimed to enable the detection of an error less than 0.0001 inch in 3 inches. Holes are provided in the square to afford an efficient finger grip for every method of applying the square to the work.

Patternmakers' Bench Planer: J. D. Wallace, 527 Van Buren St., Chicago, Ill. A small bench machine adapted to meet the requirements of patternmakers and other woodworkers. It will take heavy cuts in hard wood as well as soft, and the finish produced is entirely free from knife marks. A guard provides for the protection of the operator; and the planer is driven by a motor that takes power from an ordinary lamp socket.

Offset Boring Head: Reliance Tool Co., 134 Eliot St., Boston, Mass. This boring head consists of two essential parts, which are two eccentric bushings, one within the other. The hole in the outer bushing is bored 0.050 inch off center, and the hole in the inner bushing which supports the cutter-bar is also off center. By adjusting these two bushings in relation to the center, the required amount of offset may be obtained.

Oilstone Grinder: Oliver Machinery Co., Coldbrook and Clancy Sts., Grand Rapids, Mich. An oilstone grinder developed for use in quickly sharpening all kinds of knives and tools. Two grades of oilstones are provided, one for rapid abrasion and the other for putting a keen edge on the tool. Kerosene oil is used on the wheels and is liberally applied, a special device being provided which prevents the oil from being thrown by centrifugal force.

Sensitive Drilling Machine: Cincinnati Pulley Machinery Co., Covington, Ky. A machine with a base 24 by 26 inches in size in which T-slots are cut to provide for holding heavy castings; and in addition, the machine has a round table 24

inches in diameter that can be swung out of the way when the lower base is used. The maximum distance from spindle to round table is 18 inches, and the maximum distance from spindle to lower base is 42½ inches.

Quenching Machine: U. S. Electro-Galvanizing Co., 1 Park Ave., Brooklyn, N. Y. A machine that enables hardening, pickling, cleaning and drying of shells to be performed continuously. In operation, the shells come from the furnace at a red heat and are dumped into a perforated receiving tank which is partially immersed in water so that the shells are quenched. They then pass on through successive tanks and compartments in which are performed the other operations.

Hand Screw Machine: Stenotype Co., Indianapolis, Ind. A turret hand screw machine fitted with a three-step cone pulley, which is covered by a guard that serves the additional purpose of forming a well and tying the front and rear spindle bearings together. The headstock is cast integral with the bed, and a cut-off slide is provided with gibbed bearings. This machine swings 13½ inches over the bed and 6 inches over the cut-off slide; the capacity is for handling bar stock up to 1 inch in diameter.

Air-operated Hammer: Buffalo Foundry & Machine Co., Buffalo, N. Y. A steam forging hammer arranged to be driven by compressed air. The compressor used in connection with this hammer can be equipped for plain belt drive direct from an individual motor that forms part of the compressor equipment. The receiver tank can be placed in either a vertical or horizontal position at any convenient location near the hammer and compressor, according to the requirements of individual cases.

Band Grinder: Victor Machine Co., Albany, N. Y. An abrasive band grinder for use in the performance of surface grinding operations. The abrasive band is jointless and is drawn over the table by the main driving pulley. A band tension pulley takes up slack, and quadrants are provided for adjusting the pulley centers to allow for unequal stretch in the band. The band may be rapidly put on the machine or removed without requiring the aid of tools. This machine is built for the Selson Engineering Co. of New York City.

Cutting-off Machine: Etna Machine Co., Toledo, Ohio. A machine adapted for cutting off solid or tubular stock up to 6 inches in diameter. It is equipped with a geared head which provides four changes of spindle speed, and the machine is adapted for operation at from 100 to 110 feet per minute cutting speed of the tool. Drive is provided by either a constant-speed motor or by a single pulley and belt from the lineshaft; and control is furnished by a friction clutch having a lever located within easy reach of the operator.

Geared Speed Reducer: Foote Bros. Gear & Machine Co., Chicago, Ill. An equipment known as the IXL speed transformer which is adapted for machine tool application, and was especially designed for use in places where dust and grit are likely to cause trouble. The reducer is of the double differential type in which the first part is non-planetary and the second section planetary. It is claimed that this mechanism eliminates the objectionable feature of having the first set of idlers fastened to a flat plate and rotating on the high-speed shaft.

Hand Screw Machine: Turner Machine Co., Danbury, Conn. A hand screw machine in which the spindle is mounted in phosphor-bronze lined bearings which are grooved and provided with sight-feed oil cups. The stock feed is operated by a conveniently placed lever; and the cut-off rest is fitted with a locating clamp furnished with an adjustable stop and screws, and equipped with a rack and pinion operating lever. The two toolposts have step wedges to provide adjustment for height. This machine was built for the Macnab Machinery Co. of New York City.

Air-operated Arbor Press: Haniffin Mfg. Co., Chicago, Ill. An air-operated machine intended to increase production and eliminate fatigue caused by performing heavy pressing operations by hand. The downward stroke is steady, while the upward stroke is made at fast speed. The arbor has a stop collar which enables the downward stroke to be set to a definite stop, so that duplicate operations can be performed semiautomatically. The press is made in two sizes; the No. 1 has a maximum capacity from base to arbor of 16 inches, and the No. 2 has a maximum capacity from base to arbor of 23 inches.

Lathe Milling and Grinding Attachment: Edward N. Moor, 765 Kingston Ave., Oakland, Cal. A universal milling and grinding attachment which is capable of handling all classes of work that can be done on centers or on the faceplate of a lathe. The device is attached by a bolt passing through its column to the carriage, or to the compound or plain cross-slide; and the interchanging of spindles for grinding or milling is accomplished by releasing and tightening two nuts on the sleeve. The attachment may be used to the right or left, in front or behind the column, and at any elevation or angle, so that it is fully universal.

Hacksaw Blade Grinding Machine: Wardwell Mfg Co., Cleveland, Ohio. In the July, 1914, number of MACHINERY a description was published of a model A-2 hacksaw blade sharpening machine of this company's manufacture. The present model H machine is of very similar design, being adapted for sharpening the blades of power hacksaw machines. This grinder is automatic in operation and saws can be fed through at the rate of sixty-five teeth per minute. This means that from fourteen to eighteen blades 18 inches in length can be resharpened in an hour; and the adjustment is so perfect that as little as 0.0005 inch can be removed from the teeth.

Cold Saw: Newton Machine Tool Works, Inc., Philadelphia, Pa. A small sized cold saw adapted for handling round stock up to 5½ inches in diameter. In many respects the design of this machine is similar to that of previous types of cold saws built by this company; the present machine is provided with geared feed in place of friction feed. This cold saw is of the spindle-driven type, the spindle revolving in capped bearings and being driven by spur gears which receive power from a worm and worm-wheel. The worm is fitted with a roller thrust bearing and the worm-wheel is made of solid bronze. The saw blade is 20 inches in diameter and may be of either the solid or inserted-tooth type.

Disk Grinder: Pioneer Dustless Disk Co., Syracuse, N. Y. A motor-driven disk grinder especially adapted for use in wood and metal pattern shops, although it could be used with satisfaction on many other classes of disk grinding. The most noteworthy feature of the machine is the provision of a self-contained vacuum dust removing system which collects dust as fast as it is formed and carries it away from the machine through an exhaust pipe into a sack or out of the window. The back of the disk is made in the shape of a fan, and a guard encloses the whole back of the disk and lower portions of the front part of the disk, thus forming a complete exhaust system so that there is practically no dust permitted to accumulate on the work.

Horizontal Rail Drilling Machine: Newton Machine Tool Works, Philadelphia, Pa. A five-spindle horizontal rail drilling machine which was designed to provide for drilling holes on close centers and to afford ample driving power. The machine is furnished with a two-spindle head and a three-spindle head; the position of the center spindle in the three-spindle head is fixed, and the two outside spindles are adjustable by means of an operating screw; both spindles in the two-spindle head can be located within one inch of the center line of the fixed spindle in the three-spindle head, thus making possible the drilling of holes within one-inch center distance from each other. The range of spindle adjustment on the three-spindle head is from 4 to 10½ inches between centers. On the two-spindle head the range of adjustment is from 4 to 19 inches between centers.

* * *

N. M. T. B. A. CONVENTION

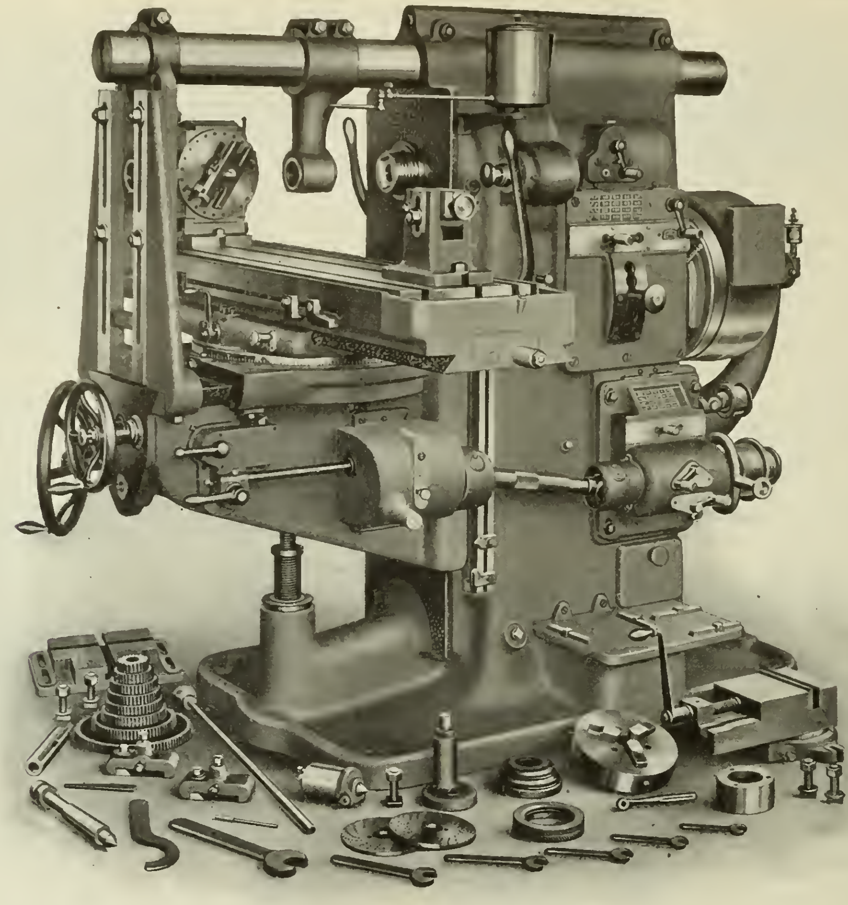
Continued from page 261.

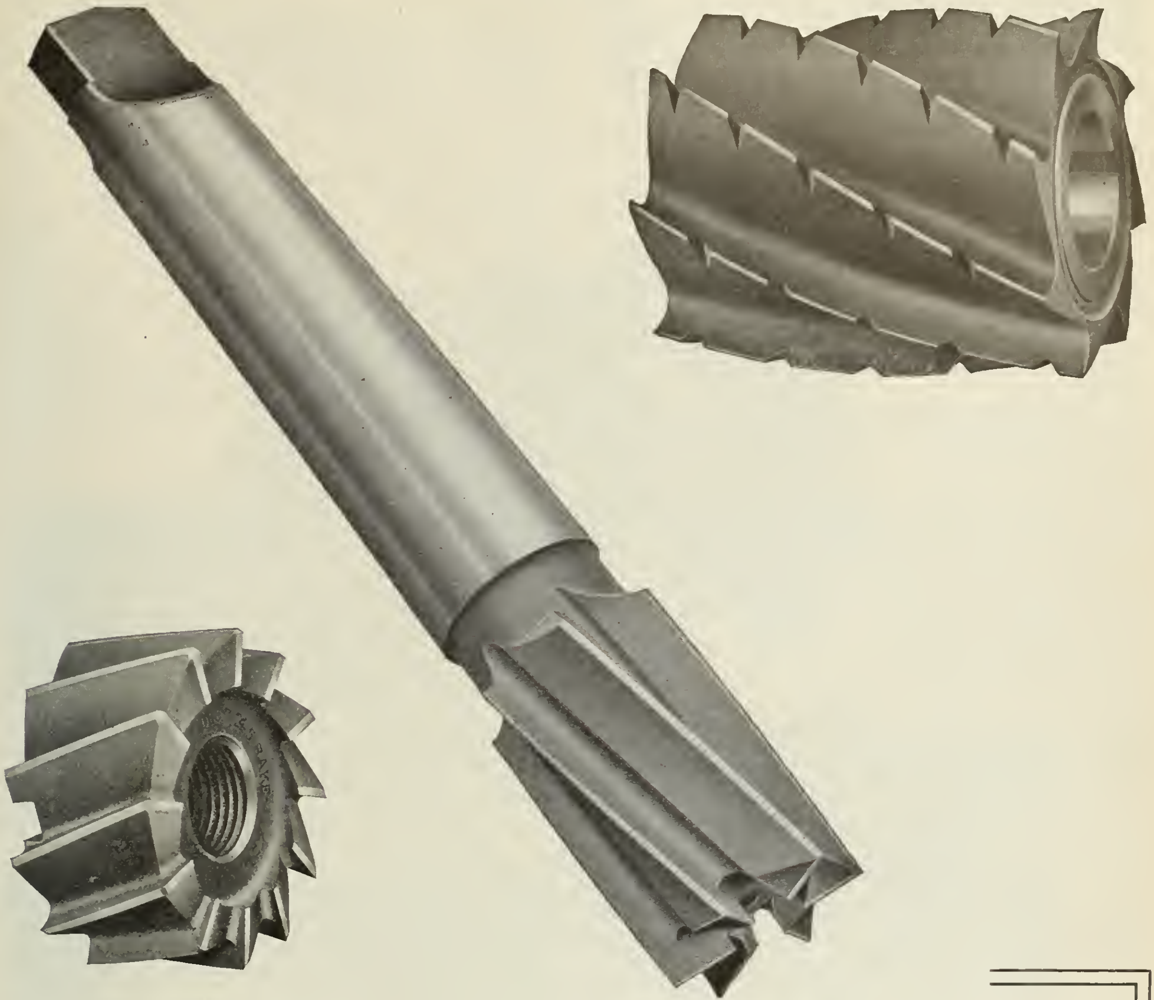
Frank F. Dresser of Worcester, Mass., counsel for the American Steel & Wire Co., delivered a scholarly and exhaustive address on health insurance, in which he reviewed the proposed health compensation or insurance law of twenty-two states and pointed out some of the difficulties and dangers attending the establishment of compulsory health insurance, quoting from the experience of Germany, Great Britain and other countries. Mr. Dresser advocated sickness prevention as being preferable to health insurance, both as regards the welfare of the worker and the welfare and prosperity of the employer and community as a whole.

On Tuesday afternoon and the following forenoon the time of the members was given over mainly to committee meetings on lathes, gear-cutting machines, boring machines, grinding machines, hand screw machines, planing machines, milling machines, shaping machines, vertical drilling machines, turret lathes and radial drilling machines. The committee meetings Wednesday forenoon were suspended to hear a talk by Alexander Luchars, publisher of MACHINERY, on machine tool conditions observed in Europe during his visit to Great Britain, France, Italy and Switzerland last summer.

Wednesday afternoon James A. Emery of the National Association of Manufacturers, Washington, D. C., addressed the convention on the subject "Industry and Politics." He pointed out the danger of rising labor costs and decreasing labor efficiency that will confront American manufacturers in the competitive struggle for world-trade which will inevitably follow the close of the war.

The officers of the association were re-elected as follows: J. B. Doan, president; D. M. Wright, first vice-president; A. H. Tuechter, second vice-president; C. S. Taylor, secretary; A. E. Newton, treasurer. The spring convention will be held at Cincinnati, Ohio, May 21 and 22.





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PERSONALS

Carl L. Svensen has opened an evening school of drafting under the name of the Ohio Technical Drawing School, in Columbus, Ohio.

G. F. Oliver, for the past year on the engineering staff of the Hopkins & Allen Arms Co. of Norwich, Conn., has been appointed night superintendent of the plant.

P. W. Gilbert, assistant sales manager of the Standard Welding Co., Cleveland, Ohio, for the past five years, has been made sales manager following the resignation of H. A. Flagg.

Benton G. L. Dodge, who for some years has had charge of the advertising and publicity work of the Standard Welding Co., Cleveland, Ohio, has been made manager of sales promotion.

B. D. Gray, manager of the Hess-Bright Mfg. Co., Philadelphia, Pa., has been elected president, succeeding F. E. Bright. Mr. Bright will continue to act as chairman of the board of directors.

H. W. Dow has been made sales manager of the Nordberg Mfg. Co., Milwaukee, Wis. Mr. Dow has been associated with the company in the engineering and sales departments for the past twelve years.

Walter C. Voss, formerly in charge of the Cleveland district of the Standard Welding Co., Cleveland, Ohio, has been put in charge jointly with Ted Palmer of the Detroit office, following the resignation of Charles E. Miller.

William R. King, formerly of the E. S. Jackman Co., agent in the Pittsburg territory for the Firth-Sterling Steel Co., has become associated with William K. Stamets, machine tool dealer, Jenkins Arcade Bldg., Pittsburg, Pa.

B. M. W. Hanson, vice-president and works manager of the Pratt & Whitney Co., Hartford, Conn., has been appointed member of the board appointed by Secretary Baker of the war department to investigate the machine gun situation.

James Cran, a well-known contributor to MACHINERY on forge work and kindred topics, has taken a position with the De Laval Separator Co., Poughkeepsie, N. Y., where he will have charge of the forging and heat-treating departments.

Donald Baker, assistant superintendent, Liberty Fuse & Arms Corporation, Long Island City, N. Y., and a contributor to MACHINERY, has resigned his position to become tool-room foreman of the Williams Mfg. Co., Ltd., Montreal, Canada.

B. A. Quayle, who for years has had charge of the Chicago office of the Standard Welding Co., Cleveland, Ohio, and who was one of the first salesmen employed by the company, has been made general representative, with headquarters at Cleveland.

Sven Wingquist of Gothenburg, Sweden, inventor of the S. K. F. ball bearing, visited the new American factory of the S. K. F. Ball Bearing Co. at Hartford, Conn., in September. Mr. Wingquist is president of the Swedish company and trustee of the American company.

P. H. Reardon has resigned his position as president of the General Machinery & Supply Co., San Francisco, Cal., having disposed of his interest to his associates. Joseph A. Buckley succeeds Mr. Reardon as president. A. L. Green is vice-president and H. F. Jurs, manager.

Thomas Crowther of T. Crowther & Co., 170 Oliver St., Boston, Mass., machinery merchants, has sold out his interest in the company, and has started another business in the same line, which will be known as the Thomas Crowther Co. The address of the new concern is 19 Pearl St., Room 24, Boston, Mass.

OBITUARIES

Frederick W. Hoefer, president of the Hoefer Mfg. Co., Freeport, Ill., died September 28, aged sixty-two years.

James H. Anthony, for many years employed by the Brown & Sharpe Mfg. Co., Providence, R. I., died at his home in Providence, October 7, aged seventy-six years.

E. W. Tucker, traveling engineer salesman for the Allis-Chalmers Mfg. Co., Milwaukee, Wis., and formerly with the E. P. Allis Reliance Works, died October 5, following a long illness, aged sixty-seven years. He was born in Milwaukee and enlisted during the Civil War, serving until its close, when he followed the profession of a civil engineer for a time. He later became associated with the E. P. Allis Reliance Works, and was a confidential co-laborer with the late Edwin Reynolds. Mr. Tucker was a large-hearted man, having many friends in the organization and in the engineering field; he traveled over the country—from Maine to California—and was well known. He leaves a widow and one daughter.

Samuel N. Trump, president of the Trump Bros. Machine Co., Milwaukee, Wis., died at his home in Wilmington, Del., October 5; the following day he would have been eighty-one years old. Although born in Baltimore, he began his manufacturing career in Port Chester, N. Y., where he joined his brother, C. Newbold Trump, who was engaged in the manufacture of machinery. In 1873, the two brothers and Christian Frederick moved from Port Chester to Wilmington, Del., where they started the establishment that six years later was organized as the Trump Bros. Machine Co., with C. Newbold Trump as president, Samuel N. Trump, vice-president, and Christian Frederick, superintendent. After the death of C. Newbold Trump, in 1912, Samuel Trump was elected president, George R. Hoffecker, vice-president and treasurer, Christian Frederick, general manager and secretary, and William Frederick, superintendent, which is the present organization. Mr. Trump, however, had not taken a very active part in the management for several years, having practically retired from business about ten years ago. Mr. Trump was a director of the Wilmington Trust Co., and for some time was president and general manager of the Arnoux Electric Co., the predecessor of the Wilmington Electric Co., and was largely responsible for its development. He was also at one time a member of the board of education, and it was largely through his influence that the manual training system was introduced into the schools of Wilmington. He is survived by a widow, four sons, and two daughters.

ROBERT C. McKINNEY

Col. Robert C. McKinney, chairman of the board of directors of the Niles-Bement-Pond Co., died at his home in Belle Haven, Conn., October 3, aged sixty-four years, after an illness of more than two years, the result of a nervous breakdown. He was born in Troy, N. Y., at a time when that community was especially distinguished by manufacturing interests associated with machinery, stoves and ranges, and other iron and steel products. His father, Robert McKinney, appears to have been identified there with certain lines of hardware manufacture, and in 1861 he became a member of a firm of hardware manufacturers in Cincinnati, Ohio, to which city he therefore moved. Later, two of his sons established a manufacturing company at Hamilton, Ohio, so that young McKinney early acquired a knowledge of the business of manufacturing. Robert C. McKinney was educated in the grammar and high schools of Cincinnati, graduating from the latter when eighteen years of age. Having a strong bent for mechanics, he entered the mechanical engineering department of Cornell University in the early seventies. After leaving the university, he was

Col. Robert C. McKinney

employed in the drafting-room and office of Cope & Maxwell, manufacturers of steam pumping machinery in Hamilton. The plant, business, and machinery of this firm he later purchased, when the International Steam Pump Co. was formed. At this time Hamilton had already gained considerable distinction as a manufacturing center and a producer of machine tools. In 1877 Mr. McKinney became associated with the Niles Tool Works, which was then one of the most important builders in the United States west of Philadelphia. Two years later he was made secretary of the company and a short time afterward treasurer and general manager. In this position he showed marked ability as an organizer and mechanical engineer, and a thorough knowledge of manufacturing. Later in life he was recognized throughout the nation as one of the foremost organizers of big business. So well did he fill the positions of treasurer and general manager, that though the country was just recovering from the effects of the panic of 1873, the business grew so rapidly that it became necessary to reorganize and increase the capital to $2,000,000. It was during this period that he gained the title of Colonel by service on the staff of Governor Bushnell of Ohio. The first step in the formation of the Niles-Bement-Pond Co. was taken, in 1898, by purchasing the Pond Machine Tool Works, of Plainfield, N. J. The purchase of the Bement-Niles Co. of Philadelphia, and the Philadelphia Engineering Works soon afterward, was followed by the organization of the combination in 1899. This company is now one of the largest in the world and produces machine tools for all purposes, electric traveling cranes, small tools, rifle-making machinery, etc. It has since acquired the Pratt & Whitney Co. of Hartford, Conn., the John Bertram Co. of Dundas, Ontario, and the Ridgway Machine Co. of Ridgway, Pa. Col. McKinney always took an active interest in the civic and religious life of his city, but refused to seek an election as Congressman from a desire to devote all his energies to the business he had so active a part in building up. He was a member of several clubs, the American Society of Mechanical Engineers, and the Machinery Club of New York, of which he was at one time president. He is survived by his wife and a daughter, Mrs. Sanford Ethrington, of New York.

COMING EVENTS

November 15-18.—Annual meeting of the Electric Power Club at Hot Springs, Va. Homestead Hotel, headquarters. C. H. Roth, secretary-treasurer,, 1440 W. Adams St., Chicago.

November 16-18.—Open conference of the Efficiency Society in New York City. Willis B. Richards, chairman, and M. L. Havey, secretary, 52 Broadway, New York City.

November 30.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St. E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

December 5-8.—Annual meeting of the American Society of Mechanical Engineers in New York City. Engineering Societies' Bldg., 29 W. 39th St., headquarters. Calvin W. Rice, secretary.

January 6-13.—National Automobile Show in Grand Central Palace, New York City.

SOCIETIES, SCHOOLS AND COLLEGES

Engineering Society of Buffalo, Buffalo, N. Y. Program of the meetings for the season, comprising papers on motion study, aeronautics, graphite, four-cylinder engines, highway bridge floors, non-ferrous alloys, pure science applied to engineering, standardization, industrial education and apprenticeship. W. J. Gamble, 247 Rano St., Buffalo, N. Y., is the secretary.

Ohio Technical Drawing School, 1348½ N. High St., Columbus, Ohio, was opened October 3 by Carl L. Svensen. The school offers an evening course in drafting, and its purpose is to furnish an opportunity for draftsmen, machinists, patternmakers, molders and others engaged in mechanical lines to study drawing as a means to increase their value and obtain better pay. The addition of courses in mechanism, mechanics, strength of materials, and machine design is planned in the near future. Catalogues and blueprints are requested from manufacturers.

NEW BOOKS AND PAMPHLETS

A System of Accounts for Retail Merchants. 19 pages, 6 by 9 inches. Published by the Federal Trade Commission, Washington, D. C.

Health Conservation at Steel Mills. By J. A. Watkins. 36 pages, 6 by 9 inches. Published by the Department of the Interior, Bureau of Mines, Washington, D. C., as Technical Paper No. 102.

Specific Gravity Studies of Illinois Coal. By Merle L. Nebel. 49 pages, 6 by 9 inches. Illustrated. Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill., as Bulletin No. 89. Price, 30 cents.

International System of Electric and Magnetic Units. By J. H. Dellinger. 32 pages, 6 by 9 inches. Published by the Department of Commerce, Washington, D. C., as Scientific Paper of the Bureau of Standards No. 292.

Dry Preparation of Bituminous Coal at Illinois Mines. By E. A. Holbrook. 133 pages, 6 by 9 inches. Illustrated. Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill. Price, 70 cents.

Automobilist's Pocket Companion and Expense Record. By Victor W. Page. 169 pages, 5 by 7½ inches. Published by Norman W. Henley Publishing Co., New York City. Price, $1.

This book contains blank forms for the keeping of expense accounts by motor car owners. About thirty-five pages are devoted to useful information for motorists on lubricating oil, care of storage batteries, tires, road troubles, etc.

The Model T Ford Car. By Victor W. Page. 300 pages, 5 by 7 inches. Illustrated. Published by Norman W. Henley Publishing Co., New York City. Price, $1.

This is the 1917 edition of a book for owners of Ford automobiles. It treats of the construction, operation and repair of Ford cars in a non-technical but thorough manner. Over 100 especially made drawings and photographs are used to illustrate the text.

How to Make Low-pressure Transformers. By F. E. Austin. 22 pages, 4½ by 7¼ inches. Illustrated. Published by Prof. F. E. Austin, Hanover, N. H. Price, 40 cents.

The increasing popularity of this book has made a third edition necessary. The additional matter in the new edition covers a simple form of core construction, instructions to amateurs for making a core for a small transformer without disks, and the utilization of discarded tin cans as transformer cores.

Electric Units and Standards. 68 pages, 6 by 9 inches. Published by the Department of Commerce, Washington, D. C., as Circular of the Bureau of Standards No. 60. Price, 15 cents.

The publication gives comprehensive and up-to-date information regarding the units and standards in terms of which electric and magnetic measurements are made. It includes the history of the units and the evolution of the definitions upon which the laws on electrical standards are based. The laws of this and other countries are given.

Examples in Alternating Currents. Vol. I. By Prof. F. E. Austin. 223 pages, 5 by 7½ inches. Illustrated. Published by Prof. F. E. Austin, Hanover, N. H. Price, $2.40.

This work, previously noted in MACHINERY, has passed into the second edition and new matter has been added. The success of the work made the publication of the second edition necessary. While not designed for a textbook, it is being used as such by students of electrical science. The title expresses the nature of the work clearly, it being devoted to a demonstration of the principles of alternating currents by the use of many well-chosen examples.

Electric Motors—Direct and Alternating. By David P. Moreton. 241 pages, 4¼ by 6½ inches. Illustrated. Published by Frederick J. Drake & Co., Chicago, Ill.

This book is of a convenient pocket size, and is intended for the practical man. It deals with the fundamental principles of electrical and magnetic circuits in the first three chapters. Chapter four treats of the common methods of measuring current, pressure, resistance, and power, and chapters five and nine are devoted to armature windings for both direct- and alternating-current motors. Chapters six, seven and eight are devoted to the different types of direct-current motors, and chapters ten, eleven and twelve treat of the different types of alternating-current motors.

Handbook of Machine Shop Electricity. By C. E. Clewell. 461 pages, 4 by 6¾ inches. Illustrated. Published by McGraw-Hill Book Co., Inc., New York City. Price, $3 net.

This book was written to supply the need for a convenient electrical reference book adapted to the machine shop. The contents are grouped under ten main headings, as follows: Abbreviations, Terminology and Units; Circuits; Costs; Communication and Distant Control; Current Supply, Generators and Transformers; Electrochemical, Soldering and Welding Applications; Heating and Magnetic Apparatus; Lamps and Shop Lighting; Measuring Instruments and Measurements; Motors and Applications. The book is printed on thin paper and bound in flexible cloth, to make it of convenient thickness and form to carry in the pocket for ready reference.

Hendricks' Commercial Register of the United States. 1890 pages, 7½ by 10 inches. Published by S. E. Hendricks Co., Inc., New York City. Price, $10.

The twenty-fifth annual edition of Hendricks' Commercial Register of the United States for buyers and sellers, which has just been issued, rounds out a quarter of a century of usefulness for this well-known publication. The work is especially devoted to the interests of the architectural, contracting, electrical, engineering, hardware, iron, mechanical, mill, mining, quarrying, railroad, steel and kindred industries. It contains about 350,000 names and addresses, with upward of 45,000 business classifications. Lists are included of producers, manufacturers, dealers and consumers, listing all products from the raw material to the finished article, together with the concerns handling these products from the producer to the consumer. An indication of the scope of the work is the fact that the index alone contains 149 pages, covering over 50,000 trade references. A new feature is the listing of trade-names, brands, titles of identification, etc., to which 202 pages are given. This section, printed on pink paper, furnishes ready reference for purchasing agents and prospective buyers to distinctive products manufactured by the firms listed.

Modern Shop Practice. Editor-in-chief, Howard M. Raymond. In six volumes. Vol. I, 345 pages; Vol. II, 375 pages; Vol. III, 347 pages; Vol. IV, 327 pages; Vol. V, 365 pages; Vol. VI, 377 pages. Page size, 5½ by 8 inches. Published by the American Technical Society, Chicago, Ill. Price of set, $15.80.

A general reference work on machine shop practice and management, productive manufacturing, metallurgy, welding, toolmaking, tool design, die making and metal stamping, foundry work, forging, patternmaking, and mechanical drawing. The first volume deals principally with measuring tools and gages, the use of hand tools in connection with assembling and fitting, and general methods of operating various classes of machine tools, such as lathes, planing machines, drilling machines, milling machines, grinding machines, and gear-cutters. Machine shop management, metallurgy, welding and die-stamping are the subjects treated in the second volume. The section on metallurgy is a general review of the standard processes of producing iron, steel, copper, and other common metals. The section on welding includes information on autogenous, electric and thermit welding, in addition to ordinary smith- or hand-welding operations, and different kinds of electrical and gas welding equipment are described. The eighty-six pages in this volume on die work deal principally with methods of making different types of punches and dies for blanking, drawing, forming and embossing sheet metal parts. The subject of toolmaking is treated in the third volume, in which is explained the general procedure in making small tools, such as arbors, taps, dies, milling cutters, reamers, etc., and the making of jigs and gages. This volume also deals with different types of dies and contains general information on tool design. The fourth book of this set is on foundry work and forging. The foundry section includes the making of cores and various classes of molds, and explains the construction and use of molding machines. It also treats of cupola operation, the production of malleable castings, brass castings, etc. In the forging section the general subjects are hand-forging operations, application of power hammers, drop-forging, and heat-treatment of steel. The fifth volume is on patternmaking and mechanical drawing. Many typical patterns and core boxes are shown and the method of construction is explained. The subject of mechanical drawing is divided into two parts: The first part deals with drawing instruments, construction of geometrical figures, methods of projection, and lettering. The second part, which is the beginning of the sixth volume, is on machine drawing, and treats of the practical side of drafting work, by explaining the methods of drawing various machine parts. The sixth volume also contains 112 pages on the features of motor car construction. Each volume, with the exception of the last, is supplemented by a list of review questions, pertaining to the more important subjects. The work as a whole is profusely illustrated and contains little that the average man would find complex or difficult to understand.

NEW CATALOGUES AND CIRCULARS

Porter-Cable Machine Co., Syracuse, N. Y. Circular illustrating and describing the taper attachment for the Porter-Cable manufacturing lathe.

Stenotype Co., Indianapolis, Ind. Circulars descriptive of the "Steno" 1 by 7 inch turret hand screw machine and the "Steno" duplex surface grinder.

Tate-Jones & Co., Inc., Pittsburg, Pa. Circular 151 on bolt heading forges and rod heating furnaces. Circular 152 on tool dressing furnaces and blacksmith forges.

Cowan Truck Co., 8 Water St., Holyoke, Mass. Circular giving specifications for the Cowan transmobile, a new electric transveyor of 2000 and 4000 pounds' capacity.

High-Speed Hammer Co., Rochester, N. Y. Catalogue illustrating the line of riveting machines made by this company. These machines can be furnished with motor drive if desired.

Chicago Pneumatic Tool Co., Fisher Bldg., Chicago, Ill. Bulletin 34-Z describing and illustrat-

ing single steam-driven air compressors with balanced steam valve and automatic flywheel governor.

National Machinery Co., Tiffin, Ohio. National Forging Machine Talk No. 16 describes the forging of grab-irons on the National forging machine and points out the advantages of this machine for similar classes of work in railroad, industrial and automobile plants.

Vulcan Engineering Sales Co., Chicago, Ill. Catalogue showing the line of squeezers manufactured by the Mumford Molding Machine Co., of Chicago. Catalogue illustrating the Mumford Molding Machine Co.'s pattern drawing machines and castings produced in them.

Gurney Ball Bearing Co., Jamestown, N. Y., has begun the publication of a house organ, "Bearing on Bearings," which will appear at intervals. Volume I contains "Old Charlie," "One-Third Off," "Pushmobile," "Four of a Kind," "Sawdust" and "The Moral."

Macleod Co., 2232-2236 Bogen St., Cincinnati, Ohio. Bulletin O of the "Buckeye" file sharpening machine which may be operated with compressed air or steam. The bulletin gives some data on the savings effected by the use of the file sharpening machine for renewing worn files.

Himoff Machine Co., 50 Church St., New York City. Circular descriptive of the "Hercules" 21-inch heavy-duty manufacturing lathe, designed especially for heavy-duty plain, taper and form turning. This machine is adapted for any work done on the ordinary lathe with the exception of thread cutting.

New Departure Mfg. Co., Bristol, Conn. Sheets for loose-leaf catalogue, 75 FE to 78 FE, inclusive, treating of "Radax" type bearings in novel clutch; ball bearings in motor-driven elevator gearing; ball bearings in Riensch-Wurl sewage screen brush; head and spindle assembly of vertical surface grinder.

Tate-Jones & Co., Inc., Pittsburg, Pa. Circular 153, descriptive of plate and angle heating furnaces for heating plates for flanging or annealing, angles for bending or forming and rods for continuous bolt or rivet machines. Circular 154 on Tate-Jones overfired furnaces, for annealing and heat-treating.

Chicago Pneumatic Tool Co., Fisher Bldg., Chicago, Ill. Bulletin E-44 descriptive of the "Duntley" electric sensitive drilling stand, built in five sizes to take the standard "Duntley" side spindle drills of either the universal or direct-current types, ranging in drilling capacity from 3/16 to ½ inch in metal.

General Electric Co., Schenectady, N. Y. Bulletin 44419, illustrating and describing railway motor gears and pinions, made in several types for various classes of service, the chemical characteristics, physical characteristics and price being given for each type. The bulletin gives tables of gear formulas and shows diagrams of the comparative sizes of gear and pinion teeth.

Templeton, Kenly & Co., Ltd., 1020 S. Central Ave., Chicago, Ill. Catalogue 216, covering the complete line of "Simplex" jacks for steam and electric railroads, contractors' industries, automobiles, mining, public utilities and ordnance purposes. The catalogue illustrates these jacks in use for various purposes and gives the capacity of the different sizes, which is as high as forty tons for the railroad car jacks.

Waltham Grinding Wheel Co., Waltham, Mass. Catalogue of grinding wheels, containing information on ordering, selecting wheels for different kinds of work, and methods of mounting. Price lists are given for straight wheels, taper wheels, cup wheels, cylinder wheels, and wheels for various types of standard and special grinding machines, as well as wheels for tool grinding machines, knife grinding, hollow-ware grinding and saw gumming.

International Machine Tool Co., Indianapolis, Ind. Catalogue treating of the "Libby" lathe in manufacturing machine shops. The booklet shows the "Libby" lathe employed on various classes of work in manufacturing machine shops and reproduces sketches of pieces machined on these lathes, giving the time taken for each piece. The company has also issued similar booklets showing the "Libby" heavy-duty turret lathe in machine tool shops and "Libby" lathes in automobile shops, with examples of work.

Diamond Power Specialty Co., Detroit, Mich., has increased the size of its house organ, "Power Notes." The object of this four-page monthly is to bring to the attention of the consulting engineer, steam engineer, mechanical engineer and architect, information on certain phases of power plant work. Records of tests and photographs of installations are included. The company will mail the publication regularly to all engineers interested in power plant development and will send a loose-leaf folder in which the monthly copies may be filed for reference.

Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletin descriptive of the "Spraco" paint gun, a hand tool for use in applying all kinds of liquid coatings. The complete equipment consists of the paint gun proper, connected by a flexible hose to a portable unit combining the material container, air drier and strainer, pressure control attachment and pressure gage. It is adapted for use in shop or field, and may be adjusted for spraying the highest grade of varnishes and lacquers, as well as heavy asphaltum and structural paints, producing finely finished surfaces without streaks or brush marks. It is also adapted to applying heavy, durable coatings to rough structures.

Pratt & Whitney Co., Hartford, Conn. Catalogue 9 of Pratt & Whitney small tools, including taps, dies, milling cutters, reamers, punches, drills, taper pins, lathe mandrels, ratchets, threading tools, counterbores, knurling tools, cutting-off tools, hollow-mills, circular forming tools, etc. The catalogue also contains a section of tables giving data on standard screw threads; pipe threads; standard machine screws; thread dimensions and tap drill sizes; constants for finding pitch diameter and root diameter of screw threads; decimal and millimeter equivalents; drill size decimal equivalents; and tables of speeds; weights per foot and weights per inch of bars of iron and steel; wire gage standards; table of tapers, etc.

Hyatt Roller Bearing Co., Newark, N. J. Bulletin 122, devoted to Hyatt flexible roller bearings for lineshafting, listing the advantages to be obtained by the use of these bearings and giving price lists and dimensions for bearings and hangers. Bulletin 202, describing Hyatt flexible roller bearings with planished steel outer races, suitable for light loads and medium speeds. Bulletin 401, on high-duty bearings for high-speed and heavy-load applications. Bulletin 1523 entitled "Engineering Helps on the Selection and Mounting of Hyatt Roller Bearings." This pamphlet contains instructions for mounting, which insure that a proper installation will be made in all cases. It is illustrated with halftone and sectional line engravings.

Greenfield Tap & Die Corporation, Greenfield, Mass. New catalogue 37, covering the entire line of gages, taps, dies, screw plates, reamers, threading machines, tap and die holders, friction tap chucks, Wells self-opening dies, pipe threading tools, etc., made by this company. This includes the products of the Wells Bros. Co., Wiley & Russell Mfg. Co. and A. J. Smart Mfg. Co., formerly catalogued separately. The catalogue also contains tables of tap drill sizes, screw threads, decimals of millimeters and equivalent decimals of inches, wire gage standards, three-wire thread measurements, allowances for fits, and other valuable data. A glossary gives the meaning of the various terms used in connection with the cutting and measuring of screw threads.

TRADE NOTES

Bath Grinder Co., Fitchburg, Mass., has changed its name to the Universal Grinding Machine Co.

Latrobe Electric Steel Co., Latrobe, Pa., has opened an office for the sale of its tool steel products in Cincinnati, Ohio. Edwin M. Ong is manager.

Precision Gage & Tool Co., Bridgeport, Conn., has moved to 166 Elm St., where larger quarters and new machinery have been provided to take care of the growing business.

Edgemont Machine Co., 2700 National Ave., Dayton, Ohio, maker of friction clutches, has completed a large addition to the plant that will about double the manufacturing facilities.

Woburn Gear Works, Woburn, Mass., manufacturers of gears, sprockets, chains, etc., are moving into their new, concrete shop, which will afford larger and better facilities for securing business.

Clarage Fan Co., Kalamazoo, Mich, has established a branch office in Chicago, at 123 W. Madison St. L. O. Monroe, who has had several years' experience in the fan business, is a representative in charge.

Colburn Machine Tool Co., Franklin, Pa., has purchased four and a half acres of land in Cleveland, Ohio, and will establish a branch plant there. The plot is on Ivanhoe Road, near the Reliance Electric & Mfg. Co.'s plant.

M. Adler, 32 Union Square, E., New York City, has established a temporary office for handling export of motor cars and motorcycles. Mr. Adler will also represent a few firms making tools and machinery used in motor car repair shops.

F. Raniville Co., Grand Rapids, Mich., manufacturer of leather belting, has opened a branch office in New York City at 6 Church St. George S. Baker, formerly secretary-treasurer of Olmsted-Flint Co., is the head of the New York selling organization.

Adamant Iron & Steel Co., Kent, Ohio, has brought out a brand of high-speed steel known as "Adamant," for which superior characteristics are claimed. The steel is said to be much harder than other brands of high-speed steel, and it can be tempered in oil or water without water-checking.

Doehler Die-Casting Co., Court and 9th Sts., Brooklyn, N. Y., has moved its brass-back bearing department from Brooklyn to its Toledo plant. An entire new factory building, housing foundry and machine shop, fully equipped with all labor-saving devices will be devoted to the exclusive manufacture of the Doehler babbitt-lined brass-back bearings.

Cisco Machine Tool Co., Cincinnati, Ohio, has completed a large addition to its plant which doubles the productive capacity. The company will soon place upon the market a 24-inch engine lathe. Considerable new equipment has been added and it is expected that the additional facilities will enable the company to make early deliveries in the near future.

Russian Metal Trading Co. (Iznosskoff, Suckau & Co.), Singer Bldg., 149 Broadway, New York City, will hereafter be known as Iznosskoff & Co. There has been no change in the organization and its policies will be the same as heretofore. S. A. Strolman, G. I. Demcker and V. A. Sindaeff of the machine tool and tool department continue in their respective relations. A. L. Bulwitt is in charge of the New York office.

F. O. Stallman Supply Co. has leased the premises at 129 First St., San Francisco, Cal., and will carry a complete line of high-grade machine tools, supplies and materials for machine shops, garages, factories, railroads, mines, mills, etc. F. O. Stallman, the senior member of the firm, was formerly vice-president and manager of the Pacific Tool & Supply Co., a firm which he and his brother, the late Charles Stallman, established twenty-five years ago.

Union Chain & Mfg. Co., Seville, Ohio, has increased its capital stock from $20,000 to $40,000, in order to take care of its rapidly growing business. Additional machinery will be purchased, including turret lathes, multiple-spindle drilling machine, automatic gear-cutter, keyseating machine, rolling mill, automatic screw machines, etc. The company has opened a New York office at 47 W. 34th St., in charge of J. R. Shays, Jr.

T. A. Willson & Co., Inc., 3rd and Washington Sts., Reading, Pa., has been awarded a large government contract for "Albex" eye protectors for use in the regular army. The "Albex" eye protector has been adopted and standardized by the War Department, and will soon be a part of the regular equipment of 50,000 troops. In addition to this order the company is making approximately 25,000 goggles for shipment to El Paso and other southern points for the National Guard.

Union Caliper Co., Orange, Mass., has changed its name to Union Tool Co. This change was considered advisable owing to the fact that since the company was started in 1908 for the purpose of manufacturing calipers, the line has been considerably enlarged. At present the company is manufacturing one of the largest lines of mechanical tools, including steel rules, combination squares, tool-holders, etc., and hence it was thought that the old name was misleading. No change has been made in the officers or personnel of the business staff.

G. L. Simonds & Co., 230 S. La Salle St., Chicago, Ill., announce that the company will be known in the future as the Vulcan Fuel Economy Co. The personnel and policies of the organization will remain the same as heretofore, the only change in addition to that of the name being an increase in capital, which was necessary in order to handle the growing business. The company will continue to sell Vulcan soot cleaners as well as Hays gas analysis instruments, and it has added to its line a new air-tight coating for covering boiler settings known as "Vulcan Lastite."

Haynes Stellite Co., Kokomo, Ind., has established branch offices as follows: 120 Broadway, Room 1846, New York City, Roe L. Johnson, manager; 900 Lytton Bldg., Chicago, Ill., A. F. Young, manager; 910 First National Bank Bldg., Cincinnati, Ohio, G. O. Litt, manager; 911 Citizens Bldg., Cleveland, Ohio, J. T. Plummer, manager; 318 Telegraph Bldg., Detroit, Mich., J. J. Cruice, manager. These branches will carry a complete stock of standard size solid stellite tools and arc welded stellite tools. The company was organized in the present form in November, 1915, and will close its first fiscal year with a sale of over $1,000,000 worth of stellite tools.

New Departure Mfg. Co., Bristol, Conn., gave an old-fashioned barbecue dinner to its 2700 employes on September 30. To feed this large number, eighty spring lambs were stretched on skewers and cooked over a trench 328 feet long filled with burning charcoal. Nine thousand ears of corn were prepared, and it was found necessary to supplement these with two thousand cans of corn. Thirty bushels of potatoes were boiled, and the bakers throughout the section were kept busy the night before making old-fashioned New England pumpkin pies. A miniature ice house was erected on the grounds to keep the beverages cold. Following the dinner a program of athletic sports was provided.

Inter-Continental Machinery Corporation, 165 Broadway, New York City, has been incorporated in the state of Delaware with a capital of $500,000. The company will deal in machinery in general, but will specialize in machine tools both in the United States and foreign countries. The president is Charles N. Thorn, who has been connected with the machine tool industry for twenty-five years, being associated with Manning, Maxwell & Moore, Inc., for fourteen years, and recently with the Allied Machinery Corporation of America as vice-president. The other officers are Joseph S. Clark, R. E. Robinson and Chester B. Overbaugh, vice-presidents; and Arthur M. Watkins, secretary and sales manager for the United States. The directors are, in addition to the president and vice-presidents, Frank J. Humphrey and George W. Kendrick.

Gisholt Machine Co., Madison, Wis., exhibited its "Periodograph" for recording workmen's time, at the Cleveland Foundry and Machine exhibit, September 11-16. The exhibit consisted of two controlling clocks operating several "Periodograph" registers. These registers were placed on stands or tables representing foremen's desks with a routing or production rack on each. The arrangement of the equipment gave a clear idea of how the registers might be placed in the different departments of the foundry or machine shop and all controlled by the clock in the superintendent's office. The help which the "Periodograph" gives the foreman was shown by the production rack at each register. These racks enable him to lay out a job ahead for each man at his convenience, and show him at a glance the jobs in process and the amount of interrupted work in his department.

Cowan Truck Co., 8 Water St., Holyoke, Mass., has moved into its new three-story building on North Canal St. The new building has a front of 100 feet and a depth of 200 feet, and a floor space of about 60,000 square feet. The building is of brick and concrete and is provided with foundations that will permit of the erection of two additional floors when required. The growth of the business has been phenomenal. In 1910, H. W. Cowan, then superintendent of the White & Wyckoff Mfg. Co., conceived the idea of the first Cowan truck, for moving paper in the White & Wyckoff plant, and its use has rapidly spread to all lines of manufacturing that handle parts. Over 2000 Cowan transveyors are in use in France and England alone. The officers of the company are H. W. Cowan, president; J. L. Wyckoff, vice-president; E. N. White, treasurer; and R. F. Lyon, general manager. The company is about to place on the market an electric transveyor equipped with a motor for transporting it and for elevating and lowering the load.

Heat-Treatment of Steel[1]

by Martin Syte

This article is the first installment of an elementary treatise on steel and the changes wrought by heat-treatment. Much has been published on the heat-treatment of steel which presupposes considerable technical knowledge on the part of the readers; the importance of the subject makes it desirable that knowledge of means and methods for improving the physical characteristics of the common material of mechanical construction be more widely spread and generally understood.

CARBON steel is an alloy composed chiefly of iron and carbon, but contains also man-
nese, sulphur, phosphorus and silicon. In alloy steels, one more of the following elements are found: chromium, ckel, vanadium, tungsten, molybdenum, etc. We can therere readily see that carbon steel may be a very complex alloy. hile the two constituents which are really responsible for s distinguishing characteristics are iron and carbon, each the remaining elements contributes to the properties of this loy. In some cases they are valuable, and in other cases ey exert a harmful effect, but owing to the difficulty of tirely removing them on a commercial scale, they are alwed to remain in the metal, provided they do not exceed rtain well established limits. In alloy steels, such as nickelrome and chrome-vanadium steel, valuable properties are tained by the addition of these elements.

There are today many metallic alloys which are valuable th from a commercial and a scientific standpoint, and many them possess properties that are exactly contrary to what ight be anticipated. For instance, the alloying of a hard d a soft metal may result not in one of intermediate hardss, but of greater or sometimes less hardness than either of s constituents. Again, in most alloys the melting point is wer than the mean melting point of all its constituents; t in the case of an alloy of 78.4 per cent gold and 21.6 per nt aluminum it is higher. While steel is the most valuable loy commercially and has therefore been the subject of conant investigation, there still remain many points which are t thoroughly understood.

For instance, why is it possible to take a bar of this alloy and by giving it what is termed an annealing treatment, put it in such a state that it will have a tensile strength of 90,000 pounds per square inch, together with marked ductility and considerable softness? Also, why is it possible to take this same bar and by heating it to a certain temperature and plunging it into oil, change its properties entirely? It may now possess a tensile strength of 270,000 pounds per square inch, or three times the former figure, practically no ductility and extreme hardness. What has taken place? If this process were not done every day on a large commercial scale, we would call it magic. We have taken a bar of this metal and by subjecting it to a gradual temperature change and then a sudden change of temperature in the opposite direction, have increased its strength three times. From a chemical standpoint, the alloy is still steel, containing all the ingredients that it had before we gave it this treatment. What changes in structure have taken place to produce such marked changes in its properties?

Thirty years ago we had very few means at hand to investigate the changes taking place under heat-treatment, but today we have the metallurgical microscope and the thermo-electric pyrometer. By the former we are enabled to examine the structure of the steel minutely, and by the latter we can measure very small quantities of heat and obtain an accurate record of the heat-treatment to which steel is subjected. As we shall refer to the use of these two instruments frequently, it will be well to give a brief description of their design and principles of operation. The metallurgical microscope differs from ordinary microscopes in that opaque specimens are used instead of transparent specimens mounted on glass, and this requires a special means of lighting. Any microscope to which has been added an attachment for illuminating opaque specimens may be used as a metallurgical microscope, but the types

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[1] For other articles on the beat-treatment of steel published in MACHINERY, e "Roll Hardening," June, 1916; "The Heat-treatment of Drop-forging es," February, 1916; "Method of Local Hardening," February, 1916; "Carrization and Heat-treatment," September, 1915, and other articles there erred to.

built especially for this purpose are, of course, much more convenient to use and give better results. Fig. 2 shows how light is utilized to illuminate the specimen.

It will be observed that the light ray, coming from whatever source of light is used, enters through a hole in the microscope tube and strikes a transparent glass disk *A* which reflects the light downward onto the polished and etched surface of specimen *B*, from which it is, in turn, reflected back through disk *A* and up to the eye of the observer. In place of the glass disk, a small mirror may be used or a prism, but the glass disk has found general favor. Several sources of illumination may be used with a suitable set of condensing lenses to regulate the beam of light. Welsbach burners, Nernst lamps, acetylene burners and electric arc lamps each have their advocates. When it is desired to take a photomicrograph of the specimen, a camera attachment is connected to the microscope. Fig. 1 shows a complete outfit with microscope, source of light and camera attachment connected.

The specimen to be examined must be polished by a series of operations with finer and finer abrasives until a mirror-like

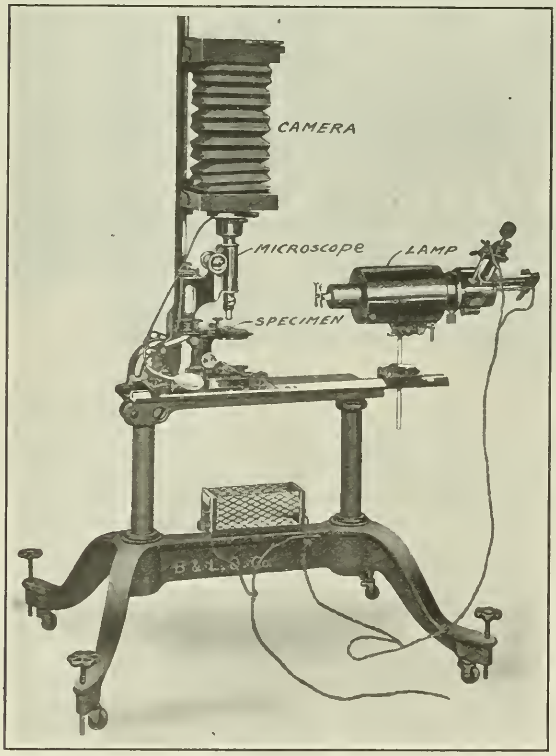


Fig. 1. Metallurgical Microscope with Camera for taking Photomicrographs

finish is obtained. Successive grades of emery paper may be used for the preliminary steps after the specimen has first been roughed down with an emery wheel or file. To obtain the final polish, use is made of rouge or fine levigated alumina suspended in distilled water and applied to a revolving disk covered with a cloth. Still quicker results may be obtained by polishing with the various power polishing outfits on the market. After the specimen has been polished, it is etched by dipping it into acid for a few moments, and then washed in alcohol and dried. This brings out the structure of the metal. A 5 per cent solution of picric acid in absolute alcohol and a 10 per cent solution of nitric acid in absolute alcohol are quite commonly used for etching steel specimens.

The thermo-electric pyrometer is an instrument for measuring temperatures. It makes use of the well-known principle that when two wires—each composed of a different metal or metallic alloy—are joined together and the junction is heated, an electromotive force is set up. The higher the temperature the greater is the electromotive force generated. Therefore, by measuring this force, we can tell the temperature to which the junction of the pyrometer is heated. Fig. 3 shows a section of a pyrometer, one wire of which is composed of pure platinum and the other of an alloy containing 90 per cent platinum and 10 per cent rhodium. The ends of the wire which are joined compose what is called the "hot junction," and this is the end placed in the furnace; the other ends of the wire, called the "cold junction," are connected to a milli-voltmeter to measure the number of milli-volts generated by the pyrometer. However, instead of being graduated in milli-volts only, there is also a scale showing the temperature that corresponds to each fraction of a milli-volt.

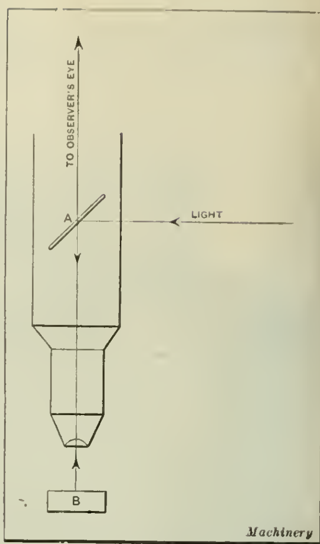


Fig. 2. Diagram showing how Light is utilized to illuminate Opaque Specimens examined under Metallurgical Microscope

Some pyrometers, instead of having wires of noble metal, such as gold, silver, platinum, rhodium, iridium, etc., have wires made of base metals, such as iron, nickel, chromium, etc. They are not as accurate or durable as the noble-metal wire pyrometers, but they are stronger and much cheaper, and for most commercial operations possess sufficient accuracy. They cannot be used, however, at the high temperatures that the noble metals withstand effectively, namely, up to about 3000 degrees F. As pyrometers are usually calibrated when the cold junction is at a temperature of 0 degrees C. (32 degrees F.), it is necessary to make certain corrections in the temperature they record when this junction is at any other temperature. The makers supply formulas for doing this, and in some cases they have designed automatic devices for this purpose. When the correction must be calculated, it is essential to keep all the cold junctions at the same temperature; otherwise, there will be a different correction for each pyrometer. Not only this, but the cold junction of the pyrometer must also be kept at a constant temperature; otherwise, there will be a different correction as the temperature of the junction varies. Owing to the low cost of pyrometers with base-metal couples, it is often practical to run wire leads of the same material as the pyrometer wire itself directly to the milli-voltmeter, and if this is done with each pyrometer, the cold junction would then be at the milli-voltmeter and would be at the same temperature for all pyrometers. Each system of noble or base-metal couples has its advantages, and only a thorough study of existing conditions will suffice to make a proper choice for any given service.

Returning now to the piece of steel we have been considering, let us examine it under the microscope just as it comes from the mill. It will appear as shown in Fig. 4. This photomicrograph has enlarged the view 200 diameters. Let us bear in mind that this represents the micro-structure of this particular steel when it is in such a state that it possesses a tensile strength of 90,000 pounds per square inch. Let us now heat the piece of steel to a temperature of 840 degrees C. (1544 degrees F.), hold it at this tem-

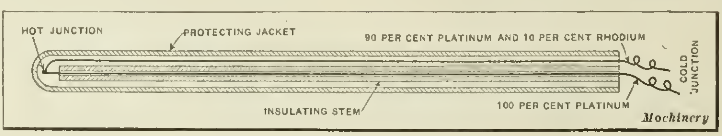


Fig. 3. Sectional View of Thermo-electric Pyrometer with Platinum, Platinum-rhodium Couple

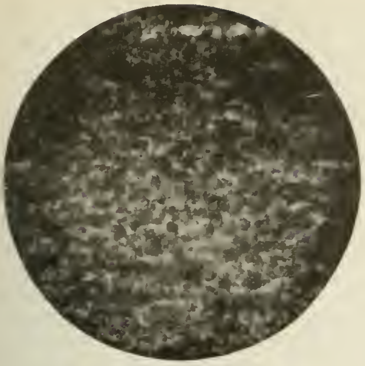


Fig. 4. Photomicrograph of Steel in Condition in which it leaves Mill—Magnification, 200 Diameters

Fig. 5. Photomicrograph of Steel after being quenched at 1544 Degrees F.—Magnification, 200 Diameters

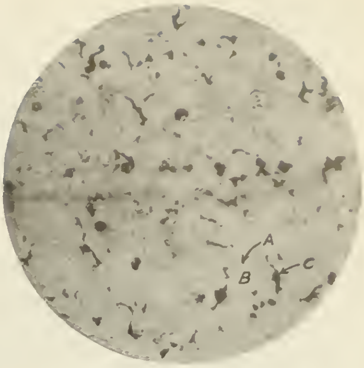


Fig. 6. Photomicrograph of 0.10 Per Cent Carbon Steel after being "normalized"—Magnification, 65 Diameters

perature for ten minutes and then quench it in oil. It now has a tensile strength of 270,000 pounds per square inch. Under the microscope it will appear as shown in Fig. 5, from which we note that there is a great change in structure from that shown in Fig. 4, and undoubtedly this is directly connected with the change in physical properties. But while we can readily see this change, we are at a loss to understand or to really appreciate it. What are the dark spots and what are the light ones in Fig. 4? In order to know this we must start in an elementary way and build up our facts little by little.

Fig. 7. Photomicrograph of Specimen shown in Fig. 6, but with Magnification of 650 Diameters

Steel may contain variable proportions of carbon, from a very small amount, such as 0.05 per cent, up to as high as 2.20 per cent. In order, therefore, to cover the subject completely, it will be necessary to study samples containing different amounts of carbon between the limits stated. Let us first procure, therefore, several samples of 0.10 per cent carbon steel from different sources. When we examine this steel under the microscope, we will probably note that some of the samples present an entirely different appearance from others. In some, dark grains may be seen clearly defined on a white background, while in others there may be a more blended effect so that nothing is sharply defined, either as to outline or color. This is due to the fact that these pieces, coming from different sources and receiving different degrees of temperature in the treatment they were last subjected to, have had imparted to them correspondingly different structures. In order, therefore, to study all the samples we are to investigate, let us give them a uniform heat-treatment, imparting to them all a clearly defined structure in which we may be better able to distinguish one constituent from another. This treatment has been called "normalizing" and consists of heating the specimen to about 1000 degrees C. (1832 degrees F.) and then cooling it very slowly. If we do this to all our 0.10 per cent carbon specimens, we will find that they all present about the same structure as in Fig. 6. There will, of course, be a difference in texture in the different specimens and also in different parts of the same specimen, but Fig. 6 represents a characteristic structure, shown at a magnification of sixty-five diameters.

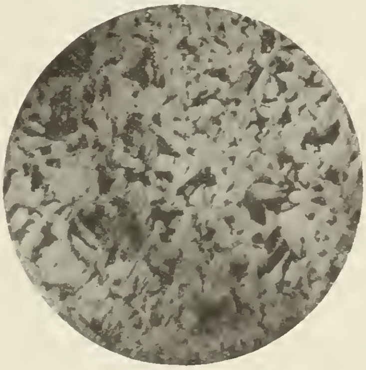


Fig. 8. Photomicrograph of 0.30 Per Cent Carbon Steel showing Increase in Pearlite—Magnification, 65 Diameters

Now, if we examine Fig. 6, we note that it shows a dark network *A* surrounding white grains *B*, and that, in addition, there are some dark grains *C*. This network will not always appear unless the metal has been etched considerably, but it always exists, as it constitutes the boundaries of the white grains. These white grains are composed principally of iron.

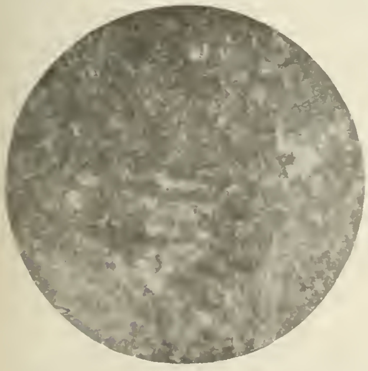


Fig. 9. Photomicrograph of 0.90 Per Cent Carbon Steel showing almost Unbroken Pearlite—Magnification, 65 Diameters

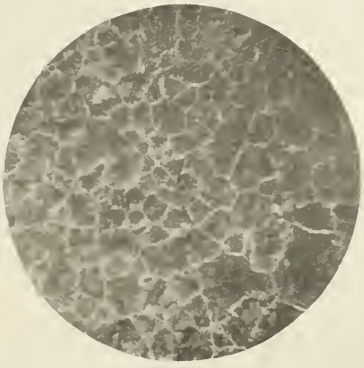


Fig. 10. Steel with 1.5 Per Cent Carbon, showing Network of Cementite around Pearlite—Magnification, 65 Diameters

Fig. 11. Photomicrograph of Same Steel shown in Fig. 10, but with Magnification of 260 Diameters

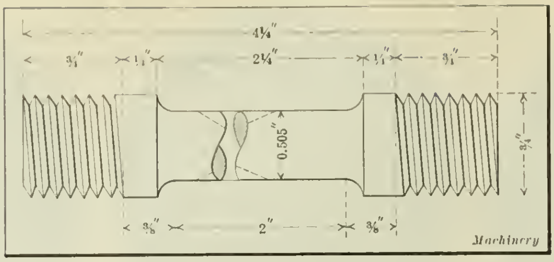


Fig. 12. Steel Specimen prepared for making Tensile Tests

although they may contain some impurities or alloying elements, but we will consider them iron. They are called "ferrite" grains; and the dark grains are called "pearlite." If we enlarge further, we will see that, instead of being composed only of dark matter, the pearlite grains consist of some lighter matter and generally present an appearance somewhat like that shown in Fig. 7. This is because they are composed of alternate plates of ferrite and of a constituent called "cementite."

We would naturally think that the white plates were ferrite, because this substance appears white in the grains of ferrite *B*, Fig. 6; but this is not the case, because the cementite plates are very hard and stand out in relief in the light, while the ferrite, being softer, is worn away by the polishing process so that it is below the level of the cementite plates, and hence is not so brightly illuminated. An additional reason for its darker appearance is the fact that it is more readily attacked by the etching acid than are the cementite plates. Cementite is carbide of iron, with the chemical formula Fe_3C. It is, therefore, a definite chemical compound. Ferrite may be considered as iron and has the formula Fe. Pearlite is not a chemical compound, but is a mechanical mixture composed of alternate plates of iron or ferrite (Fe) and carbide of iron or cementite (Fe_3C). In certain lights pearlite has the same appearance as mother of pearl and derives its name from this similarity.

We have noted in the foregoing the most important points in the structure of a normalized piece of 0.10 per cent carbon steel. Let us now see if we can make some use of this knowledge and anticipate the structural appearance of a specimen of 0.30 per cent carbon steel. As all the carbon is contained in the cementite plates, we would naturally infer that there would be three times as many of these plates in the 0.30 per cent carbon steel as in 0.10 per cent carbon steel. Now, as all the cementite is mixed mechanically with alternate plates of ferrite to form pearlite, we would also infer that there would be three times as much pearlite in the 0.30 per cent carbon steel. Fig. 8 is a photomicrograph of such a steel, and this shows that our assumption is correct, as there is about three times as much of the dark material—pearlite—as there is in Fig. 6.

If we examine steels of higher carbon content, we will observe more carbon-bearing (pearlite) grains, until at a content of about 0.90 per cent carbon, we note that practically the whole piece is composed of pearlite. (See Fig. 9.) If we examine a steel higher in carbon, say 1.50 per cent, we would naturally expect to find it composed mostly of pearlite, but what has happened to the extra carbon in excess of 0.90 per cent? Examination shows that it combines with the iron, forming carbide of iron, Fe_3C, which occurs as a network around the grains of pearlite. In other words, the piece is composed practically of pearlite with the exception of a network of cementite or carbide of iron. (See Figs. 10 and 11.) As the carbon increases, this network increases slightly.

We have now investigated enough specimens to form an idea of the appearance of the micro-structure of normalized steels of various carbon contents. Let us bear in mind that we do not always encounter steel in the normalized state, but that we have changed all our specimens to this state, so we can have a common ground for comparison and also because in this state, as already mentioned, we can easily distinguish the carbon-bearing grains from the iron grains. Let us now summarize the facts:

1. The micro-structure of low-carbon normalized steel shows a background of light ferrite grains interspersed around their boundaries and junctions with a few dark pearlite grains.

2. If we enlarge these pearlite grains, we note that they are composed of alternate plates of ferrite (iron) and cementite (carbide of iron).

3. As we examine pieces of higher and higher carbon content, we note that the only pronounced difference in appearance

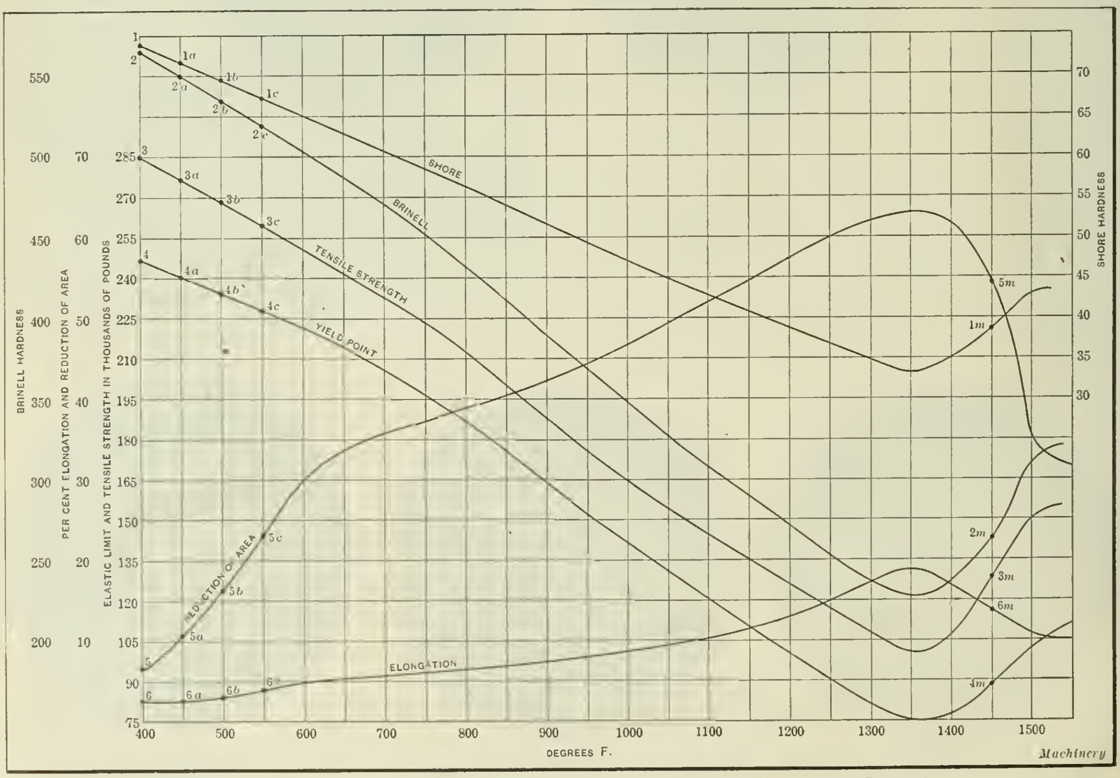


Fig. 13. Chart showing Changes in Physical Properties of Steel produced by drawing at Different Temperatures

is in the increase of the amount of pearlite until finally, when we reach a steel of about 0.90 per cent carbon, it exhibits all pearlite. If we further increase the carbon, a white network of cementite in excess of that required to take part in the formation of pearlite is shown around the pearlite grains.

We have, therefore, noted the micro-structure of normalized steels, so that it will now be of interest to learn something about their physical properties. Before doing so, however, it will be best to describe what the physical properties of metals are and just how and with what instruments we measure them.

Physical Properties of Steel

The physical properties of steel in which we are particularly interested are: first, tensile strength; second, elastic limit; third, ductility; and fourth, hardness. To test a specimen of steel for the first three properties mentioned, a sample is taken—preferably in the standard form shown in Fig. 12—and placed in a testing machine. The thread on the upper end of the sample fits into a holder which is connected with a system of weighing levers such as are found in a weighing scale. The lower end of the specimen fits into another holder, which may be driven up or down by means of a motor and gears. By starting this motor, the piece is slowly subjected to a gradually increasing load, which may always be determined by keeping the scale beam balanced by moving the counterbalance weight along it.

Testing Proportional Limit

Let us now place a piece in the machine and balance the scale beam at zero, after which the motor is started and the piece subjected to a gradually increasing load. Now, as this load is increased the steel sample stretches in proportion to the load. For instance, if a load of 2000 pounds causes it to stretch 1/64 inch, a load of 4000 pounds will cause it to stretch 1/32 inch. This continues until a point is reached in the loading of the piece where an increase in load of 2000 pounds, for instance, instead of producing an elongation of 1/64 inch, produces, say, half as much again, or 3/128 inch. In other words, we have arrived at a point where the elongation is not proportional to the load. This point is therefore called the "proportional limit."

Testing Yield Point

The increase in the elongation or stretching of the piece becomes more and more pronounced until we arrive at a point where the piece keeps on stretching, even when no further load is applied. This point is called the "yield point." In practice it is often determined by the "drop" of the beam on the testing machine; it is frequently confused with the elastic limit, and often considered as such by those who are not fully informed. The true elastic limit occurs a little after we have passed the "proportional limit." It may be located accurately by the fact that after the elastic limit is passed, if the entire load is released the piece will not return to its original length, but will have suffered a permanent "set" or lengthening. At any point prior to the elastic limit the piece would have returned to its original length when the load was entirely removed. We therefore can readily understand the definition of elastic limit, which is given as the least load per square inch that produces a permanent set.

Returning now to our testing of the piece, we continue to load it after the yield point has been reached and the piece continues stretching as the load is applied until we reach the maximum load that the piece will stand. When this point is reached, if we endeavor to add a larger load, we will find that the piece will not support it, but will stretch and "neck in"; and if we continue this loading, the piece will finally break. The instrument used to determine the amount of stretching and set, and thus to locate the elastic limit, is called an extensometer, and is attached directly to the specimen.

After the specimen is broken it will generally appear as shown by the dotted lines in Fig. 12. If, before testing, we had placed two slight punch-marks on it we could, by fitting the ends together, determine how much the piece had stretched; and by measuring the diameter of the decreased section, we could determine how much the cross-sectional area had been reduced. For instance, let us figure out the properties of a specimen, the dimensions of which before testing were the same as shown in Fig. 12; elongation after testing, ½ inch; diameter of reduced section, 0.300 inch; load on piece at yield point, 15,000 pounds; maximum load on piece, 20,000 pounds.

The cross-sectional area of the piece before testing was 1/5, or 0.200 square inch. Hence, if a piece 1/5 square inch in area withstood a load of 20,000 pounds, the estimated strength of a piece five times that area, or one square inch, would be $5 \times 20{,}000$ pounds, or 100,000 pounds per square inch; and it would possess a yield point of $5 \times 15{,}000$ pounds, or 75,000 pounds per square inch. As the area before testing was 0.200 square inch, and the diameter after testing had been reduced to 0.300 inch, which corresponds to an area of 0.071 square inch, the specimen had its area reduced from 0.200 square inch to 0.071 square inch, or a reduction of area of 65 per cent. As the piece elongated ½ inch in 2 inches, it elongated ¼ inch in 1 inch, or an elongation of 25 per cent. Hence the test gave the following physical properties: Tensile strength, 100,000 pounds per square inch; yield point, 75,000 pounds per square inch; reduction of area, 65 per cent; elongation, 25 per cent. The last two properties, reduction of area and elongation, are, in reality, a measure of the ductility of the piece.

Testing Hardness of Metals

The remaining property we have to consider is hardness. There are several instruments designed for testing the hardness of metals, but we will discuss only those most commonly used, namely, the Shore scleroscope and the Brinell hardness tester. The former instrument consists chiefly of a glass tube with suitable means for leveling vertically, and a small tap or hammer with a diamond point embedded in its lower end. By means of a bulb and cylinder arrangement, this hammer may be sucked up to the upper end of the glass tube and allowed to drop on the smooth, flat surface of the metal under test; then by noting the height to which the hammer rebounds on a scale provided for that purpose, a measure of the hardness is obtained. In the Brinell machine the chief parts are a hydraulic press and a hardened steel ball, which is generally 10 millimeters in diameter. This ball, by means of the hydraulic press, operated by a small hand pump, is driven into the steel with a certain specified load. The softer the steel, the farther the ball sinks in; and the harder the steel, the less it sinks in. By measuring the exact amount that the ball sinks in, or, more easily, the diameter of the impression left by it in the steel under test, which is generally done by means of a small microscope, we may obtain a measure of the hardness of the steel.

With this information at hand, let us consider the results we would obtain if we tested the normalized steels previously discussed. We would note that the lower carbon samples would have a lower tensile strength, yield point and hardness than those of higher carbon content. Their elongation and reduction of area, however, would be greater, *i. e.*, they would be weaker but more ductile. This is due to the fact that ferrite has a tensile strength estimated at about 50,000 pounds per square inch and pearlite 125,000 pounds per square inch. Consequently, the higher carbon steels have more strength due to the larger amount of this stronger constituent which they contain. When we have a steel that contains all pearlite, *i. e.*, a eutectoid steel, we would have a strength of 125,000 pounds per square inch in the normalized state. Higher carbon steels than this would contain a network of cementite and would be no stronger, as this constituent is hard and brittle, and possesses a tensile strength of possibly only 5000 pounds per square inch. By observing the physical properties of a eutectoid steel which is all pearlite, and of a very low-carbon steel which is practically all ferrite, we can get a good comparative idea of the properties of these two constituents.

Effects of Heat-treatment

We have confined ourselves so far principally to normalized steels. Let us now take up the important consideration of heat-treated steels. Before we go into the theory involved,

let us first endeavor to understand clearly the practical results obtained by heat-treatment. It will be impossible to describe these results in detail for several different analyses of steel; but we can take one steel and study it in detail, and this will teach us what we can expect from other steels. Let us, therefore, consider a steel with 0.50 per cent carbon. The various properties it has under heat-treatment are shown graphically in Fig. 13, which gives the average results of over 20,000 tests on this particular steel. A chart of this nature may not be readily understood at first glance, but a little study will make it clear, and it will then be retained in the memory much more easily than the long written description which would be required without it. By interpreting this chart correctly, many facts can be ascertained and the proper treatment to obtain a given result may be found from it. In order to understand the chart thoroughly we must know how it was obtained, and this we will now consider.

All samples of this steel were first hardened with great care and uniformity at the correct hardening temperature. How this temperature was ascertained will be described later. In this case the temperature was 832 degrees C. (1530 degrees F.), and this was maintained as closely as possible; after heating, the pieces were quenched in oil. After receiving this treatment, all samples were very hard and brittle, and possessed a high tensile strength. Owing to their extreme brittleness, it was impracticable to get a good test of them, so that a few were drawn at a temperature of 204 degrees C. (400 degrees F.) and then tested. The physical properties determined in this test were then marked down on the chart at points 1, 2, 3, 4, 5, 6, directly above the 204 degrees C. (400 degrees F.) drawing temperature. We note that the tensile strength was 285,000 pounds per square inch, yield point 246,000 pounds per square inch, elongation 2.5 per cent, reduction of area 6.5 per cent, Brinell hardness 565, and Shore hardness 74.

Let us now take another lot of samples of this steel which we have just hardened and draw them at a temperature of 232 degrees C. (450 degrees F.). We note that the tensile strength is 276,000 pounds per square inch, yield point 241,000 pounds per square inch, elongation 2.5 per cent, reduction of area 11 per cent, Brinell hardness 550, and Shore hardness 72 (see points 1*a*, 2*a*, 3*a*, 4*a*, 5*a*, and 6*a*). It is therefore apparent that drawing the steel at this higher temperature has caused it to lose in tensile strength, yield point and hardness, but to gain in ductility, *i. e.*, amount of elongation and reduction of area. By taking additional lots of samples which have been hardened and drawing them at higher temperatures, we obtain the points 1*b*, 2*b*, 3*b*, 4*b*, 5*b*, 6*b*, 1*c* . . . 6*c*, etc. For instance, by drawing the hardened pieces at 482 degrees C. (900 degrees F.), the tensile strength has dropped to 187,000 pounds per square inch, yield point to 164,000 pounds per square inch, Brinell hardness to 390, Shore hardness to 52, and the reduction of area and elongation have increased to 42.5 and 7.5 per cent, respectively.

We therefore note that if a steel is merely hardened, it possesses its maximum tensile strength, yield point and hardness, and its minimum ductility. Now, if we draw this hardened steel, it loses in tensile strength, yield point and hardness, but gains in ductility. If we draw our samples at still higher temperatures, we will finally pass beyond the temperature to which the term "draw" applies. In other words, we will begin to draw at such a temperature that the piece has a visible color, and we eventually arrive at an "annealing" temperature. We note that the lowest tensile properties and greatest ductility were obtained by drawing the steel at about 738 degrees C. (1360 degrees F.). Comparing the properties at this point on the chart with those at 400 degrees F., we obtain the following results:

	Hardened at 832 Degrees C. (1530 Degrees F.) Drawn at 204 Degrees C. (400 Degrees F.)	Hardened at 832 Degrees C. (1530 Degrees F.) Drawn (Annealed) at 738 Degrees C. (1360 Degrees F.)
Tensile strength	285,000 lbs. per sq. in.	100,000 lbs. per sq. in.
Yield point	246,000 lbs. per sq. in.	75,000 lbs. per sq. in.
Reduction of area	6½ per cent	63 per cent
Elongation	2½ per cent	19 per cent
Brinell hardness	565	228
Shore hardness	74	33

The preceding comparison shows what a remarkable change in the properties of steel can be wrought by heat-treatment. The tensile strength was increased or decreased, as desired, from 100,000 to 285,000 pounds per square inch, and the other properties almost in like measure. The question might here arise as to whether by drawing the steel at a still higher temperature, say 788 degrees C. (1450 degrees F.), we would not still further reduce the tensile properties and increase the ductility. In drawing the steel it was heated to the desired temperature for one hour and then cooled in the air. If we should draw at a temperature much above 1360 degrees F. and then cool in the air, the steel would "air harden," because we have heated it above its first critical point, as will be more fully explained later. In this case the tensile strength would be increased and the ductility decreased, as is shown on the chart at points 1*m*, 2*m*, 3*m*, 4*m*, 5*m*, and 6*m*. In other words, as we draw this steel from 204 degrees C. (400 degrees F.) to successively higher temperatures, we get a definite and constant change in its properties, but as soon as we draw at a temperature much above 1360 degrees F. we get a complete reversal of these changes.

From this chart we can tell just about what properties we may expect from a given hardening and drawing treatment of this steel, or we may tell just what treatment will be required to obtain a given set of properties. For instance, if the steel is hardened at 832 degrees C. (1530 degrees F.) and drawn at 443 degrees C. (830 degrees F.), we will obtain a tensile strength of 204,000 pounds per square inch, yield point of 179,000 pounds per square inch, elongation of 6.5 per cent, and reduction of area of 40 per cent. If, on the other hand, we want to use this steel for an application where we must have a reduction of area of at least 15 per cent and want to know what the other properties would be and what heat-treatment to give the steel, we look on the chart and note the point where the reduction of area curve rises to 15 per cent and see that this point is directly over a drawing temperature of 254 degrees C. (490 degrees F.), that the tensile strength would therefore be 270,000 pounds per square inch, the yield point 235,000 pounds per square inch, and elongation 3 per cent.

If we should want to treat this steel so it would have a Shore hardness of 71 and a reduction of area of 40 per cent, we will find that drawing at 238 degrees C. (460 degrees F.) would give the hardness desired, but the reduction of area would be only 12 per cent. In consequence, the steel would not answer the purpose desired. This leads to the important consideration that it is often impossible to fulfill every requirement desired in a steel, and we must therefore compromise and get the nearest combination of properties which will answer our purpose. This is due to the fact that hardness and strength are obtained at the expense of elongation and reduction of area. The chart shows this very clearly, and in a manner which can be easily memorized, as the tensile strength, yield point, and Shore and Brinell hardness curves all slope downward from left to right (except beyond the 1360-degree F. mark), while the reduction of area curve and elongation curve slope upward.

The question might arise in regard to charts of this nature, as to why the hardening temperature is not varied like the drawing temperature. The main reason for this is that every steel has but one correct hardening temperature, while it has any number of drawing temperatures, according to the application. It must be borne in mind that the chart gives the results for the particular steel chosen, and that it would not give accurate results for any steel. It does, however, show the general trend in the properties of all the ordinary steels after hardening and drawing. In lower carbon steel the hardness and strength would be lower and the ductility greater; and in still higher carbon steels the opposite would be the case.

* * *

At the autumn meeting of the British Iron and Steel Institute, Sir Robert Hadfield advocated the admission of women as associate members on the ground that women were now filling a most important part in the industrial life of the nation.

ERECTING AND STARTING A NEW ENGINE LATHE

Through a desire to get a lathe or other machine tool working at the earliest possible moment, many points in the erecting and starting of the machine are frequently neglected or overlooked entirely. Yet it is the care with which this preliminary work is done that determines whether or not a machine will do satisfactory work. The first essential in all cases is a good foundation; unless this is provided, accuracy and smoothness of finished work cannot be obtained. This foundation should be thoroughly laid before the lathe is placed in position. The lathe should not be bolted to the floor nor should any grouting be run over the feet when the tool is being leveled. The holes in the legs are for the lag screws that secure the lathe to the skids when it is crated for shipment. Before a lathe is used, it should be carefully cleaned and leveled. Every particle of grit and dirt must be removed from all bearing surfaces and from all oil holes; should any remain in the latter, it may be carried into a journal by the oil. The following information is given in a bulletin issued by the Lodge & Shipley Machine Tool Co.:

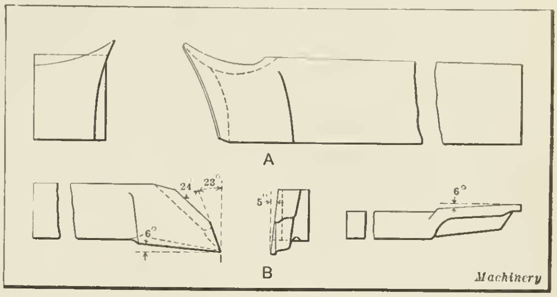
The slush compound that protects the finished surfaces of a lathe may be removed with benzine. The sliding tumbler gear under the headstock and the slip gear on the lead-screw should work easily. To clean and oil the dovetail surface of the bridge, the cross-slide guard or extension of the lower compound rest slide should be removed. This may be done by running the slide to the center of the carriage and then lifting off the guard. After the surface of the bridge is cleaned and oiled the guard should be replaced.

Unless a lathe is accurately leveled, it cannot do accurate work. No matter how stiff a bed may be it is not strong enough to prevent springing out of line when set on an uneven base. The level used for this purpose must be very sensitive and accurate; an ordinary carpenters' level will not do. After a lathe has been placed in position on its foundation, it should be leveled lengthwise; to do this, the level should be laid on the flat track lengthwise with the bed; that is, parallel with the track. When the lathe has been leveled in this direction, the carriage should be run close up to the headstock, the level placed upon a straightedge that rests on the front and rear arms of the carriage, and the bed carefully leveled by the head-end leg. The carriage should then be moved along and the bed leveled by each leg as the carriage rests over it. The position of the level across the wing should not be disturbed, and in the preliminary leveling the middle legs should be a trifle low rather than a little too high. As soon as the whole bed has been leveled, the carriage should be returned to the head-end and the operation repeated, to make sure that there is no wind.

A lathe that is not properly leveled will neither bore straight, face straight, nor turn straight; besides, it may chatter. Chattering may also be caused by the cutting edge of the tool being below the center of the work, by dirt getting between one of the centers and its bushing, and by the failure to clamp the tool securely in the toolpost. It is sometimes caused by end play in the spindle; this may be corrected by adjusting the collar and nut on the rear end of the spindle. When it is due to the loose fit of the cross-slide on the bridge the gib should be adjusted; if the compound rest gib is loose, this too should be adjusted. Chatter also occurs when all the feet are not solidly supported and when the work extends too far from the chuck. In the latter case the method of chucking should be changed or the outer end should be run in a steadyrest. In the case of a slender shaft, chattering may occur when there is too great a distance between the centers without support; in this case, also, a steadyrest should be used. The failure to use a steadyrest or follow-rest when a long piece is being turned between centers may result in poor work, as the piece is likely to spring away from the tool. An inaccurately fitted chuck plate will cause chattering. It is also produced by running at too high a speed for the class of work; by throwing the machine out of balance by the addition of special chucking fixtures; by the failure to bolt the chuck tightly against the chuck plate; and by work of an irregular shape or weight. If a tool-holder is used, the set-screw holding the inserted cutter should be tight.

When a lathe has been cleaned and set up, all the bearings should be flooded with oil. Only the best mineral oil should be used; animal oil has a tendency to clog the oil tubes in cold weather. The oil should be rich enough to lubricate the bearings, and should have sufficient body to last a reasonable length of time and withstand a cold test of 20 degrees. While there should be ample lubrication at all times, the bearings should be flooded with oil during the first few weeks of operation.

Should a lathe cut a drunken thread, the nut on the tail-stock end of the lead-screw should be tightened, if loose. It should not be made too tight, however, or it will be difficult to get the sliding tumbler knob into the holes when the lathe is running. The lead-screw of a Lodge & Shipley lathe is always in tension, whether a right- or left-hand thread is being chased, because the pull is against the outer ends of the bearing in either case. Should it be necessary to remove any of the gears from the reverse plate, care must be taken, when they are being replaced, to locate them properly by dowel-pins.



A, Improperly Ground Tool; B, Good Form of Necking Tool

The cutting edge of a turning tool should be nearly straight, because the tool should work close to the shoulder and leave little metal for the necking tool to remove. Tools ground as shown at *A* in the accompanying illustration, though common, easily crumble and break. The finishing tool is of the same general design, but has a back slope of 8 degrees. For squaring and necking, an ordinary slender cutting-off tool is frequently used. The tool shown at *B*, however, is much superior.

When turning dry, the rake of a tool should not be as great as when a lubricant is used, because the cutting edge will then be too thin to carry away the heat. Tools for cast iron should be nearly flat on top. As a rule, with this metal, the coarser the feed the less is the chatter and the longer the tool will last. Tools for brass should be flat on top, or preferably should have a negative rake. For copper, bronze and aluminum the tools should be ground like those used for cutting steel.

When making cutting tools, the instructions for heat-treating any particular brand of steel should be carefully followed. In many up-to-date shops tools for cast iron, very hard iron, steel, cast steel, etc., are treated differently, although they may be of the same stock. Generally a tool will work better and stand up longer if it is ground down at least 1/32 inch after hardening. When grinding, a tool should not be pressed hard against the wheel.

As a rule, shafts should be rough-turned to within 0.015 or 0.02 inch above the finished size, rather than within 0.01 inch or less. The lathe operator can then use a coarse feed; besides, the greater range in size thus obtained eliminates the possibility of the grinding wheel failing to take out the tool marks. The coarser feed also makes the operation easier for the grinder, as the coarser the feed the easier it is on the wheel. In the case of shafts of small diameter, which are likely to spring when being roughed in the lathe, sufficient metal should be left to insure that the grinding wheel will true them up.

THREATENED DEARTH OF SKILLED WORKMEN

According to the New York *Times*, the greatest menace to American prosperity at the close of the war is not the possibility of the country being flooded with cheap foreign merchandise, but the great dearth of skilled and semi-skilled workmen that will exist. It said that makers of high-priced wares of the luxury class and other things that require considerable artistic or mechanical ability to produce are going to be hard put for several years, after peace is declared, to fill the benches when the present employes are gone. Most of the skilled labor in what might be called the arts' trades has for years come from Europe. But owing to the great burden of debt and taxation that will be placed on the people of the belligerent countries, an embargo will probably be placed on emigration, especially from those countries that have supplied the bulk of the workers for the artistic trades. As a result, the workers will be in a position to demand almost anything they want in the form of wages, hours of employment, etc. Precious metal workers cannot be made from anybody, and the supply of apprentices in this and other trades, both artistic and utilitarian, is lower than it has been for many years. In one of the best conducted jewelry shops, where the working conditions are ideal and the hours and pay are all that can be desired, there is not a single apprentice. The conditions are the same in the silk dyeing industry. This is work that requires considerable skill, for the dyer may do considerable monetary damage quickly if he is incapable or does his work in a slipshod way. Yet the younger men and boys seem to be avoiding the dye houses because they do not like the vapors, the odors, and the sloppiness of the work. Most of these workers are of foreign origin, possibly one or two generations removed, and many of them come from the countries that are most likely to restrict emigration after the war.

This dearth of men will also be felt in lines that do not require so high a degree of training and skill. It is no secret that England has offered all sort of inducements to American mechanics to go there and help in the manufacture of munitions. If American skill is needed in destroying much of Europe, it will be much more needed in restoring that which has been destroyed, and it is practically certain that the stricken nations will have to draw on the labor resources of other countries. Those who will go will be the unmarried men, the future labor strength of this country, and if they go, no one knows how many will come back or when.

Many reasons have been given for this dearth of skilled workmen. Most of them are based on the desire of the parents to have their children obtain more comfortable positions than they have filled or a disinclination of the children to follow the trade of their fathers. But the present lack of young workers and learners in many lines is partly due to the restrictions and rules imposed by the labor unions. Almost invariably the rules and regulations of the union specify the number of beginners or apprentices that may be employed in any given case, but wherever possible the number actually working is kept below the specifications. As an illustration of the manner in which the unions discourage the learning of the trades, there might be cited the case of the proprietor of a garment manufacturing house who wanted to teach his nephew the business from the bottom up so that the young man could take his place as soon as possible as an executive with a full understanding of the work that was being done in the place. He started his nephew at the most unskilled task of all, but soon afterward, deciding that he had learned all that was necessary of that work, moved him a step higher. The business agent of the union, however, held that the working agreement with the organization was being violated. He insisted that the other workers on the union list ahead of the nephew should be placed in the position first, and that if this were not done a strike would be called in the shop. This left the manufacturer just three things to do: he could take his nephew into the firm "green" and let him learn the business from the top down; he could let him learn it in his turn, in conformation with the union's rules, which might require years; or he could discharge him.

PRIMITIVE TOOLS

BY GUY H. GARDNER[1]

Some time ago there was found, among bone needles, flint axes and other relics of the long-forgotten races who inhabited Europe in prehistoric times, the object shown in Fig. 1. It is a stone 6 or 8 inches long by 1½ inch thick, having rounded

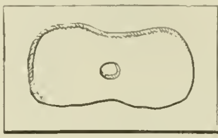


Fig. 1. Balance Wheel for Prehistoric Pump Drill

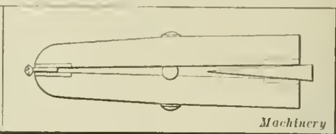


Fig. 2. Wooden Clamp for setting Gems in Rings

edges and a hole, about ½ inch in diameter, exactly through its center of gravity. It's use no one had been able to guess until a visitor to a jeweler's shop in the United States, idly turning over the leaves of a tool-dealer's catalogue, saw an illustration of the pump drill shown in Fig. 3. At once a possible solution of the puzzle came to him: it was a balance wheel for a prehistoric pump drill.

The writer cannot vouch for the accuracy of this conclusion, but it is easy to believe that the pump drill is very old. However, it was probably invented later than the fiddlebow, which was simply a cord wrapped about the drill shank and secured at its ends to a bent stick or the rib of an animal. The mechanics with whom these contrivances originated had, of course, no steel tools, but are supposed to have used as a drill a stick charged with sharp sand, the precursor of the modern lap. Though it may seem strange to many persons familiar with the tools and methods of modern shops, both of these drilling machines devised in the Stone Age are in use today.

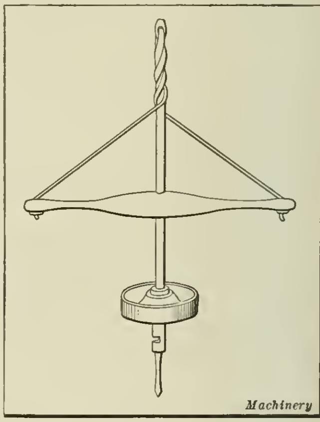


Fig. 3. Jewelers' Pump Drill

A toolmaker, desiring to have a ring made, took a pearl and a number of gold coins to an old jeweler of high local repute and sat down to watch the process of manufacture. The casting presented no features of special interest, being done in an iron flask in which the mold had been made by using a brass pattern; but the method of making a seat for the pearl was a surprise. The ring was grasped in a clamp, Fig. 2, that was evidently a lineal descendant of the split stick used by our arboreal ancestors who felt the need of a hand vise. The fiddlebow arrangement shown in Fig. 4 was

[1]Address: New London, N. H.

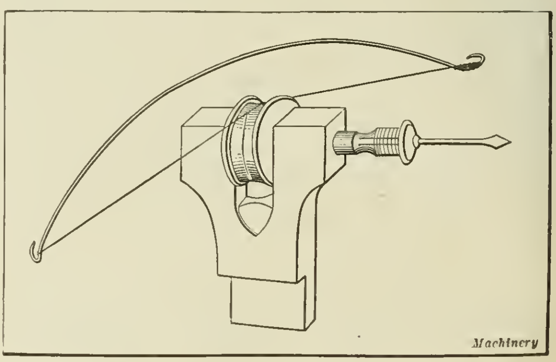


Fig. 4. Drilling Head operated by a Bow String

then put into the bench vise, the clamp held in the hand, and a hole made in the place where the pearl was to be. This hole was to guide the pearl drill, which might be called a two-lipped flat counterbore with a pilot teat. The fiddlebow drill was then taken from the vise and the clamp placed in it, after which the pearl drill, operated by the pump drill shown in Fig. 3, completed the seat. The subsequent operations on the ring were performed by methods quite similar to those anyone might use if called on to do the same work, though wholly unlike those of the manufacturing jeweler.

As the man had a fine lathe, the toolmaker asked why he used the primitive tools. The jeweler said that they gave him the "feel" of the cut, and enabled him to control the direction and the pressure more accurately than if he used the lathe. Whatever our ideas on this subject may be, the opinions of so excellent a mechanic as this man's work showed him to be must be respected. Besides, the fact that the tools are carried in stock by dealers and sold in considerable numbers indicates that he is not alone in the conviction of their superiority for certain classes of work.

Another tool of ancient origin, though much more modern than the drills and clamp just shown, is the lathe illustrated in Fig. 5. This lathe was in daily use in 1900, when a salesman for a firm of lathe manufacturers visited a European shop that was fairly well supplied with up-to-date tools and machines, but which had in one room twenty or thirty of these venerable relics. The superintendent explained that the fathers and grandfathers of the men had used such lathes, and it would be considered almost an act of sacrilege to displace them—a spirit of reverence for age which it would be hard to duplicate on this side of the Atlantic. The chuck used in these lathes, at least in some cases, is a block of wood having a cavity bored to hold the work, and made to grip it by moistening the wood. This device, by the way, is sometimes used by watchmakers when turning a bezel (the ring that holds the crystal) which they are afraid will be squeezed out of round by the jaws of the regular chuck.

As shown, this lathe is operated by pressing a pedal *A* that is connected, by a belt, to the small end of the cone pulley *B*.

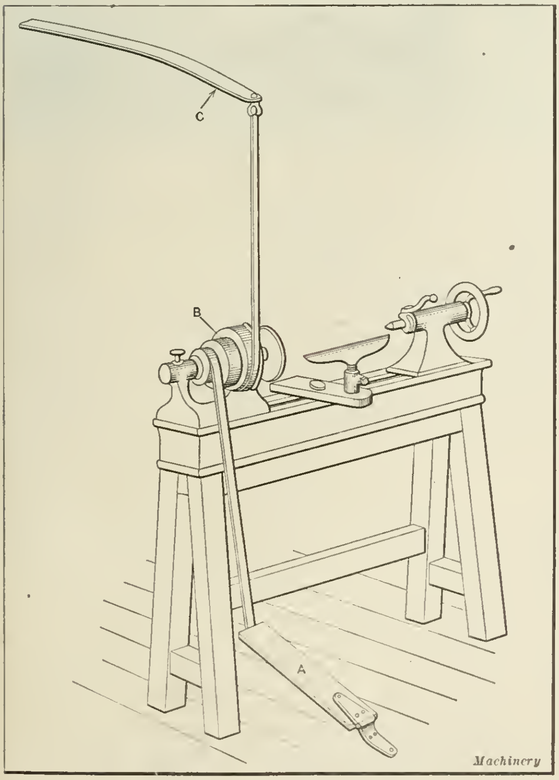


Fig. 5. Spring-pole Lathe

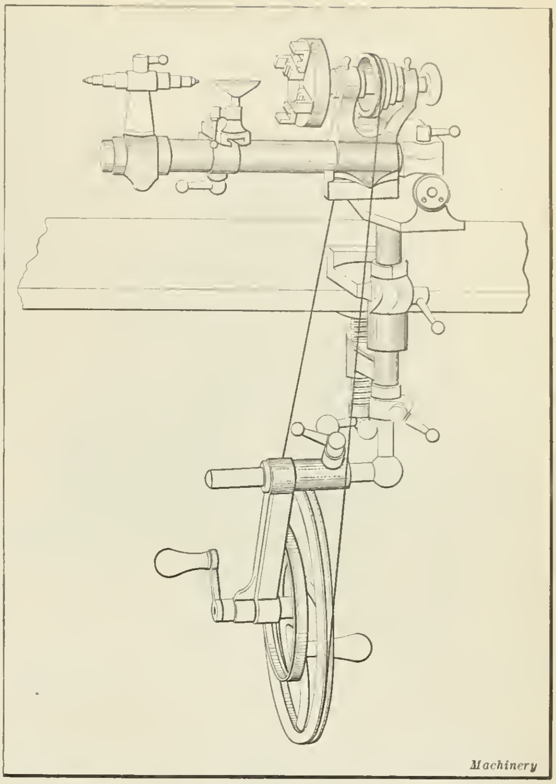


Fig. 6. Watchmakers' Lathe

The other end of this pulley is connected, by a belt, to a spring *C* fastened to the joists overhead. When the pedal is in the position shown, its belt is wrapped around the pulley several turns. So, as the pedal is pressed down, the belt is unwound and the pulley is made to rotate. This rotation winds up the belt connected with the spring. As this puts the spring under tension, as soon as the pressure of the foot is removed, the pulley is revolved in the opposite direction and winds up the belt attached to the pedal. Sometimes this spring is made of wood and a stirrup is used instead of the pedal.

Fig. 6 shows another machine which is strange to the American, but which is used by thousands of the finest workmen in the world. As shown, this watchmaker's lathe is fastened to the work-bench and run by a countershaft below. The operator turns this shaft with his right hand and guides the hand-tool or slide-rest with his left. Though clumsy in appearance and slow in operation, no better work is done anywhere than is turned out by the men who, after seven years' apprenticeship, earn their daily bread by "grinding" the hand crank.

* * *

LUBRICATION OF POPPET VALVE SUPER-HEATED STEAM ENGINE

Some interesting data on lubrication of superheated steam engines have been furnished in terms of area swept by piston rings, and amount and cost of lubricating oil. The Thos. S. Watson Co., Milwaukee, Wis., reported that the cost of cylinder lubrication for a 20- by 32-inch Nordberg poppet valve engine at the plant of the Rockwell Mfg. Co. in Milwaukee is extremely low. The test covered a running time of 224.5 hours, during which period two gallons of cylinder oil, costing fifty-five cents a gallon, was used. The area of cylinder surface swept by piston rings per revolution is 27.92 square feet. The engine runs 150 revolutions per minute, and the surface swept over by the rings in an hour is 251,280 square feet; for the period of the test the area was 56,412,360 square feet, and 28,205,180 square feet per gallon of lubricating oil. The steam pressure was 150 pounds gage, superheated 120 degrees F., the average temperature being 480 degrees F.

MANUFACTURING PARTS OF TYPE 80 TIME FUSES[1]

MACHINING OPERATIONS ON TOP AND BOTTOM RINGS—DESIGN OF SPECIAL MACHINERY AND TOOLS

BY DONALD BAKER[2]

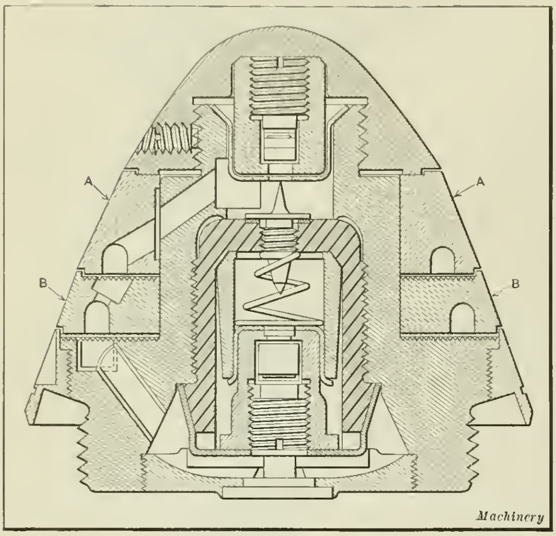


Fig. 1. Type 80 Time Fuse for which Upper and Lower Rings A and B are to be made

CONTRACTS for making many millions of types of time fuses, which have been placed in this country during the past two years, have led American manufacturers and mechanics to study the methods and machinery employed in this industry. There are many features of this work which are not encountered in other lines of manufacturing, and the difficulties experienced led many firms who took contracts to turn the work over to others who were better equipped or more successful in securing the desired results. It is the purpose of the present article to describe the manufacture of two parts of the Type 80 fuse, a cross-sectional view of which is shown in Fig. 1. The parts under consideration are the top ring *A* and the bottom ring *B*, which are shown in position in Fig. 1 and in detail in Figs. 2 and 3, respectively. These are the parts with which American fuse manufacturers have experienced the most difficulty. In the factory where the writer is employed these rings are formed under a punch press, the center hole is reamed, and one side faced, after which the work is placed on an expanding draw-in chuck to provide for turning the outside taper and cutting the groove in the face. After these operations, the work is sent to the shop in which all subsequent machining operations are performed.

[1] For other articles on fuse manufacture and allied subjects published in MACHINERY, see "Under-cutting Machine with Finger Guard," June, 1916; "Machine for Cutting Powder Train Grooves," May, 1916; "Making Cartridge Cases on Bulldozers and Planers," January, 1916; "High-explosive Shell Manufacture," December, 1915; "Metals Used in the Manufacture of War Munitions," November, 1915; "The Heat-treatment and Testing of Shrapnel Shells," September, 1915; "Shrapnel and Shrapnel Manufacture," April, 1915; and "Machining Shrapnel Shells," March, 1915.

[2] Address: Williams Mfg. Co., Ltd., Montreal, Canada.

Operation 1: Drilling Escape Hole.—The first machining operation consists of drilling the escape hole *A*, Fig. 3; and the accuracy obtained is a matter of particular importance, because the work is located from this hole for most of the following operations. The work is held in an ordinary latch jig similar to the one shown in Fig. 11, except that no locating pin is required.

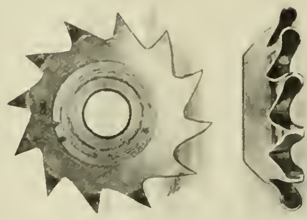


Fig. 4. Cutter for milling Powder Train Groove (Worn by Use)

Operation 2: Rough-milling Powder Train Groove.—It is the usual practice to mill the powder train groove *B*, Fig. 3, by one continuous cut, using a cutter of the end-mill type; but we found that the use of a circular cutter of the form shown in Fig. 4 made it possible to take a heavier cut at higher speed. About 0.005 inch is left on a side for finishing, and one roughing and one finishing machine have about four times the capacity of a single machine in which it is attempted to finish the groove by taking one cut with an end-mill. Figs. 5 and 6 show the machine used for this purpose, and Figs. 7 and 8 illustrate details of the design.

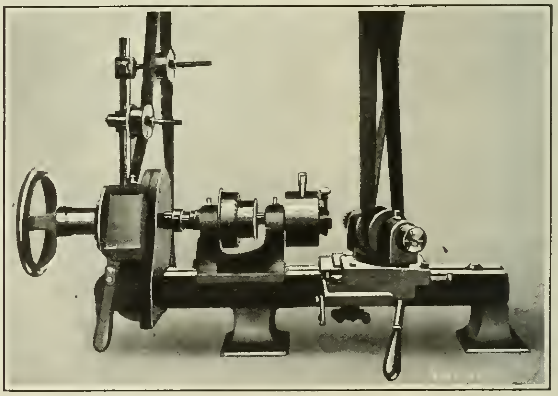
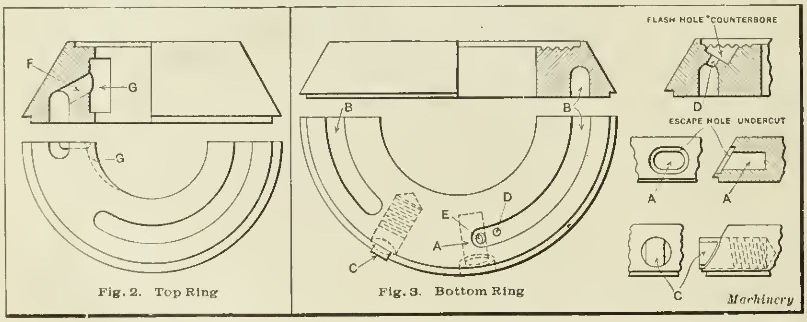


Fig. 5. Front View of Machine for roughing out Powder Train Groove

Referring first to Figs. 5 and 6, it will be noticed that the roughing machines are reconstructed bench lathes, having the usual bed and head but equipped with a special driving and feed mechanism, chuck and cutter-head, the latter being mounted on an adjustable slide. The feed mechanism is shown in detail in Fig. 7, and consists of spindle *A*, on the right-hand end of which there is a collar having two projecting pins which engage holes in a similar collar on the lathe spindle. This arrangement permits of the ready removal of the lathe head when it is in need of repair, without the necessity of disturbing the feeding mechanism. At *B* is shown a worm-gear which is a free running fit on the spindle, while at *C* there is a worm that is driven through a train of gears as illustrated in the lower left-hand corner of the illustration. Collar *D* has a number of holes drilled and reamed through it, which are tapped at one end to take the screws *E*, springs *F* and rawhide or fiber plugs *G*. This collar is pinned onto the spindle



Figs. 2 and 3. Detail Views of Top and Bottom Rings shown in Position in Time Fuse in Fig. 1

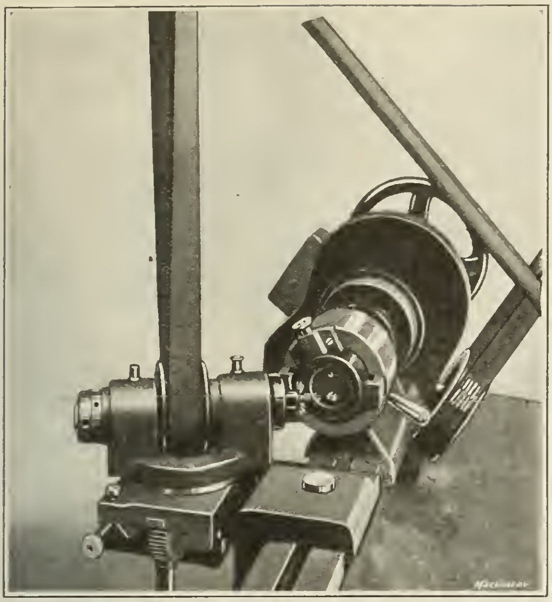


Fig. 6. End View of Machine shown in Fig. 5 for roughing out Powder Train Groove

and plungers G act as a friction on the side of the worm-gear; springs F are so adjusted as to give just the right amount of friction for driving the work against the cut, but not enough to strain the machine when index lever H drops into the slot in index plate J and brings the feed to an instant stop before the belt shifter has a chance to throw off the power entirely from worm C. The countershafts are of the usual bench lathe type which have shifters arranged to be worked by a wire leading down to a foot-treadle. Here, however, the wire is led

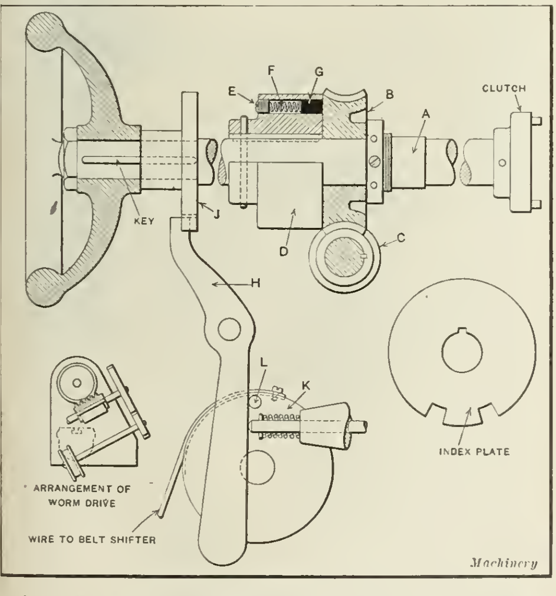


Fig. 7. Arrangement of Friction Feed Mechanism on Powder Train Groove Roughing Machine

down and up again over pulleys to sheave K, from which pin L projects and is held in contact with lever H so that motion of the lever back and forth rotates the sheave and shifts the belt accordingly. A better idea of the index plates will be given from the view shown at the right of the illustration, where the slots are shown which control the starting and stopping positions for regulating the length of the powder train groove.

Chuck for Roughing Machine

The type of chuck which is used to hold the rings on the roughing machines is shown in Fig. 8. This consists of a body A, outer sleeve B, locating nose of hardened steel, two jaws C, two slides D, coil springs E, shank F and handle G. The chuck as shown is closed; to open it handle G is thrown back in the direction indicated by the arrow, which rotates sleeve B that is threaded on the inside at one end and has two cam slots H cut in the other end. Rotating sleeve B causes chuck jaws C to be forced out, as their inner ends are threaded and engage with the threads on the sleeve. When the sleeve has been rotated far enough, the jaws are forced

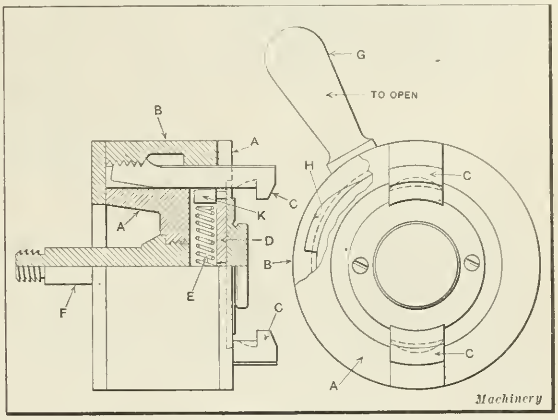


Fig. 8. Chuck in which Rings are held while roughing Powder Train Groove

back into cam slots H by the slides D, which are actuated by coil springs E acting against pins K that are riveted fast to the slides. Reversing the motion of handle G, first forces in the jaws and then draws them down onto the work, thus holding it securely for taking a heavy cut.

Operation of Roughing Machine

Fig. 6 shows an end view of one of the roughing machines in which a ring has just been placed and properly located by

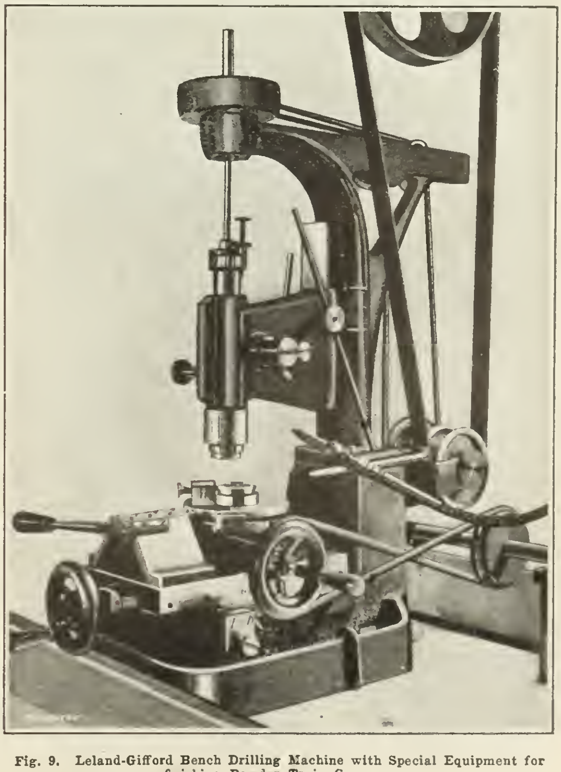


Fig. 9. Leland-Gifford Bench Drilling Machine with Special Equipment for finishing Powder Train Groove

the sliding pin which will be seen mounted on the top edge of the chuck. The jaws of the chuck are ready to be closed over the work by pulling the handle *G* forward. Referring to Fig. 5, the cutter is fed up and into the work by manipulating the hand-lever shown directly under the cutter-head; and when the cutter is in position, it is locked by means of a latch which can be seen hanging down from the left-hand end of the cutter-head slide, this latch being swung over the body of a shoulder screw in the end of the slide. Next, the feed is started by pulling out lever *H*, Fig. 7, which releases the index and at the same time throws on the belt. When the cut is finished, the end of this lever is automatically forced back into an index slot, thus stopping the machine at the right position. Then the finished ring is removed and the operations are repeated. The capacity of these roughing machines is between 1200 and 1400 rings in a ten-hour working day.

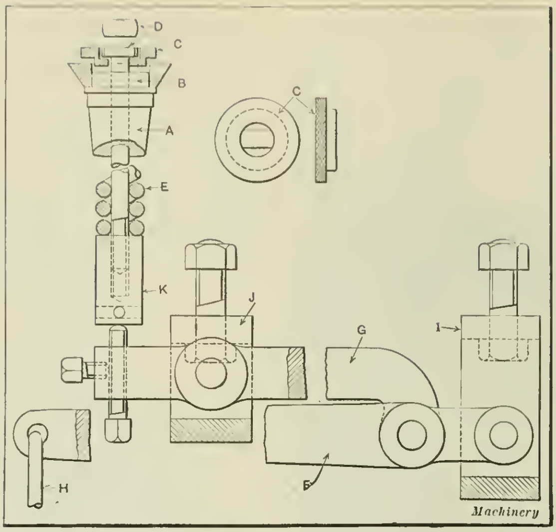


Fig. 10. Work-holding Mechanism used on Machine shown in Fig. 9

Operation 3: Finishing Groove.—From the roughing machines the rings go to the finishing machines, one of which is shown in Fig. 9. These are Leland-Gifford high-speed drilling machines equipped with special spindles to allow of taking heavy continuous cuts with the minimum of vibration. They are also furnished with special tables having a cross-feed similar to a milling machine; and on top of the table a circular milling attachment is mounted. The work is placed on top of the circular table, being positioned by a hardened stud which fits the center hole in the ring and also by a sliding pin which enters the escape hole. This pin has a vertical movement to allow for variation in the height of the escape hole, but no allowance is made for side play.

To hold the work down on the table, the mechanism shown in Fig. 10 is used. Spindle *A* revolves with the table, and has a nose *B* over which the work is placed and held by washer *C* fitted over the T-head bolt *D;* washer *C* is given a quarter turn, so that when the tension is released from spring *E* by removing the foot from a treadle which actuates the compound levers *F* and *G* through rod *H*, this tension will be brought to bear on the washer. Brackets *I* and *J* are fastened underneath the work-benches, and through them pass the levers and their fulcrum pins, while *K* is a long nut for adjusting the tension of spring *E*. After the work is in place the cutter is brought down to the proper depth by operating another foot-treadle, the depth being determined by means of a stop which is plainly shown at the top of the spindle head; the work is clamped in position by the knurled nut shown at the left of the spindle arm, which is split for the purpose. The stops which control the starting and stopping positions will be seen on the edge of the circular table, and they are adjustable by means of bolts which are held in a T-slot passing around the table. One of these stops is shown in Fig. 9, while at

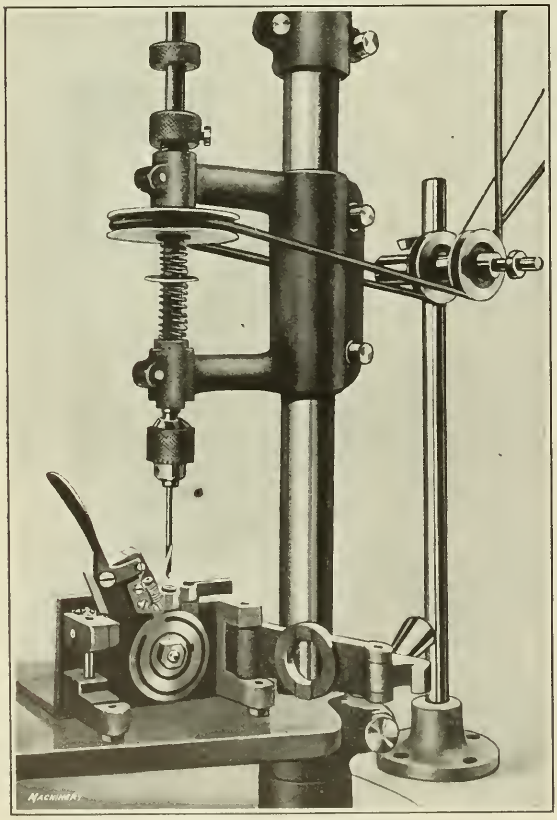


Fig. 11. Machine and Latch Jig used for drilling Setting Pin Hole

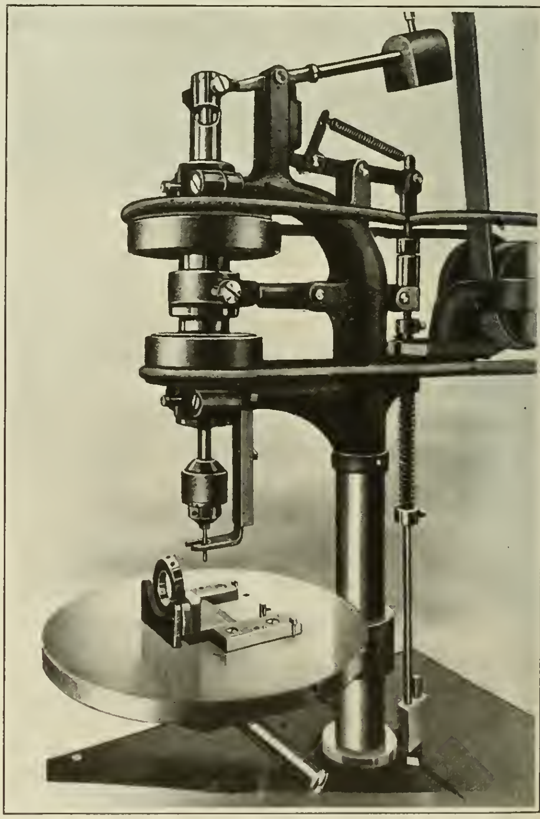


Fig. 12. Machine and V-block Fixture used for tapping Setting Pin Hole

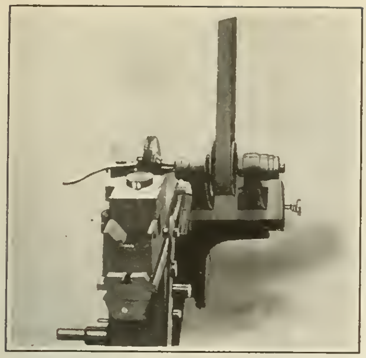


Fig. 13. Hand Milling Machine and Straddle Cutters for slabbing Sides of Setting Pin

the extreme left is shown the lever that operates the draw bolt which the stops strike against. At the front of the illustration, or on the right-hand side of the machine, is shown the hand-wheel used for revolving the circular table; and this wheel furnishes a ready means for applying power feed to the tables by simply cutting a groove in the rim and passing a round belt over it and back to a shaft which runs along the whole length of the bench on which the finishing machines are mounted. This gives a simple and effective feed mechanism, and the belts are arranged to slip when the table carrying the work has revolved and comes to a stop, continuing to slip while the operator is removing the finished ring and replacing it with a fresh blank.

Cleaning off the chips which collect on the work and table is accomplished by means of compressed air, the air hose and nozzle being shown lying across the clutch lever on the right-hand side of the machine, which starts and stops the cutter-spindle. The lubricant used is lard oil, some of the machines being furnished with a pump, while others are lubricated by the operator's dipping a brush in the oil and applying it to the rings and cutters. The capacity of each machine is between 1000 and 1300 finished rings in a ten-hour day. The cutters used for this work are of the end-mill type.

Operation 4: Rubbing off Burrs.—Rubbing off the burr thrown up by the finishing machine is done on a simple machine which carries an endless belt of fine emery cloth over a flat plate which backs it up and makes a perfectly flat surface on which to lay the rings. This operation takes but a second.

Operation 5: Drilling Setting Pin Hole.—Drilling the hole for setting pin *C*, Fig. 3, is done in a latch jig, the construction of which can be plainly seen from Fig. 11. The work is placed over a central stud, and located by a sliding pin which is worked by a finger-lever; then the leaf of the jig is closed and locked by means of the eccentric latch which is here shown open and swung over to the right. As first made, these jigs were not permanently attached to the drill press tables, but it was soon found that through the carelessness of the operators the jigs were often dropped on the floor and damaged. To prevent this, and also to increase the speed of operation, they were finally secured by means of angle-plates made of common steel angle iron planed on two sides to make them perfectly square. These angle irons were bolted to both the jig and the table. Set up in this way, the jigs were always square under the drills and the operators were free to use both hands for actual work rather than for handling the jig. At first, oil was used as a lubricant to prevent unnecessary wear on the drills and drill bushings, as the drill crowds hard against the bushing on account of the point striking against the angular edge of the ring. Later, however, it was found that for this and similar operations where the drill passes through a bushing, common

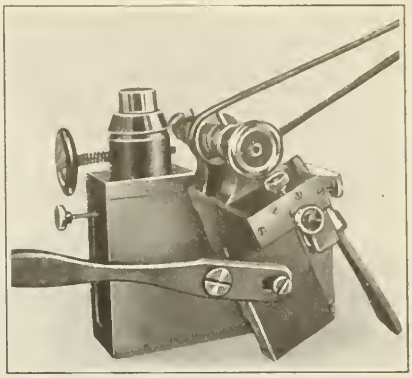


Fig. 14. Machine and Fixture used to mark Lighting Line on Fuse Rings

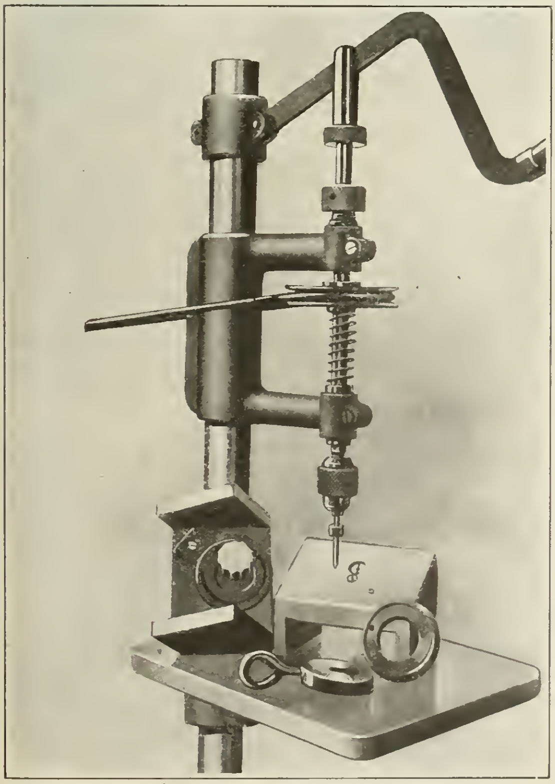


Fig. 15. Machine for drilling and counterboring Flash Hole

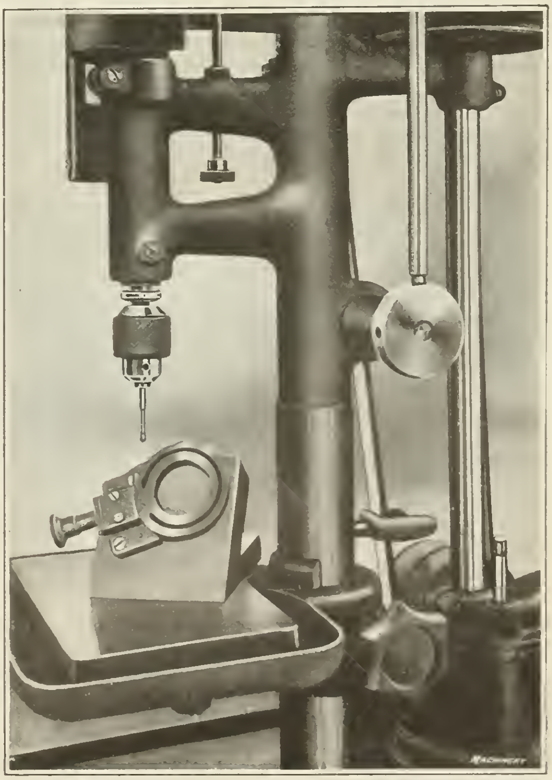


Fig. 16. High-speed Machine for drilling and reaming Connecting Hole

yellow soap gives much better results and leaves the work and the locating points clean, as the chips do not cling to them as they do when oil is used. This is a point well worth considering, as it takes time to clean away the chips from locating points.

Operations 6 and 7: Counterboring and Tapping Setting Pin Holes.—These two operations are performed by holding the rings in a simple fixture of the type shown in Fig. 12, which is to all intents and purposes a simple V-groove and angle-plate that carries the work and slides between two parallel pieces and back against a stop which positions the work under the counterbore or tap. The counterboring is done in a simple drill press, while the tapping is done on the tapping machine shown in Fig. 12.

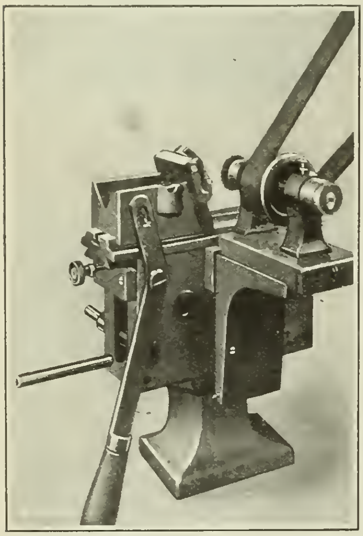


Fig. 17. Hand Milling Machine and Fixture used for cutting off Setting Pin to Length

Operation 8: Screwing in Setting Pin.—This is done by hand, starting the pin with the fingers, then catching the end in an ordinary bench vise and screwing it home.

Operation 9: Cutting Setting Pin to Length.—Fig. 17 shows this work being done on a simple type of hand milling machine. The work is mounted on a stud and the pin swung against a V-groove in a thin bracket secured to the side of the jig. It is held in place with the left hand while the right hand operates a lever at the side of the machine which feeds the work up to the saw. A guard over this saw prevents the operator from getting his hands cut, but it was removed to enable the saw to be seen in the illustration.

Operation 10: Slabbing Sides of Setting Pin.—Another hand milling operation is shown in Fig. 13, which consists of slabbing the sides of the setting pin with straddle milling cutters.

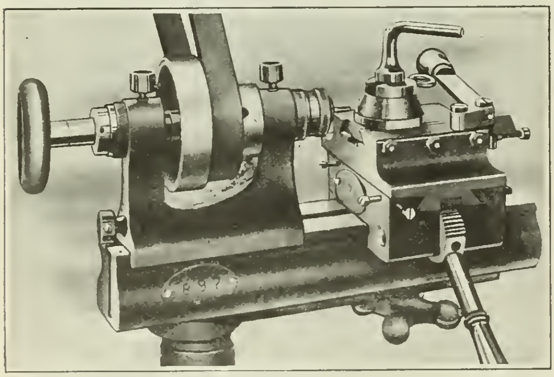


Fig. 18. Machine used for elongating and recessing Escape Hole

The work is placed over a stud shown on top of the slide and properly located by a sliding pin which is actuated by a spring and operated by the finger-lever shown at the left. The two cutters, mounted on the same arbor and spaced the proper distance apart, perform this operation very quickly.

Operation 11: Drilling and Counterboring Flash Holes.—Drilling and counterboring flash hole *D*, Fig. 3, is done on the angular jigs shown in Fig. 15, the so-called "counterboring" being done by using an ordinary twist drill which has been

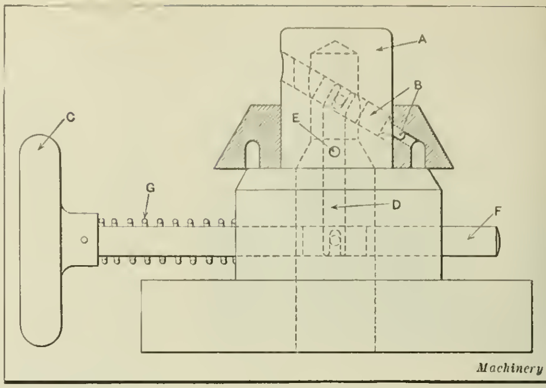


Fig. 19. Fixture used on Lighting Line Marking Machine shown in Fig. 14

ground straight across the cutting edge, with the exception of a little teat in the center that is left to cut a center by which the following drill will be located. The second drill, which is the one shown, is held in a long sleeve and is allowed to project only the short distance necessary for drilling the hole; the sleeve has saw cuts through the sides of it, and is provided with a collar and screw for binding the shank of the drill as it is adjusted after each sharpening. The sleeve also has a bearing in the bushing of the jig, and acts as an additional guide and support while the flash hole is being drilled. This work is done on two small drill presses which are placed

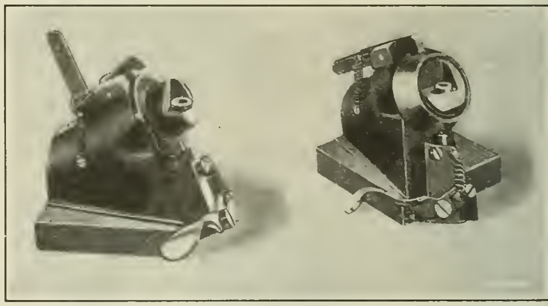


Fig. 20. Two Views of Jigs used for drilling Flash Hole in Top Ring

close to each other, with the tables adjusted to the same height so that the jig may be readily slid from one table to the other. This, of course, is a substitute for the regular multiple-spindle drilling machine usually employed for this class of work.

Operation 12: Drilling and Reaming Connecting Holes.—This is done on Langelier high-speed drill presses running at 10,000 revolutions per minute, the work being held on simple jigs as shown in Fig. 16. The drilling is done with a short, stiff twist drill which needs no bushing to support it, while the reaming is done with a reamer made in the form of a flat drill. This reamer is shown in the illustration. The connecting hole is shown at *E* in Fig. 3.

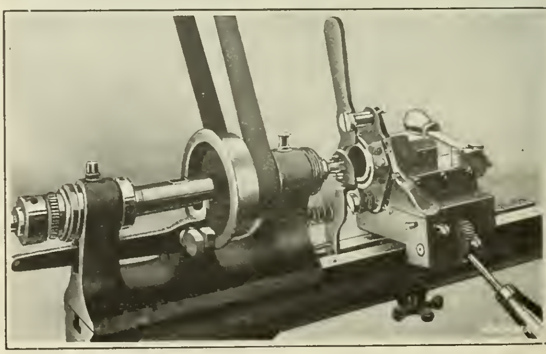


Fig. 21. Machine used for under-cutting Flash Hole

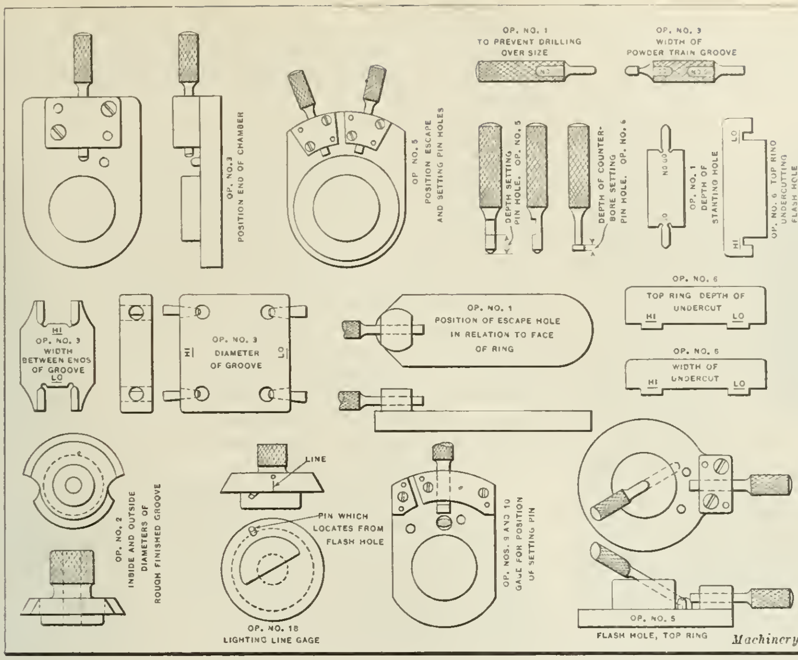


Fig. 22. Miscellaneous Examples of Gages used in testing Fuse Parts

Operations 13 and 14: Elongating and Recessing Escape Hole.—These operations are practically identical so far as the machines and fixtures are concerned, except that the recessing is done with a fixture that holds the work on an angle, one of the elongating machines being shown in Fig. 18. The operation is so simple that it needs little description. The cutters used for elongating the hole are simple four-fluted end-mills, the end teeth being cut to the center, while the recessing cutters are similar, except that they have six teeth and the center is cut away to allow of grinding to the ends of the teeth. Also, they are as short and stiff as they can be made, as their cut is not deep.

Operation 15: Burring Flash Hole.—This is done by hand with a simple three-cornered scraper.

Operation 16: Marking Lighting Line.—The machine for performing this operation is shown in Fig. 14. This is a type of hand milling machine which has a head mounted on slides that are adjustable in both a vertical and horizontal direction, and which can also be swung at an angle as shown. By the addition of the fixture shown in detail in Fig. 19, it became an excellent machine for this work. The machine is operated as follows: The ring is first placed over the locating nose *A* and properly positioned by sliding pin *B*, which has been held back by pressing on knob *C* that operates the pin through lever *D*. Lever *D* is pivoted at *E* and has slotted ends that engage pins passing through push-rod *F* and sliding pin *B*. Spring *G* is for holding push-rod *F* and also sliding pin *B* in place. When the ring is located in the proper position, it is steadied slightly by hand, and the saw is fed up to and across the work to cut the lighting line by operating the large lever shown in the foreground of the halftone Fig. 14, that illustrates the marking machine.

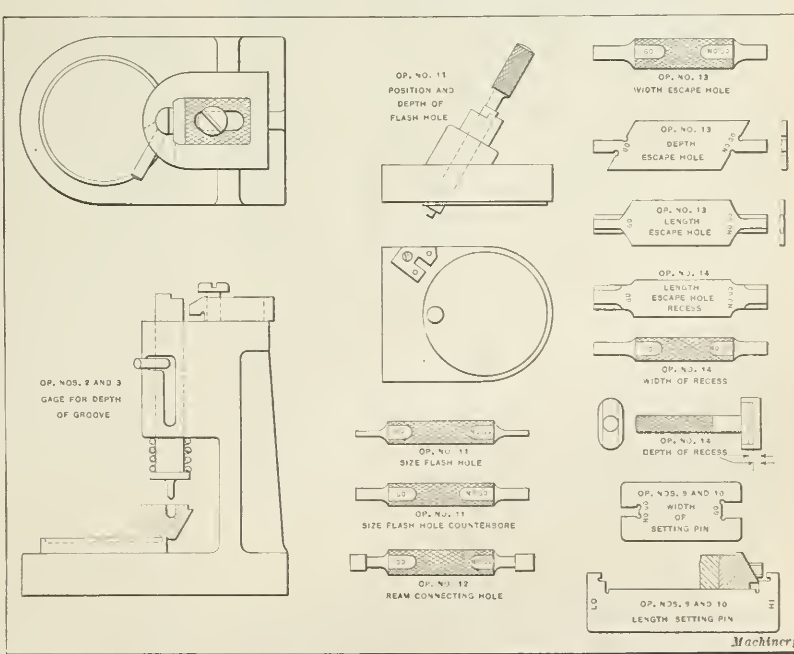


Fig. 23. Other Examples of Gages used in manufacturing Fuse Parts

Additional Operations of Interest

The operations on the top ring, shown in Fig. 2, are practically identical with those already described, except the drilling of the flash hole *F* and under-cutting it as shown at *G*. The jigs for drilling the flash hole are shown in Fig. 20. The ring is placed over the central stud and properly located by a sliding pin which is operated by a thumb-lever; for additional security, the cam clamp shown at the top of the jigs is used. The drill bushing is located in the nose of the central stud, and the lubricant used is common yellow soap. Under-cutting the flash hole is done on the machine shown in Fig. 21; but this machine and its operation were fully described in the June number of MACHINERY, and so no further description will be given here. Figs. 22 and 23 show the gages used on the various operations.

* * *

The field for the application of electric arc welding is an extremely broad one. Practically every industry making use of iron and steel can utilize the electric arc welding process to distinct advantage. In foundries and machine shops many applications for arc welding can be found. Steel mills also use this method with great success. Rolls occasionally chip out. Instead of scrapping the roll or turning it down, one of the large steel companies has found that great economies can be effected by repairing the defective spot by means of the electric arc. The chipped portion is first filled in and welded, after which it is machined or chipped and filed to shape. After the work has been completed, it is practically impossible to detect the point at which the weld has been made except by close examination. The repairs are apparently permanent and will wear as long as any other part of the roll. This company is making all its repairs of this kind with the electric arc, and is also repairing worn wobblers and broken gear teeth in this way.

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BUILDING MACHINE TOOLS FOR STOCK

The past experience of most machine tool builders goes to show that periods of exceptional activity are likely to be followed by times in which the demand for machine tools is relatively light, and that there are comparatively few periods in which the demand approximates a mean condition. But every successful manufacturer must regulate his investment in plant according to the mean demand if he is to secure a satisfactory return upon his investment. Periods of unusual prosperity present a great inducement to increase plant capacity to provide facilities for handling the full amount of business; but when the manufacturer follows this course, he often does so with the feeling that he is taking a speculator's risk as regards the returns on the increased investment that may be expected over a period of years.

Equally important with the maintenance of a balance between plant capacity and mean demand is the holding together of a manufacturing organization during periods of business depression. The most obvious way of conducting business to meet these two conditions is to first determine the manufacturing capacity necessary to produce the number of machine tools that can be sold under normal business conditions; then to develop a plant of this size and operate it at full capacity during slack times, placing unsold product in stock ready for sale at a time when the sales force is disposing of more machines than the factory is able to produce. Money put into stock accumulated in this way should yield a satisfactory return on the investment, because in slack times the cost of materials will usually be considerably below normal and the same is true of wages. Money to provide for the accumulation of stock can be borrowed at a low rate of interest during times of industrial depression. Consequently, machines produced at such times and sold during periods of unusual business activity, will yield a margin of profit considerably above the average. The experience of machine tool builders who have adopted this practice has fully demonstrated the wisdom of following such a course.

* * *

HIGH-SPEED STEEL TESTS

Comparative tests of high-speed steels may be misleading if the results are taken to indicate the real efficiency of the brands tested. Suppose that two steels, A and B, are tested at a cutting speed of, say, 100 feet per minute, and A breaks down after cutting a length of only one foot, while B stands up for ten feet. While there is no doubt that B is shown to be superior to A, the result is not a fair determination of the relative value of the two steels. It might be that if the cutting speed were reduced to, say, ninety feet per minute, A would stand up as long as B. In fact, it sometimes happens that the relative durability at reduced speed is reversed.

In judging of the relative merits of tool steels, it is apparent that a number of factors should be considered besides the actual extreme cutting speeds at which they break down. Is the difference in durability offset by disadvantages as to other characteristics? How do the costs compare? Can the superior steel be obtained of uniform grade, or do bars in the same lot vary greatly? Can it be readily forged? These and other questions may be adversely answered; and if so, the disadvantages may outweigh the slight advantage of mere cutting speed. Of course, if other things are equal, the user is warranted in paying a considerably higher price for an increase of cutting speed as low even as 10 per cent.

* * *

COOPERATIVE SERVICE

A machinist and engineer recently wrote the editor requesting some information on machine shop floors as suggestions for use later when he expected to erect a new shop. The inquiry was answered as part of the busy day's work; an unexpected letter of appreciation for the service rendered was received, from which we quote: "This is certainly a grand service you render those connected with the machine line, and we very much appreciate being able to call on you when needed to solve any such stiff problems where we can profit by others' experience."

The writer hit the nail on the head when he referred to the fact that by writing to the editor he could profit by others' experience. That is just what a mechanical journal like MACHINERY should offer in the way of service—the means by which mechanics the world over may interchange ideas and ask questions regarding problems on which others have had experience. It is by working cooperatively instead of competitively that the plane of mechanical engineering is raised. Common prosperity comes from common knowledge, and every mechanic should be liberal enough to add his little quota of experience whenever it is needed by others.

* * *

VICIOUS CIRCLE OF RISING PRICES

The European conflict has upset economic relations throughout the world, and the waste and non-productiveness of the warring nations are reflected in rising prices for clothing, food and practically every necessity of life. The high cost of living has affected seriously the welfare of workers everywhere. Strikes and demands for higher wages are general. But higher wages mean higher cost of materials and manufactured goods, which, in turn, makes the need of still higher wages imperative. Just how far the index will swing around the vicious circle of rising prices is a serious question. It is evident that it cannot go on indefinitely without causing disaster. Business men should consider to what extent they are contributing to a grave situation when they join in the movement to jack up prices. They should take heed and strive to apply the brakes wherever possible instead of adding momentum to the movement. There is no doubt that the war has been made a pretext for raising prices and adding to profits when the necessity for raising prices did not exist.

The example of one great motor car manufacturer who in the midst of a carnival of price raising has lowered the price of his improved motor car and who pays his employes the highest wages shines as "a good deed in a naughty world." It is evident that what the average manufacturer needs more than anything else is to be shown that improving the efficiency of manufacturing reflects greater credit and gives more profit in the end than mere price raising. Price raising on pretext in prosperous times because trade is brisk is a twin evil of price cutting in dull times to sell goods. Both practices cause instability and are ruinous to prosperity.

HEALTH INSURANCE[1]

POINTS IN WHICH IT DIFFERS FROM WORKMEN'S COMPENSATION—RESULTS OF HEALTH INSURANCE IN OTHER LANDS

BY FRANK F. DRESSER[2]

HEALTH insurance is not a new matter. Bismarck proposed the first compulsory health insurance law in Germany, in 1883, as a sop to the Socialists. Austria and Hungary followed in 1888 and 1891, Luxemburg in 1901, Norway in 1909, Servia in 1910, Great Britain in 1911, Russia and Roumania in 1912, and the Netherlands in 1913. Systems other than general compulsory insurance are found in Belgium, Italy, France, Spain, Sweden, Denmark, and Switzerland.

The need for such insurance in the United States appears from the following data, which, though the sources of information are meager and the data were gathered before the recent rise in wages and costs of living, seem to be agreed upon by the proponents of the measure and are sufficient for the present purpose. Of the wage earners in the principal industries who are heads of families, one-fourth earn less than $400 a year, one-half less than $600, and four-fifths less than $800. Less than one-tenth earn $1000 a year. Of the women, eighteen years old and over, in the principal industries, one-fourth earn less than $200 a year, and two-thirds less than $400. More than one-half the families of wage earners are dependent on other sources of income than the earnings of the family head. These sources are most frequently earnings of wife and children and the payments from boarders and lodgers.

Investigation seems also to show that the workingman's family of average size, that is, father and mother and three dependent children, has required an income of $800 to maintain adequate subsistence. Of this, $650 goes for rent, food, clothing, heat, and light, leaving for all other purposes, including medical care, insurance, and the like, about $150. As the employe in this country apparently loses nine days a year through illness, and as there are some 30,000,000 of wage earners, the wage loss alone at two dollars a day is over one-half a billion dollars; medical care and drugs cost about a quarter of a billion more. The attempts of the workers to distribute their loss by means of industrial insurance, membership in trades union relief funds, fraternal societies, or establishment funds are insufficient. Being purely voluntary, they reach only the thrifty and the less needy.

Proposed Health Insurance Bill

The proposed bill of the Association for Labor Legislation compels all employes earning $100 or less a month, except casual workers not employed for the purpose of the employer's trade or business and some other slight exceptions, to be insured. It excludes the self-employed and the families of workers. When the insured servant is disabled by sickness or accident he receives two-thirds of his wages from the fourth day of disability during disability, but for not more than twenty-six weeks in any twelve months. If he is in a hospital, this cash benefit is discontinued, and instead one-third of his wages is paid to his dependents. Benefits are to be paid for any sickness, accident or death not covered by the Workmen's Compensation Act, and if the insured is entitled to benefits from other sources he shall receive in all no more than 90 per cent of his wages. All necessary medical and surgical attendance and treatment are furnished from the first day of sickness during disability, but not exceeding the twenty-six weeks' period. This includes obstetrical aid to insured women during confinement. All necessary medical supplies, appliances, etc., are to be furnished, but not exceeding a cost of $50 in any year. A funeral benefit of $50 is to be paid when an insured member dies.

The cost of this insurance, including administration expenses and contributions to reserve and guaranty funds, is borne two-fifths by employes, two-fifths by employers, and one-fifth by the state. The employer is compelled to pay to the insurance carrier, on the day he pays his employes, the contribution due from him and from them, but is permitted to deduct the employe's contribution from the wages paid him. Employers in one line of industry may be required to pay sums different from employers in another line, according to the degree of sickness hazard in that industry, and an employer whose establishment shows an excessive rate of sickness may be required to pay an increased rate.

The insurance carrier may be, first, private societies approved by the insurance commission, either labor unions, benevolent or fraternal societies or establishment funds. In such cases the state's contribution is paid to the approved society and the employer's contribution for such of his employes as are insured in any such societies is paid into the state guaranty fund. Second, the carrier may be local health associations or trade health associations. A state is divided into districts, each containing not less than 5000 insured persons. In each district is established one or more local health associations and one or more trade health associations. It is also possible, in a district, for employers or employes in the same line to establish a local trade health association. The government of each association consists of a committee, which elects a board of directors from other than its own members, one-half of each body being employers and one-half employes. An employer is a member of all associations to which any of his employes belong, and he has as many votes in any association as he has insured workmen there, but no employer may have more than 40 per cent of the total vote.

The immediate control of all ratings, of medical service, and of administration is left with the several associations, subject, however, to supervision. The general control is lodged in a state social insurance commission of three members, appointed by the governor. A council of twelve, one-half being employers and one-half employes, is elected by the directors of the several associations. It is their duty to pass on the annual report of the commission and to see and discuss any general regulation of the commission before it is finally adopted. Ten per cent of the state's contribution is paid into a guaranty fund to be used for the relief of any carrier.

An insurance carrier, if it chooses, may also grant additional benefits, such as medical care and supplies to members of the insured's family, funeral benefits for members of the family, cash maternity benefits to insured women, and may extend the period of benefit, but not to exceed fifty-two weeks.

Arguments of Bill's Proponents and Cost of Plan

Like all other legislation based upon the collectivist theory, this bill looks to the advantage of a class and not of an individual and rests upon the principle that the more fortunate or efficient or thrifty among the insured, as well as the community at large, shall share the burdens of the weaker members of society. Its proponents argue that this plan, because it touches the pocketbook of everyone so sharply, will spur on preventive measures and will purchase and distribute medical care. They justify compulsion by the experience here and abroad which shows that voluntary insurance, even if subsidized, does not reach the needy. They justify the contribution of the state and of the employers by saying that the workers cannot bear the necessary cost themselves and must be helped; that it is to the advantage of the state to diminish its expenditure for poor relief and to have a well and self-sustaining citizenry; that it is to the employer's advantage to have more efficient and constant workers; and that to some degree both the state and the employer are responsible for illness among the insured class.

The cost of the plan is problematical. The data in this country are vague, and such foreign data as are available are difficult to transpose into our terms. The German costs have been rising steadily since 1884, the days of sickness per insured have increased rather than diminished, and the duration of illnesses has lengthened remarkably. A similar condi-

[1] Abstract of a paper presented before the National Machine Tool Builders' Association's convention, New York City, October 24, 1916.
[2] Address: American Steel & Wire Co., Worcester, Mass.

tion is observed in other countries having an insurance system. The actuaries' estimates for the British Act have been in several instances considerably exceeded. The state contribution is about twice what it was supposed would be necessary, while less relief is being given than the statute appears to require.

It has been computed, arguing from German and British experience, but realizing the almost total lack of necessary data, that the cost of the sickness, medical, and funeral benefits, including administration costs, but excluding, apparently, any contribution to reserves and the quite considerable sums which employers must in the first instance pay for their accounting department, would be between the limits of 3 and 5 per cent, say about 4 per cent, of wages. Applying this to a single state, say Massachusetts, and assuming the average wage to be $570 a year and that there are about a million persons who would be insured, the cost to that state would be about $23,000,000 annually. Of this amount, the workmen would contribute nearly $9,000,000, the employers $9,000,000, and the state about $5,000,000—an increase in the present state tax of over 40 per cent. The state's contribution, as well as its payment as employer of state and municipal employes, is raised by the general levy upon all taxpayers. The employer's contribution, plus his increased state and municipal tax, will become an item in his cost of production, to be charged, so far as possible in the competitive rivalry of the several states, in the price of his product and paid by the consumer, or else be saved by greater economy, as, for example, reducing wages. A great portion of the consumers are the insured workmen and their families, who thus, besides their direct contribution, will indirectly bear in the increased cost of necessaries or in lesser wages a large proportion of the contribution of the employers and the state. In this, therefore, as in so many similar proposals, it would seem that the class which it is hoped to benefit is made to pay the price.

Objections to Plan

Health insurance is desirable purely as a means of distributing illness loss. If such loss should be distributed, insurance is in some form necessary, and the inability or the disinclination of the lower paid, both here and abroad, to carry insurance voluntarily shows that resort must be had to compulsion. The method of enforcing compulsion adopted in the German, British, and most other systems, as well as in the proposed bill, through requiring employers to collect the contribution due from their employes necessarily limits the benefits of this insurance to servants, and the large class of equally needy self-employed, which in England is assumed to be somewhat greater than the employed class, must be left to voluntary insurance.

In addition, so long as the public thinks the employer and the state are paying any part of the cost, it will be willing to have them pay more. The legislature, influenced by political considerations, will year by year extend the scope of the statute, increase its benefits, alter the proportions of contributions and the like, just as in the compensation legislation, where in the five sessions since the Massachusetts Act was passed it has been altered in sixty-four particulars. The employer seeking to diminish his sickness cost may refuse to employ men likely to be sick. The defective man of any age, or the man who, reaching forty-five, has entered upon the period of increasing illness hazard, will be excluded from regular employment, and, at a time of his greater need, will see his opportunities of earning reduced. Instead of making it easier to employ such men, this plan will enlarge the class of dependents. This has been the result in England. Nor does it follow that the employer will seek to reduce this cost by study and further expenditure for health; he may more easily reduce his costs in other lines.

Health Insurance and Workmen's Compensation Theories

The scheme of health insurance applies, however, to the losses beyond the logical scope of the compensation theory. It includes non-industrial accidents and diseases, invalidity due to either, deaths due to either, and maternity benefits. The health insurance theory is thus capable logically of covering all the enumerated classes of non-industrial losses among all members of the community, but in the proposed bill, besides the limits indicated, invalidity insurance and cash benefits during confinement are excluded. To losses such as these the occupation itself has either no causative or a very slight and doubtful causative relation. Other factors, such as heredity, personal habits, ignorance, lack of public health provision, epidemics, bad home environment, and the like, are the sole or principal causes. The distinction between the compensation and the health insurance theories is clearly shown by considering the effect of hazard and premium. When business is rushing, more men are employed and more are injured; the payroll is larger and the profits are greater. Whether the rate is or is not increased, the premium paid to take care of the increased loss is larger. But when business is stagnant, men are out of work, their wages diminished or ended, and the payroll and profits are smaller, yet the hazard of illness, because of this unemployment, rises. That means both an increase in the rate and in the payments to meet the larger need, but the payments to meet the larger need must come from employers who are making no profits and from employes who are getting no wages.

While in workmen's compensation the hazard and the premium rise and fall together, the rate remaining fairly constant, in health insurance, as the hazard and the rate rise, the premium, or rather the possibility of paying the premium, falls. This difficulty can be avoided only by treating health insurance from a strict actuarial standpoint, undertaken unsuccessfully in England and entirely disregarded in the proposed bill.

The time for choice has come. Will the manufacturers permit these crude and uncertain legislative regulations to continue, agree that industry is responsible for certain preventable inducements to disease, and inflict upon themselves and the community the rule of thumb penalty of health insurance, or will they study the conditions and set about to cure the evils, whether they be evils in the mills or in the general health conditions of the towns? That matter is difficult and costly for the great majority of mills, but it is comparatively simple and inexpensive for a great industry. A committee can determine the limit of effective production of a latheman, clerk, or fireman, can discover the mill conditions of dirt, ventilation, and the like, as some boards of health are now undertaking to do, and can suggest remedies; even a six months' watch of sick workmen will produce a mass of data to prove what is now guesswork.

The possession of such knowledge may prevent much evil legislation, and the application of this knowledge may not only reduce accident and sickness loss, but increase profitable production. In Germany, the average sickness has risen during its insurance experience from six to nine days per year. In the model Leipzig Fund, the average for the years 1888 to 1905 was nine days per year; in 1912, it was 10.4, and in 1913, 11.3. In France, on the other hand, where compulsory insurance does not exist, the workmen lose fewer days of sickness than they did ten years ago.

It is said by a German investigator, Dr. Bernhard, that the knowledge of insurance has sometimes, consciously or unconsciously, caused illness and frequently delays recovery. While before the statute twenty to forty days were sufficient to heal a fractured collar-bone, for example, the doctors have had to revise that estimate, since it now takes about eight months; so a break of the upper arm, for which thirty to forty days used to be sufficient, now lasts four months. Stomach and intestinal disorders became strikingly frequent in the building trades, and no reason for them peculiar to that trade being discovered except that it was seasonal, it was thought that these troubles, difficult to detect, were used as a species of unemployment insurance. As a result of his investigation, he states: "The opinion is gaining ground that we are in reality arriving at the opposite of what was intended. For workingmen's insurance legislation is showing undesirable moral and hygienic results which were originally regarded as a necessary evil, but which are gradually making the blessings of workingmen's insurance appear very questionable. The material to prove the correctness of this proposition is grow-

ing constantly. The most prominent physicians are warning against the threatened consequences; and no one has the right to designate these physicians as 'anti-social' who have had the courage to give utterance to opinions displeasing to the toiling masses."

A similar opinion is voiced by Dr. Naegeli in his inaugural address at the University of Tübingen, while Dr. Friedensburg, former president of the senate in the Imperial Insurance Office (retired), after twenty-odd years' service, ends his article on the "Practical Results of Workingmen's Insurance in Germany" with the words: "I deem it a deed well done to have called attention once again to the all-pervading cancer that is destroying the vitals of our state."

If the matter is considered from the poverty aspect, we realize that the poverty of Europe is not that of the United States. The National Civic Federation Committee quotes Harold Begbie as saying, "There is nothing here, absolutely nothing, to compare with the most shocking and ubiquitous poverty of Europe!" And also an English social worker who, criticizing the statute, said, nevertheless: "Something had to be done. The act gave some relief somewhere, but its principles spring from the gospel of despair."

* * *

COILING SHELBY SEAMLESS TUBING

Shelby seamless steel tubing has some important advantages over butt- or lap-welded pipe for making coils and bends, as well as for the service required of the finished pipe after it has been bent. The uniform quality of the material, even gage of the walls, and freedom from burns, scabs and laminations makes it possible to coil and bend very light gage tubing on very short radii. This, with the wide range of sizes and thicknesses, allows large areas of coil surfaces for heating and condensing in a small space, and the light gages which can be used decrease the heat loss. For extremely high pressures, the freedom from defects, the absence of welds, and the high bursting point make possible a large factor of safety, without excessively increasing the thickness of the tubing.

Fig. 1. Bent Tube for cooling Open-hearth Furnace Door

The Roessing-Ernst Co., Pittsburg, Pa., has been making coils and bends of seamless steel tubing for some time, and has done considerable experimenting in coiling and bending round and special shapes. This firm has special machinery of its own design for making coils and bends in any shape or size without filling, heating, or the use of mandrels. The section of the tubing is not deformed, and the circle and pitch of coils can be made exact. For coils requiring more than one length of tubing, the tubes are placed end to end and electrically welded together, without leaving a ridge or any unevenness either inside or outside. As many lengths as are required for a coil may be joined in this way, and are supported on carriers and rollers. One end of the tube is then started through a machine which consists of a series of rolls that are driven by an electric motor. These rolls are grooved to fit the outside of the tube, and are knurled to draw the tube into the machine and force it through the bending rolls. As the tube comes from the bending rolls, an arm comes into contact with the back of the tube and records on a large dial the radius of the bent portion. By keeping the finger on the dial constant a perfect circle will be made, and by gradually changing the position of this finger a spiral will result. A series of cross rolls are provided which can be raised or lowered to give any pitch required.

Fig. 1 shows a bend made from seamless tubing 2½ inches outside diameter by ¼ inch thick, this part being used in connection with a system for cooling the door of an open-hearth steel furnace. Fig. 2 shows a mold for forming the inner tubes of automobile tires. This is made from tubing 3 inches outside diameter by 1/16 inch in thickness; and the seamless tubing is bent into a perfect circle of 36 inches outside diameter. Fig. 3 illustrates an interesting example in which a number of lengths of seamless tubing have been welded together in order to form a piece of sufficient length for the complete coil. Careful reference to this illustration will show that there are two coils, one inside the other. The outer coil is 3 feet, 6 inches outside diameter, and is made of tubing 3 inches outside diameter by 3/16 inch in thickness. The inner coil is 2 feet, 8 inches outside diameter, and is made of tubing 2½ inches outside diameter by 3/16 inch in thickness. The total length of the finished coil is 21 feet; the outer coil contains 410 feet of 3-inch tubing, and the inner coil contains 300 feet of 2½-inch tubing. These two coils are connected at the ends, and the finished coil is used for condensing light oil in an oil refinery.

E. K. H.

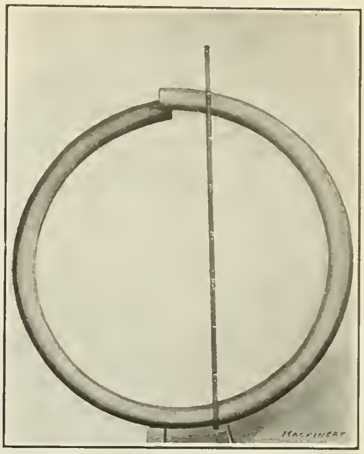


Fig. 2. Mold for Inner Tubes of Automobile Tires

* * *

The manager of a well-known machine building plant in Sweden writes that it is extremely difficult to obtain materials and tools. It is practically impossible to buy high-speed steel drills at any price, and ordinary carbon steel drills are quoted at three times the usual prices. He intimates that the smaller neutral countries are looking to America to take a definite step toward proposing peace, and it seems that the opinion in Sweden is that the United States is neglecting a duty toward the world by making no protest against the continuation of the war. Living expenses are from 50 to 55 per cent higher than usual, and the conditions generally, except in the case of a few manufacturers and dealers, are very bad.

* * *

Dr. Wertheimer, dean of the faculty of engineering of the University of Bristol, England, has proposed the following system of training: A student will attend the university until he has passed the intermediate examination for the B.S. degree in engineering. If his record is good and he is a promising student, he will be recommended to a firm which will allow him to enter its plant for fourteen months. He will then return to the university for two years; after that, if he has given satisfaction, he will return to the plant.

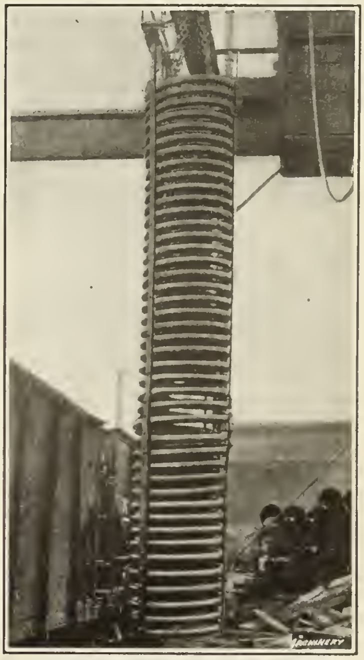


Fig. 3. Double Coil used for condensing Light Oils

Profile and Indicating Gages-2

by Douglas T. Hamilton[1]

GAGES of the indicating type are gradually superseding solid gages on many classes of work because of their greater sensitiveness. For instance, they are used for testing external and internal cylindrical work, parallelism of shafts, relation of angular surfaces, height and depth of shoulders and holes, concentricity of parts, cam shapes, strength of springs, etc. The previous installment of this article dealt with the type of indicating gages used for cylindrical external and internal work; in the following, attention will be given to the other uses mentioned, as well as to the gages used for testing balls and ball bearings, and the use of box-type inspection fixtures for work having a number of holes that must bear a certain relation to each other.

Testing Parallelism of Shafts

For testing the parallelism of shafts, the indicating gage is very satisfactory. One means of determining if a shaft lies in a parallel plane with the base of a machine is illustrated in Fig. 34. In this case it is desired to determine whether or not the needle bar lies in a parallel plane with the base of a sewing machine. The gage consists of a steel base *A* resting on four feet *C*, which, as shown, come in contact with the top surface of the table. These feet are hardened, ground and lapped in the same plane. The hardened tool steel plungers *B* which come in contact with the needle bar are flat on one end and spherical on the other. These plungers fit loosely in the bearings *E* and are held from dropping out by adjusting nuts *F*. The bearings are so constructed as to give a slight turn when the plungers are raised as high as they will go.

Fulcrumed on studs *G* are the pointers *D*, which have hardened projecting arms that are in contact with the upper end of plungers *B*. The sheet steel frame *H* is bent at right angles along the bottom and screwed to the base. Right and left coil springs *L* act in opposition to the plungers so that they turn the pointers to the extreme outer position, when the gage is not in use. When the pointers are to be adjusted, the instrument is set on parallels, and a height gage inserted under each plunger successively, the plungers *B* being adjusted so as to bring the pointers to zero. On this particular gage a limit of $\pm$ 0.005 inch is provided.

Testing Relation of Surfaces at Right Angles

Many different indicating devices have been constructed for testing the relative positions of angular surfaces, and in Fig. 35 is shown a simple gage for determining if the base of a gas engine cylinder casting is square or at right angles with the bore. This gage consists of a base *A*, frame *B*, pivot *C*, and indicating lever *D*. The body of the gage is made in two parts to facilitate machining. The indicating lever support is fastened to the body with screws and dowel-pins, and extends into the cylinder so that the center of the lever pivot is somewhat below the face of the flange of the casting. By placing the gage on the cylinder flange and bringing the knife-edges *a* and *b* on the lever into contact with the cylinder wall, any variation is shown by the mark at the upper end of the gage. This can be so laid out that plus or minus limits can be provided. The reason for placing the pivot below the cylinder flange is to have it receive the thrust when the indicator is moved against the side of the cylinder bore. A spring above the pivot holds knife-edges *a* and *b* in contact with the cylinder wall. The gage is simple in construction and operation.

Indicating Height and Depth Gages

For determining the relative heights of two shoulders, a height or depth gage is necessary. Gages of the multiplying lever or dial indicating type are best adapted for this purpose. Fig. 36 shows a height gage constructed on the multiplying lever principle. This consists of a base *D*, having two shafts *E* fastened to it and connected at the top by a link. On these shafts is a sliding member *G*, which can be locked securely in any position by screw *H*, acting upon two clamping bolts, thus obviating springing of the gage when in use. The adjusting nut *C* operates part *I*, which is carefully fitted in the slot. On the same part is a shoulder *J* to which the arm *A* is fastened. This arm is made from tubing and is similar in shape to opening *K*. It is made a tight fit on the holder at *J*, and a pin put through to fasten it securely. The oblong tube *A* is now cut along the line *Z–Z*, and inside of it are placed the levers which are arranged to give readings to one-half thousandth inch. While this gage has many admirable features from the point of view of accuracy, it is of little value except for tool-room use. In the first place, it is too complicated, and in the second place, it is too easy for the machine operator to "fake" the gage. It is evident that a gage designed for any particular piece should be so made that universal adjustment is not possible. In other words, its range should be limited to the particular work for which it is designed.

Indicating Gage for Testing Over-all Length and Thickness of Base of Shrapnel Shells

An indicating gage which fulfills two functions—gaging the over-all length, as well as the thickness of the base of shrapnel shells—is shown in Fig. 37. This gage comprises a base *A* in which three pins are driven to center the shell, an upright *B* for supporting the indicating mechanism, and attached to the top of upright *B* an indicating lever support *C*, which

[1] Associate Editor of MACHINERY.

is so mounted that it is free to swing in an arc. The device for indicating the thickness of the base of the shell consists of a rod D that has a hardened and ground tool steel point E and a limit pin F. A boss formed on bracket C is provided with a step, the height of which is 0.020 inch, or the manufacturing limit allowed on the thickness of the base. The limit pin F, when brought around, coincides with either one of these points, according to the thickness of the shell. The desired thickness, of course, is indicated when the lowest surface of limit pin F is located equidistantly between the high and low points on the limit step. To insert the shell in the gage, it is necessary that rod D be removed from bracket C.

The indicating device for the over-all length consists of a multiplying lever G, pivoted to bracket C at the point H, and attached by a pin to plunger I. Plunger I is hardened and ground on its lower surface and contacts with the end of the shell. The reading is obtained from the segment J, which indicates the limits on the work. It will be noticed that this fixture is free from springs and is of simple construction.

Indicating Thickness Gages

The simplest form of indicating thickness gage is the micrometer caliper, but as this type of gage is well known, it

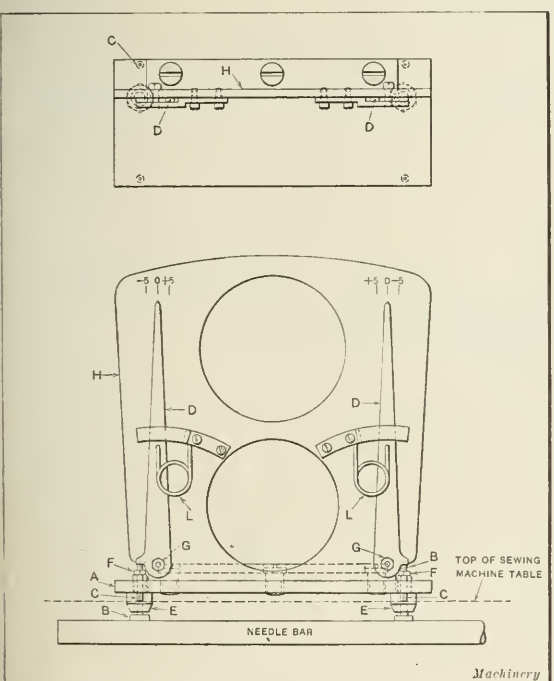


Fig. 34. Indicating Gage for testing Parallelism of Shaft

will not be described here. Another simple form of indicating thickness gage is shown in Fig. 38. This was designed especially for gaging the thickness of the wall of cartridge cases near the head end. It consists principally of two caliper jaws A and B, which are made long enough to reach down into the case, a handle C for holding the gage, indicating pointer D and graduated arc E. A combination locating stop and support F is also provided to keep the jaws in alignment with each other, and locate their measuring points at the desired distance from the open end of the case. In use, the jaws of this gage are slipped over the walls of the case, and readings taken at various points around the circumference. It is tested from time to time by the setting block G.

Another indicating thickness gage which is used for the same purpose as that illustrated in Fig. 38 is shown in Fig. 39. As this illustration shows, this gage is of the stand type, and supports the cartridge case being inspected, by means of a horseshoe support A held on upright B. Two other posts C and D carry the gaging points, one of which, E, is held rigidly in post C, whereas point F is free to slide and is kept out by

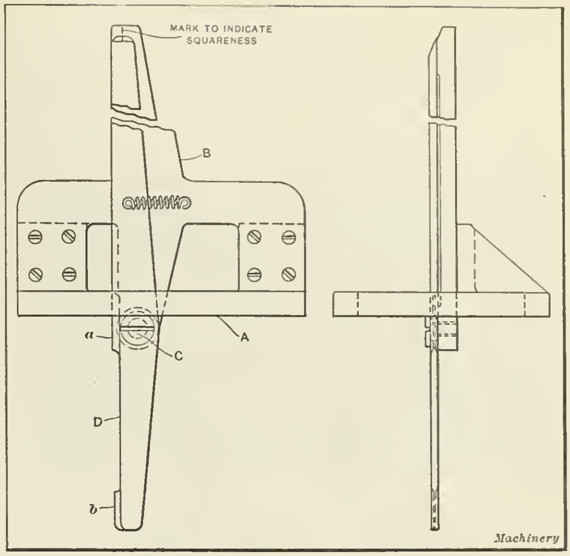


Fig. 35. Indicating Gage for testing Squareness of Base of Cylinder Casting with Bore of Cylinder

means of spring G. The upper end of post D is notched to form a limit step, and plunger F is provided with a line which must line up between the two steps when the wall is of the correct thickness. A height gage H is also provided which enables the thickness of the head to be checked at the same time that the wall is being inspected.

Indicating Thickness Gage for Shrapnel Shells

An indicating gage for testing the thickness of the walls of shrapnel at a point slightly above the powder pocket where the inner wall is straight is shown in Fig. 40. This consists of a sheet-steel frame A carrying a bushing B which fits in the nose of the shell, a roll support C for keeping the gage in line with the axis of the shell, and two measuring points D and E. Measuring point D consists of a hardened, ground and lapped block, which is riveted to the frame A, whereas point E is a roll attached to a multiplying lever F. Lever F swings over a marked segment G which indicates the limits on the work, and a flat spring H keeps roll E in contact with the work. In using this gage, the member I is inserted in the shell and located by bushing B. The gage is gripped by the handle and moved around the circumference of the shell to test its thickness at various points. Block J is used to test the gage for wear.

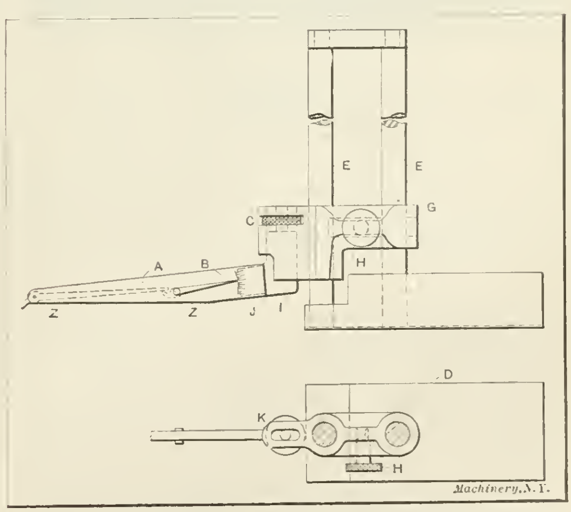


Fig. 36. Indicating Height Gage which is Objectionable because of its Wide Range of Application and Possibility of being tampered with

Concentricity Gages

There are several methods of determining whether or not a hole and an exterior surface are concentric with each other. The simplest way is to use a gage of the type shown in Fig. 41. This is not an indicating gage, but is shown here simply to illustrate the least expensive type of gage for concentricity gaging. It is built along the lines of the standard plug gage, with the exception that it is provided with a limit bar which controls the amount of eccentricity of the hole and the exterior surface. It will be noticed that bar *A* is provided with a step giving the "Go" and "Not Go" limits. It is also formed to a knife-edge to reduce the amount of bearing surface to the minimum. The plug *B*, of course, goes in the hole in the work and the knife-edge on bar *A* is located at a distance from the axis of the plug equal to the radius on the work.

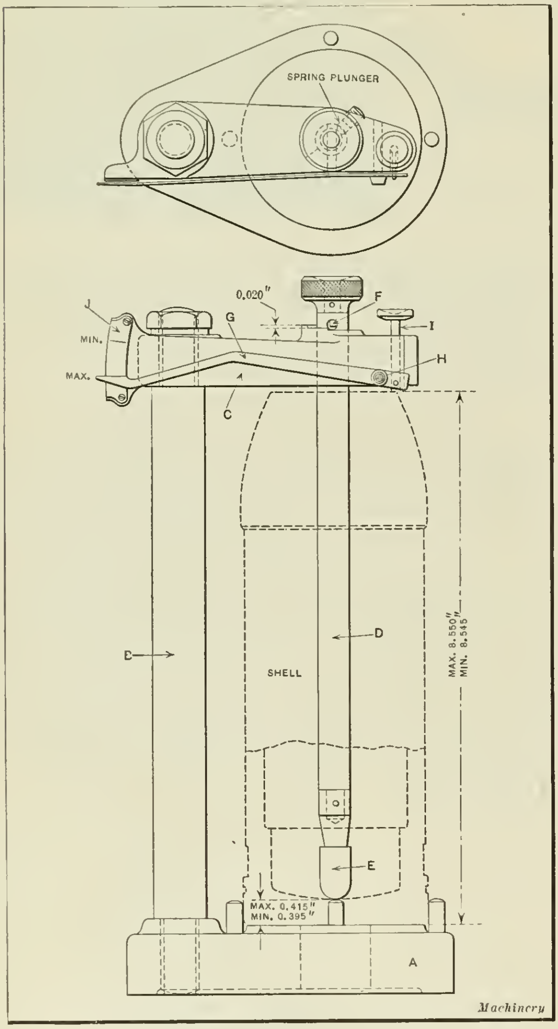


Fig. 37. Indicating Height Gage used for inspecting Thickness of Base and Over-all Length of Shrapnel Shell

Another simple gage that is used to test the relation of one hole to another, the two holes being eccentric to each other, is shown in Fig. 42. This gage is of simple construction and is also built along the lines of the plug gage, having two ends, one giving the "Go" and the other the "Not Go" size. The gage consists of a body *A*, in which two plugs *B* and *C* are fastened by pins, as shown. Two disks are also fastened to the faces of plugs *B* and *C*, one disk *D* being made so that it enters one of the holes in the work, which is a combination time fuse powder train ring. The other disk *E* is made to fit in the hole which is eccentric to the one in which plug *D* fits. Plugs *D* and *F* are of the same size, whereas plugs *E*

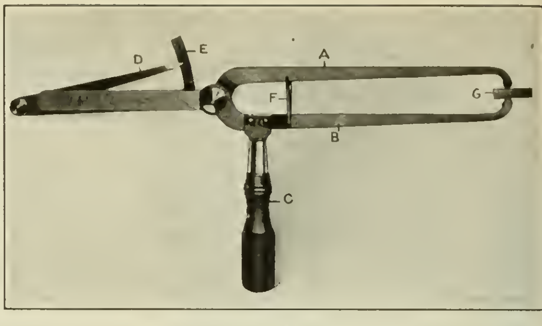


Fig. 38. Caliper Type of Thickness Gage for testing Thickness of Walls of Cartridge Cases

and *G* are of different sizes, the difference in diameter being such as to control the manufacturing limits on the work. The center location of the two disks in relation to each other is the same on both ends of the gage, the difference in diameter being the factor that controls the limit on the work. In using this gage, the work is tried on first the "Go" and then the "Not Go" end. If plug *E* goes in and plug *G* does not, the work is satisfactory.

Testing the Squareness and Concentricity of Piston-pin Holes with Body of Piston

Two interesting gages, one for testing the squareness of the piston-pin hole with relation to the exterior surface of the

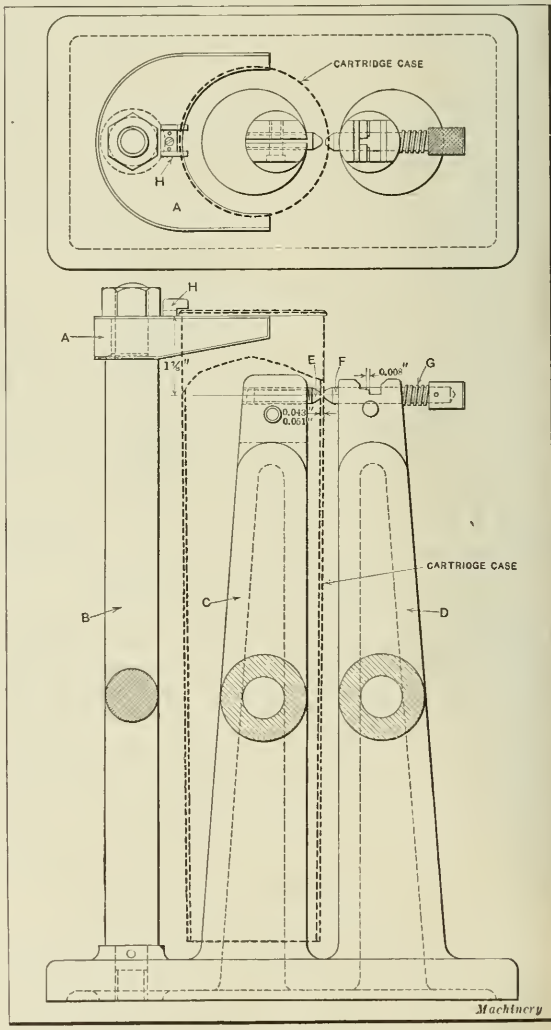


Fig. 39. Stand Type of Indicating Thickness Gage for testing Walls of Cartridge Cases

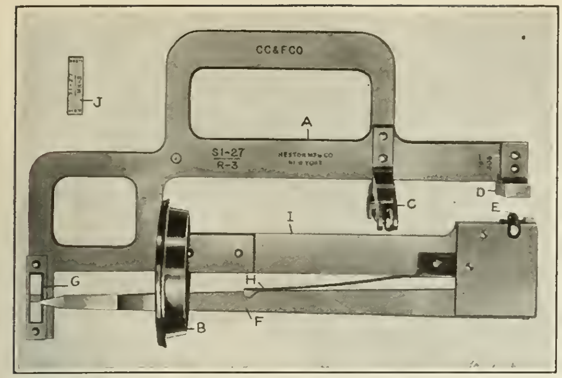


Fig. 40. Indicating Thickness Gage for testing Thickness of Walls of Shrapnel Shells

piston, and the other for testing the concentricity of the piston-pin hole with relation to the exterior surface of the piston, are shown in Fig. 43. The gage shown at *A* is for testing the squareness of the piston-pin hole with relation to the body of the piston, and consists of a plug *a*, which is made a good fit in the piston-pin hole, and carries a bracket *b* held in place by a screw *c*. Bracket *b* carries a micrometer spindle *d* which is used for testing the squareness of the hole.

In applying this gage, the plug is pushed into the piston-pin hole until the shoulder *e* contacts with the surface of the piston. The micrometer spindle is then brought to bear first at one end—near the head—and then near the base of the

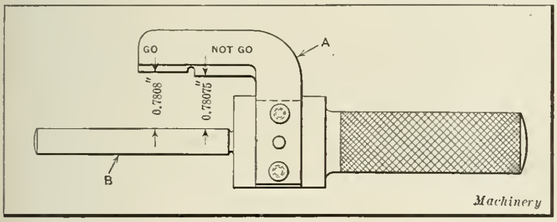


Fig. 41. Simple Type of Concentricity Gage based on Limit Principle

piston, and the amount of variation between the two points is read off on the thimble of the micrometer. The plug is made to enter freely enough into the piston-pin hole, so that the gage can be turned around to bring the micrometer spindle into the desired position.

The gage shown at *B* is of somewhat similar construction to that shown at *A*, except that a dial indicator is used in place of the micrometer screw. The dial indicator *f* is held in a bracket *g*, as illustrated, and is adjusted in this bracket so that its indicating point or plunger comes directly in line

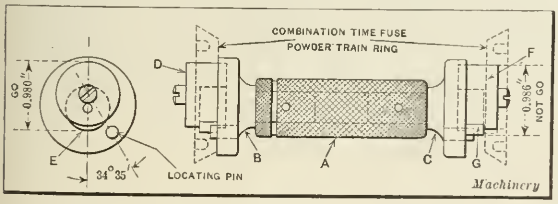


Fig. 42. Another Concentricity Gage of the Plug Type

with the vertical axis of the piston when shoulder *h* of the plug is in contact with the surface of the piston. After one side of the piston has been tested, the gage is turned around and the other side tested to see if the piston-pin hole is exactly central with the exterior surface of the piston. The gage is provided with two feet, as shown, for supporting it.

Method of Testing Concentricity of Gear Blanks

One method of testing work to see whether it is concentric or not before machining is shown in Fig. 44. This illustration shows a dial indicator testing gear blanks which are to be cut on a gear-hobbing machine. After the series of blanks is fastened on the work-holder and the work-holder supports are put in place, the dial indicator is brought in contact with the work and held by clamps as shown. The work-spindle is then rotated, and the movement of the dial indicator shows whether the exterior surface runs true or not. If not, it is an indication that the work has not been accurately machined or that the work-arbor has been thrown out of correct align-

Fig. 43. Indicating Gages for testing Squareness and Concentricity of Piston-pin Hole in Relation to External Diameter of Piston

ment. By taking this precaution, the chance of cutting poor gears is reduced.

Testing Concentricity and Radial Position of Cutter Teeth

A testing device used by the Union Twist Drill Co. for determining whether the teeth of milling cutters are equidistant from the center or not, so that they will do their correct share of the work, is shown in Fig. 46. This fixture also determines, by means of a separate indicating needle, whether the teeth

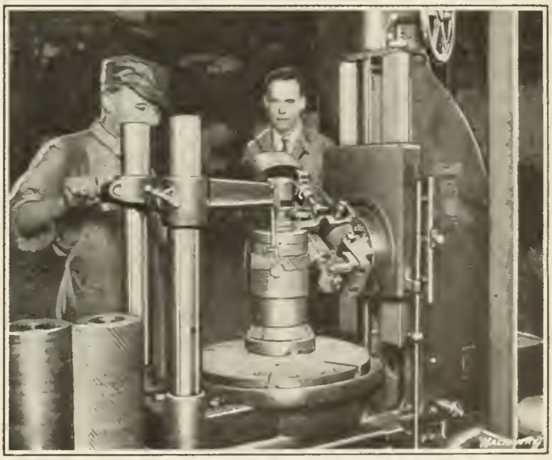


Fig. 44. Testing Concentricity of Gears on Gear-hobbing Machine

are radial or not. It consists of a base carrying an adjustable stud on which the cutter to be tested is held, bushings being supplied for fitting different sized holes in the cutters. The cutter is then brought up to the micrometer spindle and rotated to determine if all of the teeth are of the same height. The work is then shifted over to the indicating pointer, and this is brought in contact with the face of the teeth. If the teeth are radial with the center, the indicating mark on the

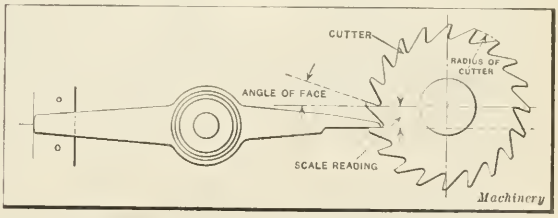


Fig. 45. Diagram illustrating how Indicating Lever for Under-cut Teeth is set off Center on Fixture shown in Fig. 47

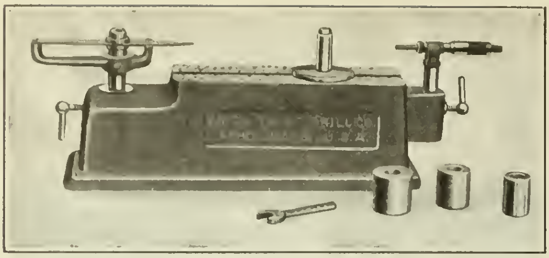


Fig. 46. Fixture for testing Concentricity of Periphery and Bore of Milling Cutters and Position of Face of Cutter Teeth of the Radial Type

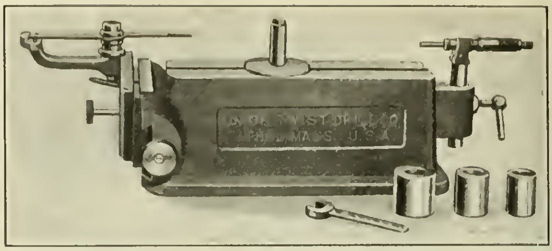


Fig. 47. Similar Device to that shown in Fig. 46, for testing Under-cut on Teeth of Milling Cutters and Hobs

opposite end of the pointer registers zero on the arm of the fixture.

A fixture which can be applied to milling cutters or hobs having under-cut teeth is shown in Fig. 47. This gage indicates if the cutter is true, if the teeth are equidistant from the center, and if the proper amount of under-cut is provided. The faces of the teeth are tested by means of a finger mounted on a slide. Readings can be taken from the scale shown at the left-hand end of the gage, which is graduated in fiftieths of an inch. The proper readings can be obtained by multiplying the radius of the cutter by the following constant for different angles of face, or under-cut:

Angle of Face or Under-cut, Degrees	Constant, Inches
5	0.087
10	0.174
15	0.259
20	0.342
25	0.423

Fig. 45 shows how this reading is obtained. For testing if the faces of the teeth are radial, the slide on the fixture in Fig. 47 is brought to zero, and consequently does not have any lateral movement. When the teeth are under-cut, however, the fixture is moved over the amount given by multiplying the constant by the radius of the cutter, and the pointer should then indicate zero if the cutter is correct. The opposite end of the fixture carries a micrometer test instrument for determining whether the points of the teeth are equidistant from the center or not; in other words, if the hole and points of the teeth are concentric with each other.

Concentricity Gage for High-explosive Shells

Fig. 48 shows a simple type of indicating concentricity gage for inspecting high-explosive shells. This consists of a base *A* carrying an arbor *B* on which there are two bushings, both slightly tapered. One bushing fits the hole near the bottom and the other at the open end or nose. The shell is simply held on the fixture by hand and rotated to determine whether the exterior surface is concentric with the bore or not. The concentricity of these two surfaces is determined by means of a multiplying lever arrangement, consisting of a movable plunger *C*, link *D* and pointer *E*. Pointer *E* is fulcrumed at the point *G*, giving a multiplying movement of 12 to 1. In other words, a variation of 0.001 inch in the work moves the extreme end of the pointer 0.012 inch.

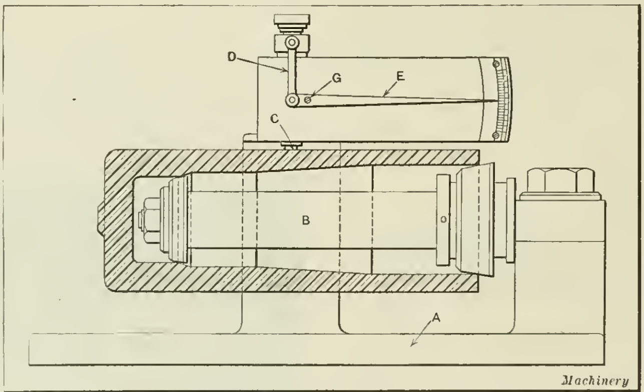


Fig. 48. Simple Type of Indicating Concentricity Gage for High-explosive Shells

Gage for Testing Concentricity of Shrapnel Shells

An indicating type of concentricity gage for testing shrapnel shells is shown in Fig. 49. This differs from that shown in Fig. 48 in that the shell is supported from the exterior instead of from the interior surface. It comprises a base *A* provided with several bosses for holding the indicating lever mechanisms, as well as the rolls *B* and *C* for supporting and positioning the shell. Rolls *B* are so positioned that the axis of the shell is inclined to the base of the fixture at an angle of 5 degrees, 25 minutes. This is done to keep the base of the shell constantly in contact with the roll *C*, and thus locate it properly in relation to the contact point of the indicating levers. The two points on the shell which are tested for concentricity are the bore of the powder pocket and the exterior surface of the shell close to the base.

The indicating mechanism which determines the concentricity of the powder pocket consists of a rod *D* to which a handle *E* is attached, provided with a flattened end fitting in the corresponding slot in the boss on the fixture. The indicating lever *G* is fulcrumed at the point *H* and swings over the arc *I* provided with three points, mean, low and high. The indicating device for the exterior of the shell is held on a post *J* and consists of an arm *K* held between two adjusting nuts *L*. The indicating lever *M* is fulcrumed at the point *N* and swings over the scale *O*, having marks, mean,

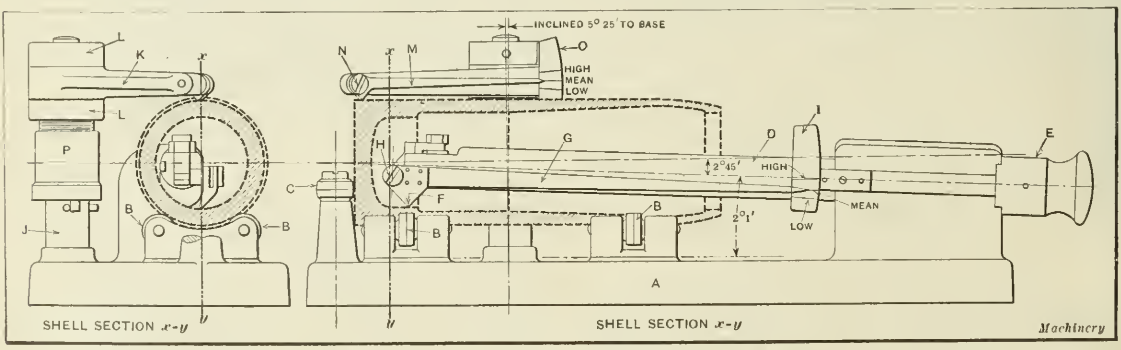


Fig. 49. Gage for determining Concentricity of Powder Pocket and Exterior Surface near Base End of Shrapnel Shells

low and high. In order to locate the point of the fulcrum lever *M* directly in line with the vertical axis of the shell at its highest point, the bushing *P* is provided, carrying a pin which comes in contact with stop-pins in the rod *J*.

Inspecting Cams on Gas Engine Cam-shaft

A class of gaging which requires accurate and careful inspection methods is the testing of cams on gas engine camshafts. These cams must be tested for shape, lift and angularity of position. The requirements are that the profile of the cam between the opening and closing points must fit a contour gage having limits of ± 0.003 inch. When the concentric part of the cam is within the limit of tolerance, which is 0.001 inch, the body plus the lift must be correct to within 0.003 inch. The arc of the opening and closing points on the cam must be correct to within ± 1½ degree. The relative positions of the opening and closing points on all cams must be correct to within ± 1 degree, and this error must not be cumulative. The usual clearance provided between the top of the valve lifter and the lower surface of the valve stem is from 0.003 to 0.010 inch.

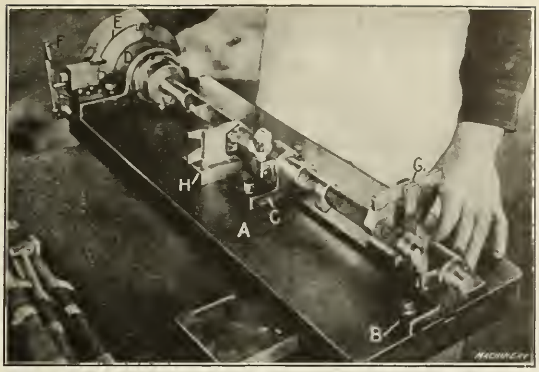


Fig. 50. Simple Type of Gas Engine Cam Testing Fixture for determining Shape of Cam, Angularity, Lift, etc.

A simple method of accomplishing this work, which, while not employing the indicating type of gage, is of sufficient interest to warrant description here, is shown in Fig. 50. This fixture is used for testing the position of the cams on an integral four-cylinder engine cam-shaft. The fixture comprises a bedplate *A* on which three brackets *B*, *C* and *D* are held. Brackets *B* and *C* are used as supports only, and are provided with hinged caps held by thumb-screws to facilitate the insertion and removal of the cam-shaft. The bracket *D* carries a special chuck for gripping the work and is furnished with an index plate *E* which has eight notches to correspond with the number and position of the cams on the shaft. This disk is located in the various positions by a tapered plunger that is held in contact with the disk by a spring and is removed by the handle *F* to index the disk. The highest point of the cam is tested by the T-gage *G*, which has "Go" and "Not Go" ends on the bar G_1. The angularity and shape of the cams are tested by the V-gage *H*, which is provided with knife-edge points and is used in connection with the indexing disk. This gage also has "Go" and "Not Go" V-grooves, which are made to the exact shape desired. The brackets on this gaging fixture are all located from a central groove in the bed which keeps them in correct alignment.

Another method which employs the use of a dial test indicator is shown in Fig. 52. This device is of comparatively simple construction and consists of a base *A* sufficiently heavy to stand firmly, and a vertical support *B* held in the base by means of screws. The upper end of the support is drilled and reamed to receive the shank of the dial indicator *I*, and is split and provided with a screw to clamp it. The indicator point *P* is a spherical segment whose radius *r* is one-half the diameter of the cam roll. The center line of the indicator must be in the same position in relation to the cam-shaft that the roll is in the gasoline engine, which in this case is on the center line of the camshaft. The distance *d* is then one-half *D* and the height *H* is such as to give a good contact between point *P* and cam *C* and allow the full limit of the indicator movement.

In use, the cam-shaft is provided with a dog and mounted between the index centers of a suitable fixture. The first step then is to find the center of the keyway for the cam-shaft gear, as the cams are generally laid out with reference to a keyway. Assuming that the cam is of the shape shown in the illustration, and the center coincides with the center line of the keyway, also that the opening and closing points are in the position occupied by the cam rolls *R* represented by the dotted circles to the right of the illustration, the actual opening and closing points are then one-half 102 degrees, or 51 degrees in advance and 51 degrees back of the starting point. Now, with the indicator set on the dwell of the cam allowing for a rise of 0.003 inch—"the clearance under the valve stem" below zero—and with the indicator in the position shown, the

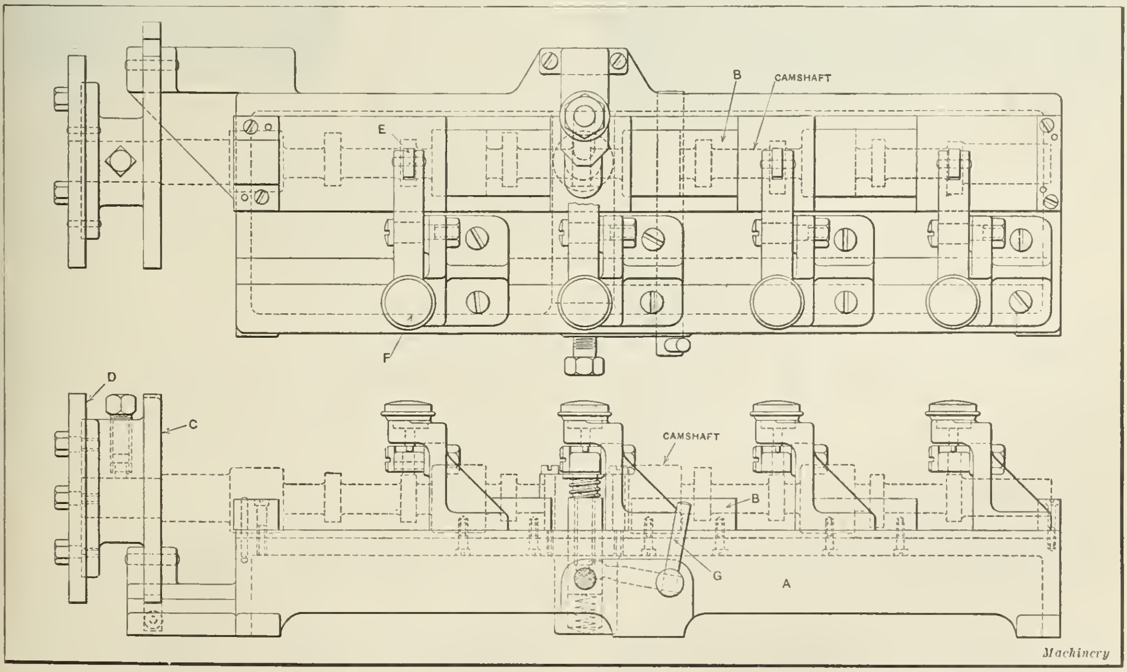


Fig. 51. Multiple Type of Cam-shaft Testing Fixture used for inspecting Cam-shafts for Twin Four-cylinder Engines

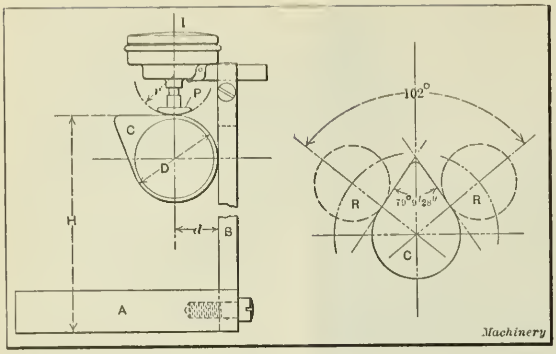


Fig. 52. Method of using Dial Test Indicator for inspecting Gas Engine Cams

cam-shaft is indexed to the correct angle. If the work has been accurately done, the indicator needle should just begin to rise at the 51-degree angle. If not, it will rise either too soon or too late, and the amount of error is read off on the index circle of the indicator. The relation of all the other cams to the keyway is tested in a similar manner, taking all the opening points in their firing order and then all the closing points. The amount of error sometimes found in spite of very careful work is surprising, and this method of testing approaches a high degree of accuracy.

Multiple Indicating Cam-shaft Gage

The multiple indicating cam-shaft gage for testing the exhaust and inlet cams for twin four- or eight-cylinder engines is shown in Fig. 51. This consists of a fixture for holding the cam-shaft and indexing it while being tested and brackets for carrying four dial indicators, so that four cams can be tested at the same setting of the cam-shaft. For the other four sets of cams, the cam-shaft is shifted and the testing operation repeated. The fixture consists principally of a base *A* to which four V-blocks *B* are attached. The bearings on the cam-shaft rest in these V-blocks. After the cam-shaft is held in the V-block and located in the correct position, a double index plate *C* and *D* is fastened to the end of the shaft in order to give the correct angular position of the cam-shaft when testing the location of the opening and closing points on the cams. Four cams, as previously mentioned, are tested at a time. The index plate is moved into the position desired and the reading is transmitted from the cams by the rolls *E* to the needle of the indicators *F*.

The reading on the dial indicator is taken when the cam has raised the roll 0.005 inch, thus allowing for the clearance between the end of the push-rod and the valve stem. As soon as readings have been taken from four cams and they are found correct, the lever *G* is operated, which releases the single clamp that holds the cam-shaft in position in the fixture, bearing down with sufficient pressure to prevent it shifting, but at the same time allowing it to be rotated by means of the index plate. The cam-shaft is then shifted along the fixture to bring the remaining four cams into position under the indicators, and a similar procedure followed. It will be noted that the fixture is constructed so that the index-plate moves with the cam-shaft when it is shifted over to bring the second set of cams into the testing position. By means of this gage the testing of cam-shafts is greatly simplified in that four readings can be taken at one setting.

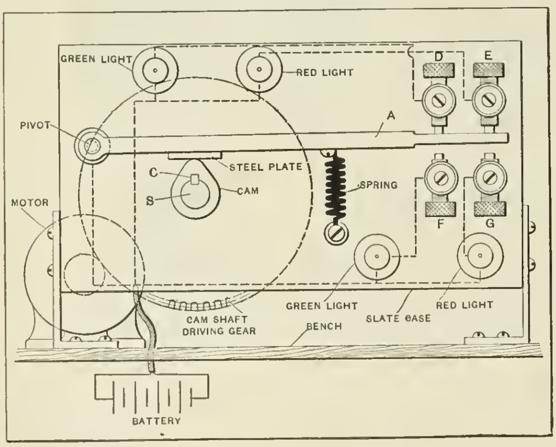


Fig. 53. Electrical Device for inspecting Gas Engine Cams of Detachable Type

Electrical Cam-shaft Gage

An electric device for testing individual cams is shown in Fig. 53. This gage consists principally of a pivoted arm *A* that is raised or lowered by the thrust of the cam being tested and is held in contact with the cam by a helical spring. The cam is carried on the shaft *B*, which is provided with a key *C*, the cam being slowly rotated by means of a small motor located behind the slate base to which the entire mechanism is attached. Connection is made with an electric battery in such a manner that when the cam raises and lowers the arm *A*, it closes the electric circuit by making contact with the adjusting screws *D*, *E*, *F* and *G*, respectively. If the throw of the cam is too slight, no contact will be made with either of the adjusting screws *D* and *E*; if the throw is as it should be, contact will be made with the screw *D*, and the green lamp on the top of the board will flash. If the throw is too great, contact will be made with both screws *D* and *E*, resulting in the flashing of both the red and the green lamps. In the same manner, the lamps at the bottom of the board are flashed; if the diameter of the cam is too great, neither light flashes; if correct, the green light shows; and if too small, both the green and red lights show. The contact screws are made from brass carrying a copper contact point which is held out by means of a brass spring. This device is adjusted by means of a master cam which has been measured by hand and found to be correct.

Fig. 54. Special Type of Indicating Gage for inspecting Interrupter Cams for Electric Starter

Device for Testing Electric Starter Ignition Cams

Fig. 54 shows an application of the indicating dial type of gage in conjunction with a multiplying lever for testing ignition cams for "Delco" electric starters. The indicator used gives readings to 0.0001 inch. The gage is rigidly built and consists of a base *A* in which a stand *B* is screwed that carries the measuring table *C* provided with a split box at the rear through which passes the post supporting the multiplying lever arrangement. The dial test indicator *D* is fastened to the rear bracket and is operated by a multiplying lever *E*. This is fulcrumed on adjustable pointer screws *F* and is provided with a boss at its lower surface in which a plunger *G* fits. This plunger is adjusted by a screw *H*, which, in turn, is clamped by a screw *I*. In this case, the cam to be gaged is held on a stud *J* and is brought in contact with a location point *K*. Previous to testing the work, the gage is set at zero by means of a master. The limits on this work are $\pm$ 0.0005 inch.

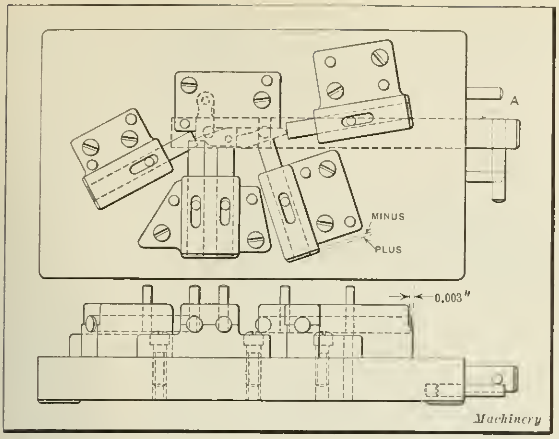


Fig. 55. Flush-pin Type of Gage for inspecting Work on the Ordinate Principle

Ordinate System of Gaging

As was explained in connection with the first installment of this article in the November number of MACHINERY, irregular-shaped parts are generally gaged by means of profile templets, the work being inspected by holding it in contact with the templet and up to the light. Of course, a very small variation in the work from the gage can be detected by the rays of light between the two pieces, but there is no definite means of determining just what this variation is. Consequently, the templet system is not satisfactory for interchangeable manufacture, as the discrepancies in the work are not measurable.

The type of profile gage used is governed largely by the shape and character of the work. In gaging cylindrical work, a profile gage called a "receiver gage" is generally employed. In this case the gage is bored, reamed and lapped to the shape of the work and is then slabbed off so that the hole in the gage is exposed; then when the work is inserted, its outline can be compared with that of the gage. The most common form of templet, as previously mentioned, is made from sheet steel and is filed down and ground on the measuring side to a knife-edge similar to that used on a straightedge. When the work to be measured has several shoulders or irregularities of outline, it is necessary, of course, that the gage be held parallel with the axis of the work if it is cylindrical in shape. There are other objections to the templet system, and in up-to-date manufacturing plants a templet is used as sparingly as possible.

By the ordinate system of gaging, a piece of irregular outline is gaged at all the principal points for the desired measurements by means of either one of two systems. One system employs the flush-pin principle and the other the dial test indicator. The system used depends, of course, on the number of surfaces to be gaged and the convenience with which these surfaces can be approached. Fig. 55 shows a simple method of gaging an irregular-shaped piece. In this case the flush-pin principle can be adopted because of the comparatively simple outline of the piece. These flush-pins are held in separate blocks fastened to a base, and the axis of the flush-pin is located at right angles to the surface to be gaged.

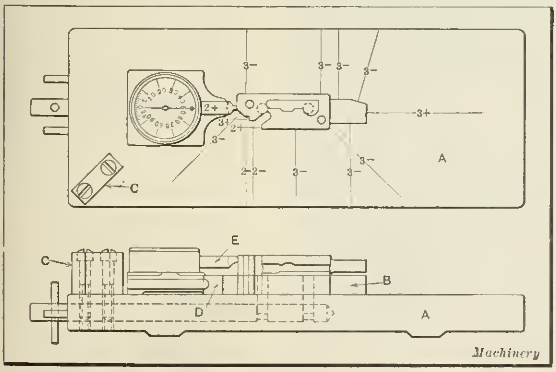


Fig. 56. Dial Indicator for inspecting Irregular Work on the Ordinate Principle

The rear end of the bracket carrying the flush-pin is provided with a plus and minus limit step. In use, the flush-pins are pushed back to insert the work in the holder, and are then pushed forward to ascertain whether the work has been machined properly or not. The test consists in comparing, by the sense of touch, the positions of the ends of the flush-pins with relation to the steps on the rear ends of the holders. A simple ejecting mechanism is used in connection with this gage; it consists of a rod *A* passing through the body of the plate and carrying two eccentrics. These work against pins held in the base that are forced upward by the eccentrics to eject the work from the dowel-pins on which it is held. Two pins in the end of the gage block act as stopping points for this rod.

Another type of gage working on the ordinate principle is shown in Fig. 56. In this case, as it will be noticed, the dial test indicator principle is employed because the points that must be measured are not accessible with the flush-pin type. The construction of this gage is comparatively simple; it consists chiefly of a base *A* carrying a hardened and lapped master block *B* which is of the same shape as the work and is hardened, ground and lapped to the mean dimensions of the work. This block is provided with close-fitting dowel-pins which are made to fit the locating holes in the work to be gaged. In the lower left-hand corner of the gage is a block *C*, which is used for setting the block *D* and spindle *E* of the dial test indicator in line with each other. The surface of this block is hardened, ground and lapped, and is at right angles to the surface of the plate. As will be noticed, lines are drawn from the points where the gaging is to be done, and opposite these lines are numbers. These numbers indicate the limits in thousandths of an inch provided on the work. For instance, 3 — means that at this point the piece can be 0.003 inch less or smaller than the master by which it is being compared.

Fig. 57. Indicating Gage for testing Pressure of Gas Engine Valve Lifter Springs

In using this gage, the block carrying the dial test indicator is swung around and the dial test indicator spindle and measuring end of the block are brought in contact with the setting block *C*. The bezel of the dial test indicator is then rotated so that the needle points to zero. The gage is then swung around and brought in contact with the work. Index

points are marked on the rear and front ends of the block D so that these are brought in line with lines on the plate A. Then the block D is brought in contact with the master, and the spindle of the dial test indicator in contact with the work, the resulting readings being taken off on the indicator. The indicator and block which are fastened to each other can be moved around to any point on the work and the variations between the work and the master can be read off in thousandths of an inch. The advantage of this system over the templet system is evident, in that it gives a direct reading and indicates to the inspector just how many thousandths inch the work varies from the required size.

Dial Indicators for Testing Pressure

The dial indicator is used to a large extent for testing pressure in the inspection of springs that must be capable of delivering the required pressure when compressed a certain amount. The application of the dial indicator to this work is shown in Fig. 57. This illustration shows a special fixture used in testing the pressure exerted by conical valve springs for gas engines. The fixture consists principally of a regular scale dial, which is attached to a base A having an upright B. This upright carries a spindle which is operated by a rack and pinion through the turnstile C, the distance that the spring is compressed being determined by the stop D, which comes in contact with a pin on the top of the fixture. The spring being tested is compressed about 1½ inch—the compression it has in the gas engine—and must show a pressure of 58 pounds on the dial.

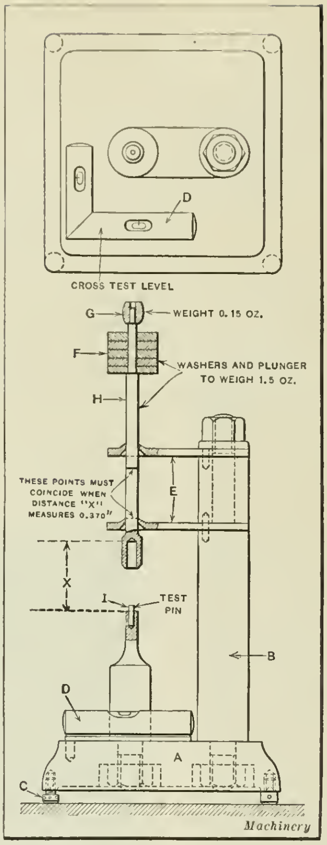


Fig. 58. Indicating Gage for testing Compressive Strength of Springs used in Combination Time and Percussion Fuses

Device for Testing Time Fuse Percussion Restraining Springs

A much more delicate instrument than that illustrated in Fig. 57 is shown in Fig. 58. In this case the device is used for testing the pressure of percussion restraining springs used in combination time and percussion fuses. In construction, it consists of a base A carrying an upright B. The base A rests on four feet C, which are capable of being adjusted so that the instrument can be brought to a parallel plane, this being determined by means of the cross-level D. Post B carries two plates E, which support the spindle carrying the washers F and G. These plates are countersunk so that only a knife-edge bearing is provided to contact with the plunger. The total weight of washers F and plunger H is 1.5 ounce, whereas the "limit weight" G is 0.15 ounce.

The spring to be tested is placed on test pin I, the spindle H meanwhile being held up by hand. The spindle is then allowed to drop and compress the spring, and if it is correct, the points marked must coincide when the distance X is 0.370 inch. If the weight of F and the spindle is not sufficient to give this reading, the limit weight G is added; if this makes the distance X correct, then the spring is O.K.; if not, it is too stiff. If the distance X, of course, is less than 0.370 inch when weight G is not on the spindle, then the spring is too weak.

Indicating Gage Depending on the Sense of Hearing

As has been previously mentioned, indicating gages depend on the sense of touch, sight and hearing for their operation. Those depending on the sense of hearing are generally of the electrical type, and an example of a gage employing this principle is shown in Fig. 59. This gage is employed for testing the closing pressure of piston rings. Piston rings have been tested for closing pressure by many other devices, all of which have been more or less satisfactory. It is generally known that a piston ring which does not possess the required amount of tension does not lie in close touch with the walls of the cylinder all around, and hence gas is allowed to leak past and compression is lost. It is therefore desirable to know if the rings have sufficient tension before they are inserted in the piston, and the gage in Fig. 59 determines this satisfactorily.

It consists chiefly of a cast-iron plate A machined on its top surface to provide two ribs B that are nicely finished so that the rings can be slipped along them without undue friction. Fastened to one side of the fixture is a bracket C, which is machined out on one edge, providing a step that is of a slightly greater height than the width of the piston ring being tested. Held on the other side of the cast-iron plate is a lever D, which is fulcrumed at the point E by two cone-pointed screws in the bracket F. At one end of the fixture, pulley G is attached, and running over this is a wire rope which carries the weight H; the size of the weight depends on the

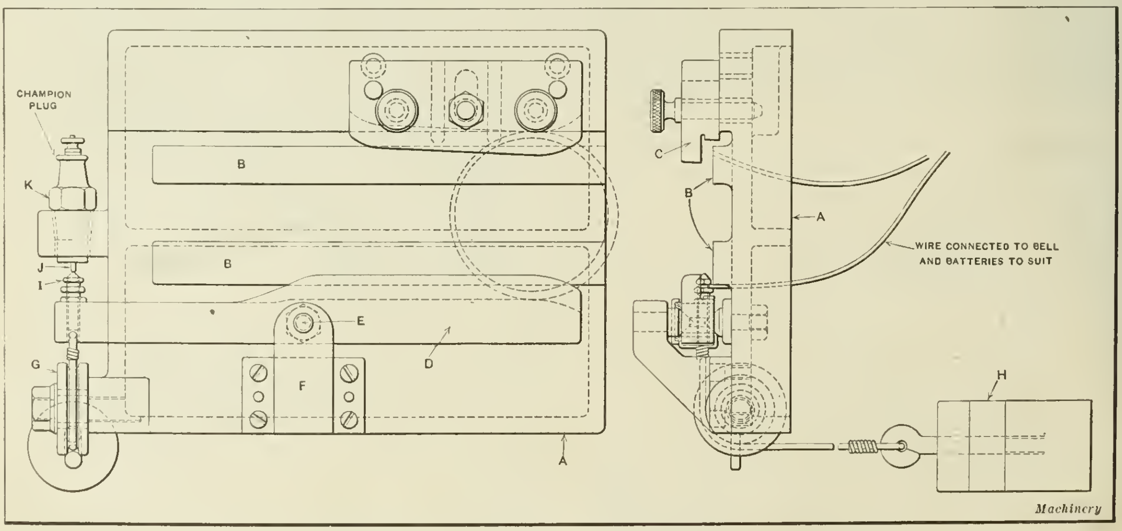


Fig. 59. Piston Ring Testing Device depending for its Reading on the Sense of Hearing

size of piston ring being tested. This wire rope, as will be noticed, is attached also to the rear end of lever *D*, which carries a contact point *I*. This contact point makes contact with the point *J* of the "Champion" spark plug *K* when the piston ring is of the desired tension. Plug *K* is connected by suitable wiring to a bell and battery in the box under plate *A*.

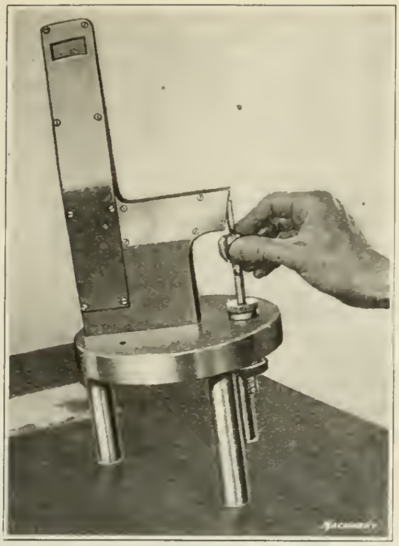


Fig. 60. Indicating Gage for testing Balls during Process of Manufacture

In operation, the inspector lays the ring down flat on the testing surface of the plate and pulls it toward him between the fixed and movable strips *C* and *D*, respectively, with the split or saw cut exactly in the center. In pulling the ring through the fixture, if the pressure is sufficient to overcome the resistance of weight *H*, which on the Ford piston ring is 18 pounds, electrical contact is made between points *I* and *J*, and the bell in the box of the fixture is rung. If the inspector pulls the ring through the fixture without the bell ringing, then the ring does not come up to the required tension, and is consequently rejected. When this fixture was adopted in one plant it was found that previous methods had been more or less inaccurate, and anywhere from 20 to 50 per cent of the rings formerly made proved to be failures. Changes in manufacturing methods, however, reduced the number of failures from 20 to 5 and 10 per cent.

Gaging and Inspecting Balls and Ball Bearings

Aside from the manufacture of rifles and similar interchangeable work, there is probably no industry in which gaging and inspection methods are developed to a higher degree of perfection than in the manufacture of balls and ball bearings. As a rule, this industry is split up; that is, one manufacturer makes the balls and another the bearings. There are, of course, some manufacturers who make the entire product, but this is the exception rather than the rule. No other industry makes more extensive use of indicating gages than the ball and ball bearing industry, and in the following particular attention will be given to the types of gages used in this work.

Gaging and Inspecting Balls

In the gaging and inspection of balls there are two main points that must be considered. First, the ball must be spherical within certain limits, and second, it must be made to a definite diameter, also within limits. The manufacturing limits to which the balls are made depend entirely, of course, on the use to which the balls are put. For high-grade balls they must be held to within a limit of 0.00005 inch of being perfect spheres, and must not vary more than 0.00005 inch in diameter. For bicycles, hardware and similar work, the manufacturing limits, of course, can be considerably wider. In the following, however, attention will be directed particularly to the gages used in making high-grade balls.

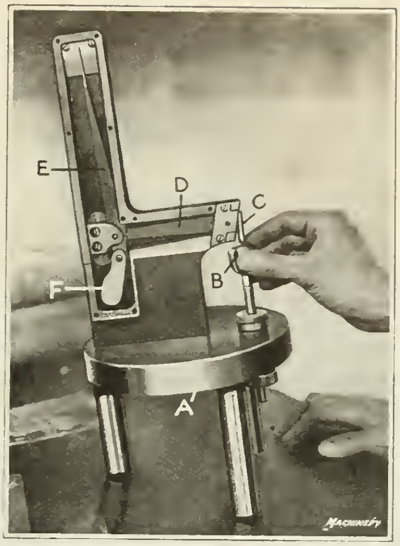


Fig. 61. Indicating Gage shown in Fig. 60 with Plate removed to show Constructional Features

During the process of manufacture the balls are gaged to see that the grinding or lapping machines are working properly. Figs. 60 and 61 show a special gage developed by the Hoover Steel Ball Co. of Ann Arbor, Mich., for this work. Referring to Fig. 61, which shows the construction of the gage more clearly, it will be noticed that it is of the adjustable type and is provided with two anvils, one of which is adjusted by means of a screw held in place by clamping nuts. The gage consists principally of a plate *A* mounted on three feet, the rear one of which is shorter than the other two, so that the gage is inclined at a slight angle. The ball to be gaged is shown held in the nest *B*, and the gage is so inclined that the ball always rests in the rear of this nest, so that its axis is parallel or in line with the two gaging points.

The upper and lower anvils are provided with diamond gaging points held in brass holders. These diamonds are so mounted that a flat face is presented to the ball surface to be gaged. The multiplying lever principle is used here in the ratio of 150 to 1, so that for variations of 0.0001 inch in the ball, the top point of needle *E* would move over the arc a distance of 0.150 inch. The construction of this indicating lever mechanism is as follows: Lever *D* is connected to anvil *C* and meshes with lever *E* through a rack tooth. There are no springs in this gage, and the upper anvil is kept in contact with the work by means of a weight *F* attached to the indicating needle *E*. By means of this gage it is possible to determine rapidly if the balls are being ground out of round or under diameter when in the rough state. While the wear on these diamonds is very slight, it is nevertheless necessary to be certain that the instrument is measuring correctly, and at certain intervals the indicating needle is set by means of a master ball. The adjusting screw holding the lower anvil is adjusted the required amount.

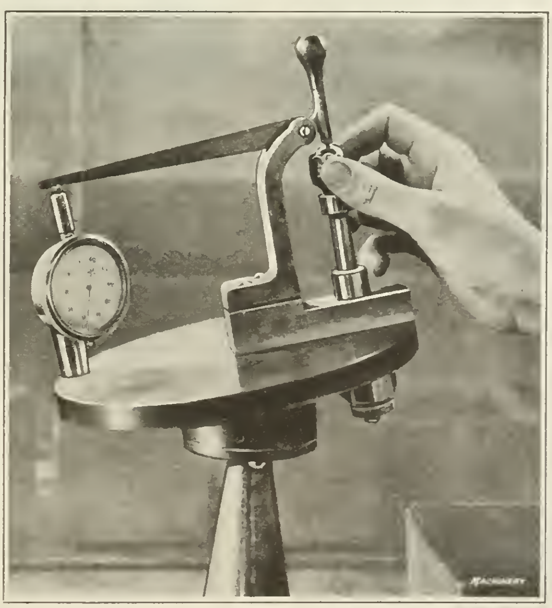


Fig. 62. Indicating Gage of Dial Type in Combination with Multiplying Lever for testing Balls over ⅝ Inch Diameter

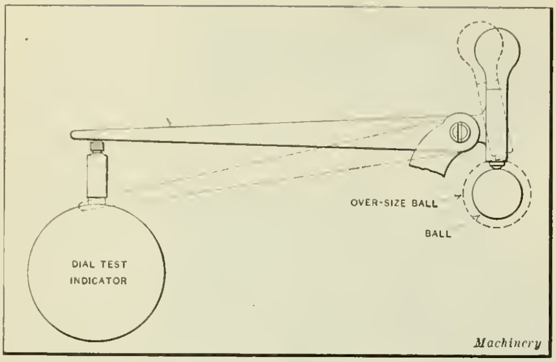


Fig. 63. Diagram illustrating Limitations of Multiplying Lever Type of Gage

Indicating Gage for Inspecting Finished Balls

After the balls come from the grinding and lapping departments, the first inspection consists in looking them over to see that they are free from pits, scale, bands, dents, tool marks, etc. This is done on the smaller sizes of balls, and particularly on those up to 3/4 inch in diameter, by rolling the balls on a glass plate. A ball that is not perfectly spherical will not roll straight, but will wobble from side to side. Balls over 5/8 inch in diameter are inspected by means of the indicating gage shown in Fig. 62. As will be seen from this illustration, this consists of a dial gage combined with a multiplying lever mounted on a plate held on a stand which is set at an angle so that the ball being gaged always lies at the back surface of the pocket in which it is retained. The lower and upper anvils carry black diamond or quartz, the flat surfaces of which are presented to the ball. The multiplying lever is in the ratio of 10 to 1, and as the indicator normally reads to 0.001 inch, this multiplication makes it possible to obtain readings to 0.0001 inch. The limit on the ball is 0.00005 inch both for roundness and diameter, so that the maximum movement of the needle for satisfactory balls would be not more than one-half the amount between any two marks on the dial.

In multiplying lever gages made on this principle, it will readily be seen, by referring to Fig. 63, that very wide variations in diameter cannot be accurately indicated. The reason for this is that the length of the arm of the multiplying lever changes as the measuring point is moved up or down. Consequently, it is essential that a master ball be used for setting this gage for each size of ball to be gaged, and then that the gage be used only as a means of comparison and not as a direct measuring instrument. Girls operating these instruments can gage 10,000 balls in ten hours, or 1000 balls an hour, and determine whether the ball is out of round, within the limits for diameter, or has any other imperfections which have passed the notice of the previous inspectors.

Fig. 64. Hirth Minimeter used for testing Diameter of Finished Balls

Hirth Minimeter for Gaging Balls

Fig. 64 shows a Hirth minimeter for inspecting balls for diameter and spherical form. It consists of a special stand carrying a lower anvil which is adjustable as shown, a support for the ball to locate it so that its axis comes in line with the upper and lower anvils, and an arm in which the minimeter proper is retained. The top measuring anvil of the minimeter is lifted by means of the finger as shown, and when the ball is inserted all external pressure is removed. This instrument is constructed so that readings as fine as 0.00005 inch are obtainable.

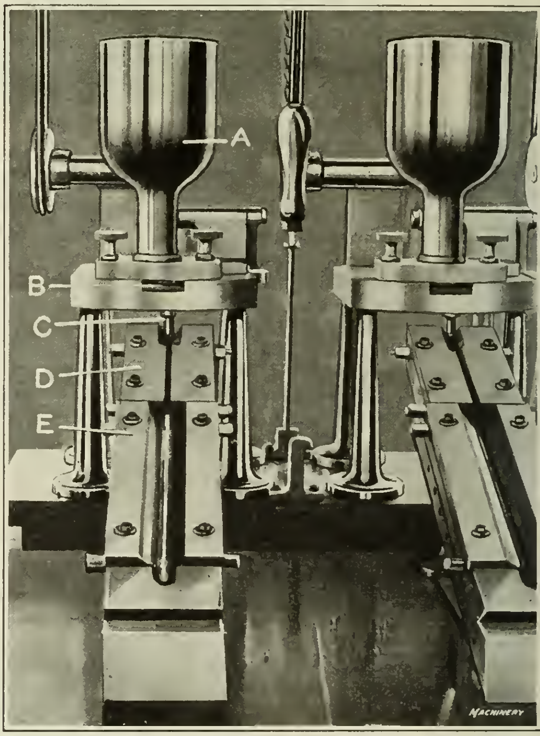


Fig. 65. Automatic Ball Gaging Machine for inspecting Balls up to 3/8 Inch Diameter

Automatic Ball Gaging Machines

High-grade balls under 5/8 inch in diameter are gaged for diameter by automatic ball gaging machines, two types of which are shown in Figs. 65 and 66. The machine shown in Fig. 65 is used for gaging balls up to 3/8 inch in diameter and comprises a hopper for holding the balls, and a slide through which they roll to be gaged. The measuring portions of this slide consist of two straightedges, the space between the edges of which gradually increases in width as the slide extends from the hopper. Passing beneath the hopper is a slide which is agitated by a rack and segment gear, operated by an eccentric motion. The balls to be gaged are dumped into hopper *A* and carried forward to the delivery spout by means of a slide *B*. Slide *B* carries one ball forward at a time, drops it through spout *C* and into slide *D*. Here the distance between the two slides is about 0.005 inch smaller than the smallest diameter of the balls to be gaged. The

balls then roll along between slides D until they come to the straightedges E. These straightedges are set to allow the maximum tolerance on the ball, and the center portion of the straightedge gives the size of ball actually demanded.

The position to which these straightedges is set is determined entirely by the limits required on the balls. If the balls must be held within very close limits, then the amount of variation in the taper of the straightedges is slight. Sometimes they are set so that a difference of 0.005 inch in diameter will be measured from one end to the other. As the balls roll down these slides due to the action of gravity, the angle to which they are set being about 20 degrees from the plane of the table, they drop through the slide at the point where the distance between the two straightedges is slightly greater than the diameter of the ball. As they drop through, they are separated by tubes which enter the various drawers in the cabinet located beneath the table top. When these drawers are full, they are removed and the balls taken out and

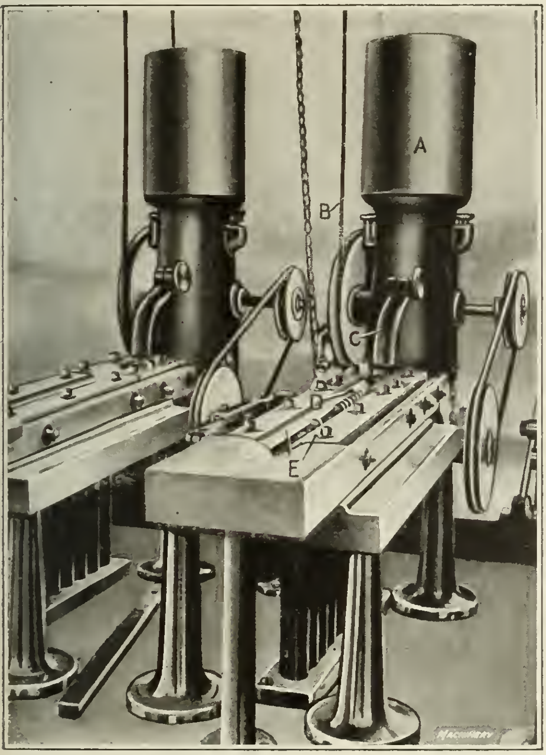


Fig. 66. Automatic Ball Gaging Machine for inspecting Balls up to ⅝ Inch Diameter

put in proper boxes according to the grading determined by the machine.

Another type of automatic ball gaging machine is shown in Fig. 66. This is used for gaging balls up to ⅝ inch diameter. In this case the slides are set almost parallel with the table, and the balls are carried between the straightedges by means of an agitator which comes up and lifts them from the surface of the straightedges. The top surface of the agitator is at an angle of about 5 degrees, and when the agitator rises the balls roll along it until they drop through between the straightedges. This particular machine is provided with eight compartments, and the variation between each compartment is 0.0001 inch. For gaging, the balls are placed in the hopper A, inside of which is an agitator operated by the belt B. This distributes the balls so that they come out of the spout C one at a time and drop into slide D. From this they are carried on by the agitator onto the straightedges E until they drop down into the required compartment.

Gaging and Inspecting Ball Bearing Race Rings

The gaging of ball bearing races is naturally work of refinement, and as far as the race rings are concerned inter-

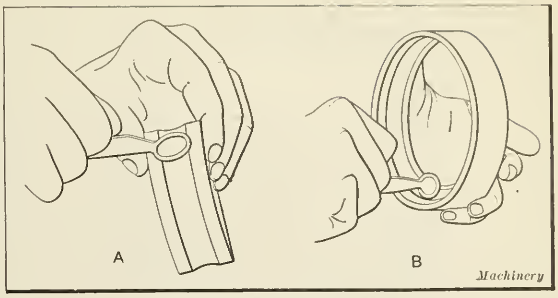


Fig. 67. Use of Templet for inspecting Raceways in Outer and Inner Ball Bearing Rings

changeability is possible. This is not true, however, as regards the assembling of the balls in the races. The reason for this is that the balls do not all come the same size, the limits varying from + 0.0001 inch to — 0.0001 inch. The ball bearing manufacturers claim that if they wanted to get all balls the same size they would have to pay a much higher price for them. Consequently, they select balls to fit the races. This is not a disadvantage, however, because if a ball in a bearing should break, it would leave the raceway in the rings in such a condition that they would either have to be reground or replaced. The limits on the race rings, however, are held very close. For instance, on the hole in the inner race which fits on the shaft the limits are + 0.0002, — 0.0004 inch. For the outside diameter of the outer race ring the limits are + 0.0004, — 0.0008 inch. In the ball bearing raceways the variation is as great as 0.0003 inch, and by selecting the proper balls the differences in races can be taken care of. The limits on the hole of ball thrust bearing races are + 0.0002 to — 0.0004 inch. For the outside diameter the limits are + 0.0006 inch, — 0.0012 inch, according to size. The height of single thrust bearings is + 0.002 inch, and the height of double-acting thrust bearings + 0.004 inch. Tables I and II give tolerances for ball and roller bearings, respectively, as established by the S. A. E. In the case of ball bearings, only the light series is listed; and in the case of roller bearings, only the narrow series is given. The tolerances, however, on the medium and heavy ball bearings and medium and wide roller bearings are the same.

For gaging ball bearings when machining, the micrometer caliper is extensively used for measuring all outside dimensions, and for internal measurements plug gages or three-point indicating gages are generally adopted. The plug gage has been found unsatisfactory for gaging ball bearing race rings. The reason for this is that the operator does not know how much material remains to come off, and consequently is working in the dark until he reaches the "Go" dimension on the gage. The result is that all grinding machine operators prefer to use some sort of indicating gage which gives them latitude. One prominent ball bearing manufacturer has de-

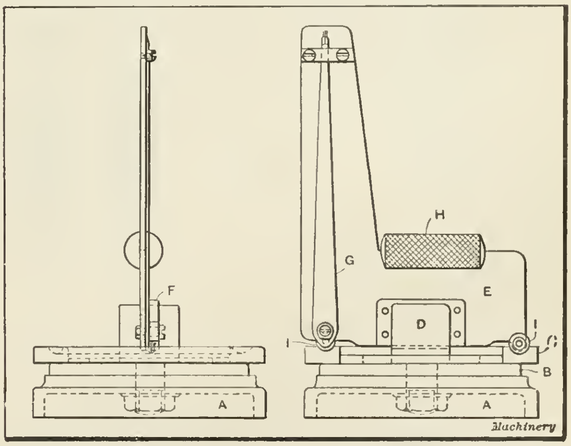
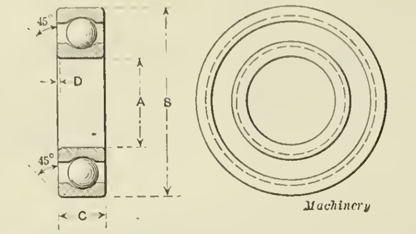


Fig. 68. Special Indicating Device for testing Raceways in Thrust Bearing Race Rings

TABLE I. S. A. E. STANDARD SIZES AND TOLERANCES FOR BALL BEARINGS (LIGHT SERIES)



Ball Bearing Number	Bore of Inner Race Ring: Bore A, Inches	Tolerance, Inches: Plus	Tolerance, Inches: Minus	Diameter of Outer Race Ring: Diameter B, Inches	Tolerance, Inches: Plus	Tolerance, Inches: Minus
200	0.39370	0.0002	0.0004	1.18110	0	0.0006
201	0.47244	0.0002	0.0004	1.25984	0	0.0006
202	0.59055	0.0002	0.0004	1.37795	0	0.0006
203	0.66929	0.0002	0.0004	1.57481	0	0.0006
204	0.78740	0.0002	0.0004	1.85040	0	0.0006
205	0.98425	0.0002	0.0006	2.04725	0	0.0008
206	1.18110	0.0002	0.0006	2.44095	0	0.0008
207	1.37795	0.0002	0.0006	2.83465	0	0.0008
208	1.57481	0.0002	0.0006	3.14962	0	0.0008
209	1.77166	0.0002	0.0006	3.34647	0	0.0008
210	1.96851	0.0002	0.0006	3.54332	0	0.0008
211	2.16536	0.0002	0.0006	3.93702	0	0.0008
212	2.36221	0.0002	0.0006	4.33072	0	0.0008
213	2.55906	0.0002	0.0006	4.72443	0	0.0008
214	2.75591	0.0002	0.0006	4.92128	0	0.0008
215	2.95277	0.0002	0.0006	5.11813	0	0.0008
216	3.14962	0.0002	0.0006	5.51183	0	0.0008
217	3.34647	0.0002	0.0007	5.90554	0	0.0012
218	3.54332	0.0002	0.0007	6.29924	0	0.0012
219	3.74017	0.0002	0.0007	6.69294	0	0.0012
220	3.93702	0.0002	0.0007	7.08664	0	0.0012
221	4.13387	0.0002	0.0007	7.48035	0	0.0012
222	4.33072	0.0002	0.0007	7.87405	0	0.0012

Ball Bearing Number	Width of Both Race Rings: Width C, Inches	Tolerance, Inches: Plus	Tolerance, Inches: Minus	Corners D[1] on Outer Race and Bore of Inner Race, Inch	Eccentricity Tolerance, Inches: Inner Race Ring	Eccentricity Tolerance, Inches: Outer Race Ring
200	0.35433	0	0.0020	0.040	0.0008	0.0012
201	0.39370	0	0.0020	0.040	0.0008	0.0012
202	0.43307	0	0.0020	0.040	0.0008	0.0012
203	0.47244	0	0.0020	0.040	0.0008	0.0012
204	0.55118	0	0.0020	0.040	0.0008	0.0012
205	0.59055	0	0.0020	0.040	0.0008	0.0012
206	0.62992	0	0.0020	0.040	0.0008	0.0012
207	0.66929	0	0.0020	0.040	0.0008	0.0012
208	0.70866	0	0.0020	0.080	0.0008	0.0012
209	0.74803	0	0.0020	0.080	0.0010	0.0016
210	0.78740	0	0.0020	0.080	0.0010	0.0016
211	0.82677	0	0.0020	0.080	0.0010	0.0016
212	0.86614	0	0.0020	0.080	0.0010	0.0016
213	0.90551	0	0.0020	0.080	0.0010	0.0016
214	0.94488	0	0.0020	0.080	0.0010	0.0016
215	0.98425	0	0.0020	0.080	0.0010	0.0016
216	1.02362	0	0.0020	0.120	0.0012	0.0018
217	1.10236	0	0.0020	0.120	0.0012	0.0018
218	1.18110	0	0.0020	0.120	0.0012	0.0018
219	1.25984	0	0.0020	0.120	0.0012	0.0018
220	1.33858	0	0.0020	0.120	0.0012	0.0018
221	1.41732	0	0.0020	0.120	0.0012	0.0018
222	1.49607	0	0.0020	0.120	0.0012	0.0018

[1] A chamfer of 45 degrees ground true with the bore and outside diameter is recommended.

vised a three-point indicating gage for use on the grinding machine for internal work which is used entirely by the machine operators and has been found to give satisfactory results.

For external grinding, snap gages are seldom used for the reason previously given. Attempts have been made by one manufacturer to replace the micrometer caliper with a dial test indicating gage. This proved unsatisfactory, however, owing to the excessive fluctuations to which the needle is subjected when it is necessary to slide the gaging point over the work. On a dial test indicator which is made to read to 0.0001 inch, very little irregularity in the surface of the work causes a considerable movement of the needle, and as there is no brake or effective means of holding it, it is difficult to use this type of gage for snap work. Consequently, it is the rule in practically all plants making ball bearing race rings to use micrometer calipers in the manufacturing department. The inspectors, of course, are furnished with plug and snap gages of the limit type.

Plug gages for ball bearing races must be made light, so as not to fatigue the inspector. With a plug gage, say 3 inches in diameter, made from solid tool steel, the weight is objectionable, and several manufacturers reduce the weight of large plug gages by making the gaging part in the form of a ring which is held on an aluminum core. The aluminum core, of course, is extended to form the handle and is knurled as usual. In some plants plug gages that have become worn are annealed and turned down to the next size. They are then hardened, ground and lapped, and in this way can be used a large number of times.

Gaging Raceways in Annular Ball Bearing Rings

The raceways or grooves in ball bearing rings must be carefully checked. The shape of the curve is usually checked by templet gages, as illustrated at *A* and *B* in Fig. 67. For testing the diameter of the raceway in the inner and outer rings, respectively, various means are employed, the most common being that in which three balls are used to determine the correct depth. Another method makes use of a micrometer caliper having three ball points.

Gaging Raceways in Thrust Bearings

For thrust bearing race rings it is necessary, of course, that the raceway be concentric with the bore of the ring; also that

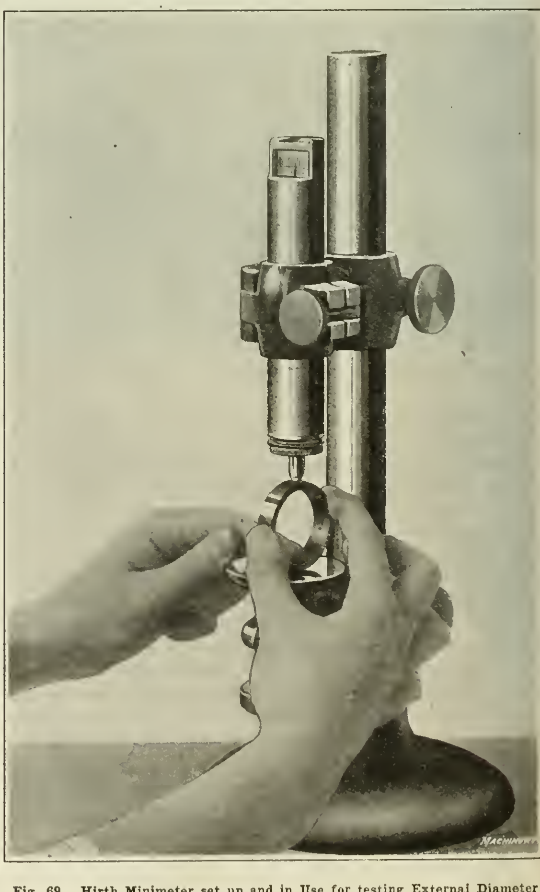
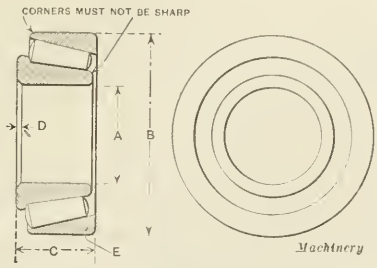


Fig. 69. Hirth Minimeter set up and in Use for testing External Diameter of Ball Bearing Race Rings

TABLE II. S. A. E. STANDARD SIZES AND TOLERANCES FOR ROLLER BEARINGS (NARROW SERIES)



Roller Bearing Number	Bore of Inner Cone: Bore A, Inches	Bore of Inner Cone: Tolerance, Inches, Plus	Bore of Inner Cone: Tolerance, Inches, Minus	Diameter of Outer Cone: Diameter B, Inches	Diameter of Outer Cone: Tolerance, Inches, Plus	Diameter of Outer Cone: Tolerance, Inches, Minus	Width of Assembled Bearing: Width C, Inches	Width of Assembled Bearing: Tolerance, Inches, Plus	Width of Assembled Bearing: Tolerance, Inches, Minus	Minimum Chamfer D, Inches	Radius E, Inches	Eccentricity Tolerance, Inches, Plus	Eccentricity Tolerance, Inches, Minus
RM-304	0.78740	0.0002	0.0006	2.04725	0	0.0008	7/8	0.020	0.020	0.040	0.040	0.0008	0.0012
RM-305	0.98425	0.0002	0.0006	2.44095	0	0.0008	1	0.020	0.020	0.040	0.040	0.0008	0.0012
RM-306	1.18110	0.0002	0.0006	2.83465	0	0.0008	1 3/16	0.020	0.020	0.080	0.080	0.0008	0.0012
RM-307	1.37795	0.0002	0.0006	3.14962	0	0.0008	1 3/8	0.020	0.020	0.080	0.080	0.0008	0.0012
RM-308	1.57481	0.0002	0.0006	3.54332	0	0.0008	1 7/16	0.020	0.020	0.080	0.080	0.0008	0.0012
RM-309	1.77166	0.0002	0.0006	3.93702	0	0.0008	1 9/16	0.020	0.020	0.080	0.080	0.0010	0.0016
RM-310	1.96851	0.0002	0.0006	4.33072	0	0.0008	1 3/4	0.020	0.020	0.080	0.080	0.0010	0.0016
RM-311	2.16536	0.0002	0.0006	4.72443	0	0.0008	1 15/16	0.020	0.020	0.080	0.080	0.0010	0.0016
RM-312	2.36221	0.0002	0.0006	5.11813	0	0.0008	2 1/8	0.020	0.020	0.080	0.080	0.0010	0.0016
RM-313	2.55906	0.0002	0.0006	5.51183	0	0.0008	2 5/16	0.020	0.020	0.120	0.120	0.0010	0.0016
RM-314	2.75591	0.0002	0.0007	5.90544	0	0.0012	2 1/2	0.020	0.020	0.120	0.120	0.0010	0.0016
RM-315	2.95277	0.0002	0.0007	6.29924	0	0.0012	2 11/16	0.020	0.020	0.120	0.120	0.0010	0.0016
RM-316	3.14962	0.0002	0.0007	6.69294	0	0.0012	2 11/16	0.020	0.020	0.120	0.120	0.0012	0.0018
RM-317	3.34647	0.0002	0.0007	7.08664	0	0.0012	2 7/8	0.020	0.020	0.120	0.120	0.0012	0.0018
RM-318	3.54332	0.0002	0.0007	7.48055	0	0.0012	2 7/8	0.020	0.020	0.120	0.120	0.0012	0.0018
RM-319	3.74017	0.0002	0.0007	7.87405	0	0.0012	3 1/16	0.020	0.020	0.120	0.120	0.0012	0.0018
RM-320	3.93702	0.0002	0.0007	8.46460	0	0.0012	3 1/4	0.020	0.020	0.120	0.120	0.0012	0.0018

it be of the correct depth and the proper radius. A satisfactory indicating gage for testing race rings is shown in Fig. 68; the race ring being tested is that used on the main drive shaft of an automobile. As shown, the gage consists of a cast-iron stand *A* in which a hardened and ground steel ring *B* is held. The top part of this ring is made a good fit for the inside diameter of the ball bearing race ring *C*. A stud *D* held to the base by a nut as shown, is slotted to receive the gage plate *E*. Stud *D* is hardened and ground and plate *E* has a reinforced plate *F* held to it by rivets, the latter being hardened and ground and made a good fit in the slot in the stud. The fulcrum of the pointer or needle *G* is so placed that any variation in the work is magnified twenty-five times at the point where the reading is taken. A knurled handle *H* is fastened to the gage for convenience in holding.

In operation, the work is slipped over the ring *B* of the gage, as shown; then the gage plate *E* is placed in the slot in stud *D*, and the gaging knife-edge rollers *I*, which in this case do not rotate but are held rigidly to the frame, are placed in the ball race groove. The position of the indicating point of the needle is then noted to see if the race is of the required diameter. A limit of 0.001 inch is allowed on the diameter of the ball race groove, which is 4.125 inches. The base of this gage is fastened to a frame, not shown, which is of sufficient height to bring the ring to be gaged in line with the operator's vision.

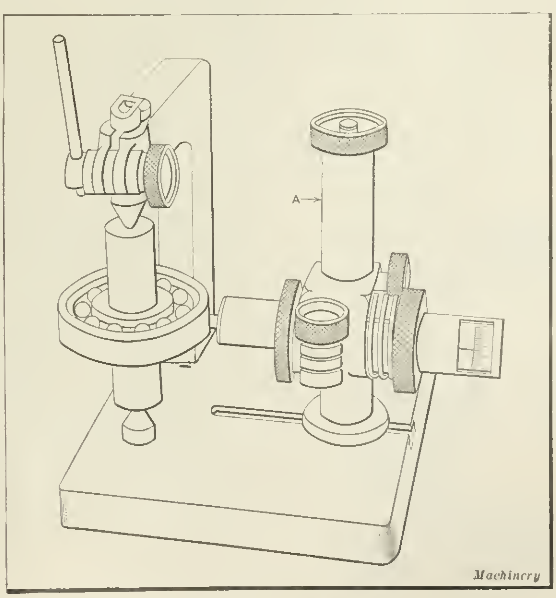


Fig. 70. Special Inspecting Fixture for testing Side Wobble and Concentricity of Assembled Ball Bearings

Testing Diameters of Inner and Outer Race Rings

As has been previously mentioned, the outer diameters of the inner and outer race rings are generally inspected by snap gages or indicating gages. Fig. 69 shows the Hirth minimeter being used for this work; the graduated scale on this minimeter is such as to give readings to 0.0001 inch, and it has been found very satisfactory for work of such refinement. For gaging the interior or hole in the outer and inner races, plug gages are sometimes used, but a more satisfactory gage is shown in Fig. 28 in the previous installment of this article. This shows a Hirth minimeter with a special attachment by means of which it is possible to tell whether the diameter is correct or not, and whether the hole is out of round, tapered, etc.

Testing Concentricity of Ball Bearings

In order to determine if the ball bearing will run true within the required limits, the cone or center race is tested for wobble or concentricity. Usually this is done by supporting the inner ring or cone on an arbor and using an indicating gage similar to that illustrated in Fig. 70, where a completed ball bearing is shown being tested. In testing a ball bearing for con-

centricity after the balls, retainers, and inner and outer races have been assembled, the inner race is forced by hand carefully onto a hardened and ground arbor. This is then placed between centers, as shown in Fig. 70, and the carrier *A* holding a Hirth minimeter is brought up so that the needle stands at zero when it is brought in contact with the outer race. The outer ring is then rotated independently of the inner one, also on centers, and the amount of side wobble or concentricity is noted on the minimeter scale.

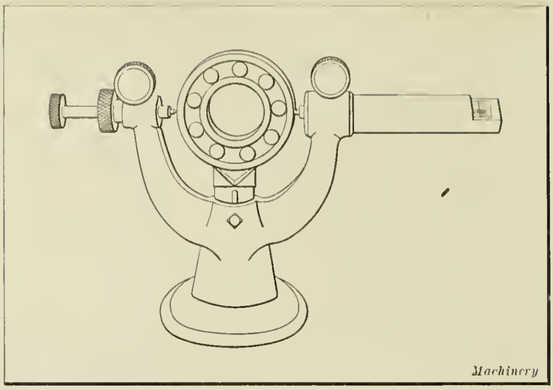


Fig. 71. Special Type of Three-point Gage using Hirth Minimeter for testing Roundness and Diameter of Assembled Ball Bearing

The amount of wobble allowed in a ball bearing depends on its size; it is usually not greater than 0.001 or 0.002 inch for large bearings, and is, of course, less than this for smaller sizes. The axial wobble or thrust, that is, the displacement of the inner race with respect to the outer, is not of such great significance as the radial wobble. Experiments in various shops have shown that a slight axial clearance does not appreciably affect the durability of the ball bearing. In general, a clearance of 0.002 or 0.003 inch may be regarded as advantageous.

Testing External Diameter of Completed Ball Bearings

A simple but satisfactory means of gaging the external diameter of a completely assembled ball bearing is shown in Fig. 71. This gage is built in the form of a snap gage and has in the middle a movable V-support, which is set in accordance with the diameter of the bearing being measured. One of the two measuring points has a coarse adjustment by means of an adjusting screw, which fits in holes 0.04 inch apart, and a fine adjustment by means of a micrometer. The measurement is taken with a Hirth minimeter, which is brought in contact with the opposite side of the ball bearing. The bearing is rotated while being tested, so that its roundness can be tested at the same time as the diameter. This particular gage is set by means of a master ring.

Box Type Inspection Fixtures

The gaging of single holes, shafts and similar work is a comparatively simple proposition as compared with the gaging of parts having a multiplicity of holes that must bear some definite relation to each other and to finished surfaces. Formerly many manufacturers depended on their jigs and fixtures to obtain the desired amount of accuracy. As will be readily recognized, however, jigs and fixtures cannot be depended upon to remain accurate for any considerable length of time, especially when they are roughly handled, and if the work that comes from these fixtures must be accurate, it is highly desirable that the fixtures be tested frequently.

Another point which must be considered is the fact that a box type of jig is likely to drill and ream work inaccurately if not kept clean by the operator. The collection of dirt in one corner of a box jig would easily throw the work out to such an extent that the holes which have to bear a certain relation to a milled surface would be located inaccurately. Consequently, the most desirable practice is to gage the work after it comes from the jig. The importance of this fact will be more fully appreciated when it is remembered that most drilling machine work is done by what might be termed inexperienced mechanics—men who know little about accurate work, and simply have sufficient knowledge to put the work in the jig, take it out again, and operate the machine.

The Dayton Engineering Laboratories Co. of Dayton, Ohio, has developed an interesting system of box gaging which is used to a large extent throughout the various manufacturing departments in its plant. This type of gage has been developed primarily in an endeavor to produce electric starting, ignition and lighting equipments on a truly interchangeable basis. In the following are described some of the gages used in this plant which incorporate interesting features.

Method of Gaging Milled Surfaces in Relation to Dowel-pin Holes

Fig. 72 shows an interesting box gaging fixture, used to determine the location of a reamed hole and milled surface on a generator end frame, in relation to the dowel-pin holes. The fixture is provided with hardened and ground dowel-pins *A* which fit in the dowel-pin holes of the work, and a hardened and ground plug *B* operated by plug *C*. When the work *D* is placed on the dowel-pins, plug *B* is raised into the hole, and if the hole is correct, the plug will pass through. If not, of course, the plug will not rise. The limits on the work are provided by having the plug the required amount smaller than the hole in the work. The milled surface on the work is inspected by means of the rotating plug gages *F* and *G*. These, as will be noticed, are each provided with two bosses, one of which is made to indicate the "Go" and the other the "Not Go" dimension. These projections are then swung past the milled surface on the work, and if the "Go" end passes by and the "Not Go" does not, the work is within the required limits. In this case, the tolerance allowed on the milled surface is 0.002 inch, and on the hole the limits are ± 0.001 inch.

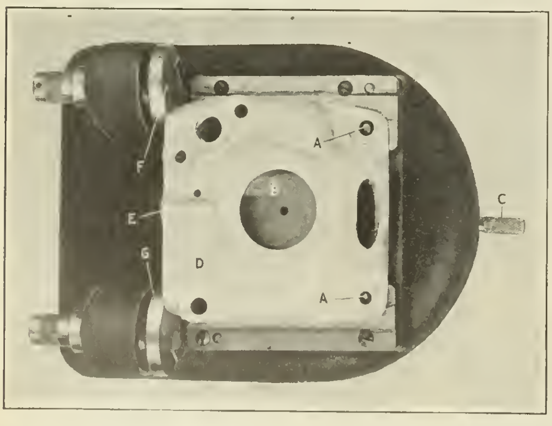


Fig. 72. Special Type of Box Gaging Fixture used for inspecting Relation of Bore to Milled Surfaces on an Electric Starter Generator Frame

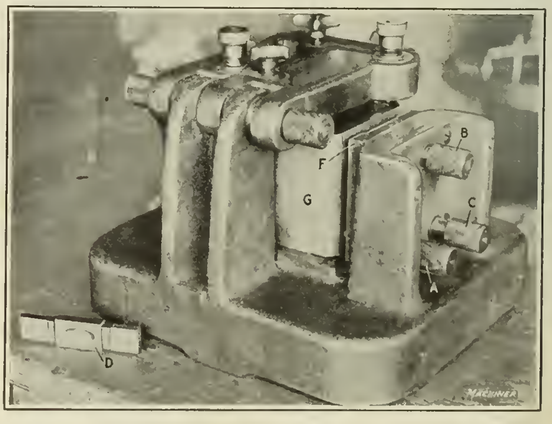


Fig. 73. Box Type of Gage for inspecting Tapped Holes and Milled Surfaces on Electric Starter Generator Frame

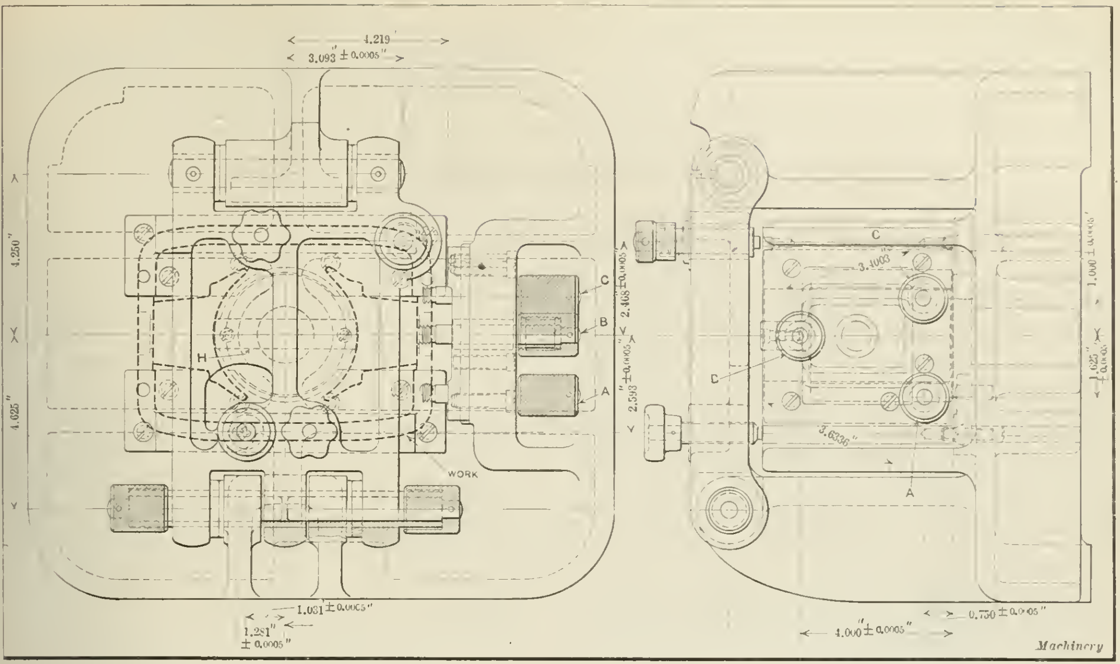


Fig. 74. Constructional Features of Gage shown in Fig. 73

Box Inspection Gage for Generator Frame

An interesting and practical application of the box type of gaging fixture is shown in Figs. 73 and 74. This gaging fixture is used for inspecting the location of the various holes in the generator frame, and is constructed along the same lines as the drilling jig used in producing the holes. The points to be gaged are three threaded holes which must bear a definite relation to the milled surface, and in addition, the milled surface must bear a certain relation to the center hole. The three holes are gaged, respectively, by the plugs *A*, *B* and *C*. The location of the milled surface is inspected by the limit gage *D*, Fig. 73, which is of the feeler type and is inserted between the hardened and ground plate *F* and the work *G*. Reference to Fig. 74 will show the variation allowed in the fixture in the location of the three tapped holes, which is ± 0.0005 inch. The limits on the work are still wider and are controlled by means of the variation between the pitch diameter of the plug gage and the threaded hole in the work. The location of the milled surface on the work in relation to the central hole, as will be noticed, also has limits of ± 0.0005 inch in the manufacture of the gage, whereas the work has a tolerance of 0.002 inch. The bore is inspected by a swinging end measuring bar *H*, Fig. 74, which is fulcrumed on a central stud and has "Go" and "Not Go" ends.

Reference to Fig. 73 will show that this gage is constructed of cast iron, and all wearing surfaces are made of tool steel or machine steel casehardened and ground. It consists primarily of a base on which a measuring surface is screwed and a swinging plate fulcrumed at the rear of the fixture and held down by means of two hardened and ground plugs. The swinging plate is provided with two clamping screws in the center and two spring plungers. The clamping screws are brought down lightly and the springs are depended upon to keep the work tightly against the lower surface of the fixture.

Generator Frame Inspection Gages

Fig. 75 shows another generator frame gaging fixture which is constructed on the same principle as that illustrated in Figs. 73 and 74. In this case, the generator is of different shape, and the fixture is shown with the lid up, exposing its interior construction. Reference to this illustration will show that the pole piece bearings are inspected by means of a swinging gage *A* having "Go" and "Not Go" ends. The bar is grasped by the inspector and is swung around past the poles to determine if they are of the correct diameter. The lid is then swung down and the feeler gage *B* used to determine if the frame is of the required length in relation to the central hole or axis. On the opposite end is a hole which must be gaged; this is done by a plug gage which is smaller than the hole in the work by an amount equal to the limits allowed.

Fig. 75. Another Type of Generator Frame Inspection Fixture

Two additional gaging fixtures are shown in Fig. 76. The one to the left is built along similar lines to the generator frame gage shown in Fig. 74. This gage shows the work removed and illustrates the method of locating and gaging it. The work fits

over the stud O, and is provided with a slot in which plunger A fits. A feeler gage is then inserted between the hardened plate B and the work to inspect the position of this slot, as well as of the milled surface in relation to the central hole. There is a bushed hole C in the top cover plate through which a plug is inserted for gaging a corresponding hole in the work. The fixture is provided with gaging seats in which dowel-pins are located for centering the work. The hinge plate, as will be noticed, is bushed, and is located accurately by hardened, ground and lapped plugs.

An inspection fixture which somewhat resembles the one shown in Fig. 73 is illustrated to the right in Fig. 76. This gage is also used for inspecting a generator frame, and determines the relation of a second bored hole having two diameters at right angles to the first which is located from stud F. The work is located by two dowel-pins, and the central plug is raised by operating lever G. Reference to this fixture will show that the traverse plugs D and E are prevented from turning. These two plugs and the central one determine the relation of the center distances between the spiral gears in the generator frame, and the relation of these holes may vary more in one direction than in another. In addition, two other rotating "Go" and "Not Go" plugs H and I are used to determine the location of the milled surface. The work is held

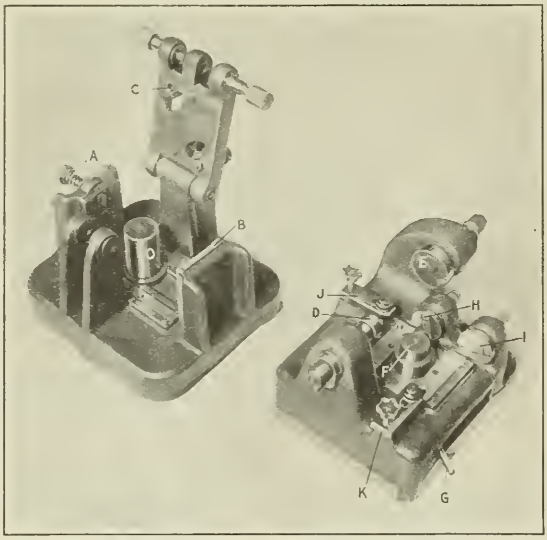


Fig. 76. Two Generator Inspection Fixtures somewhat Different from those previously illustrated

in place by toe-clamps J and K. The same locating and clamping points are used in the gaging fixture as were used in machining the parts. These gages, while somewhat similar in construction, cover principles having a wide application in general manufacturing work. They determine accurately the relations of the milled surfaces to the machined holes within limits that are close for work of this kind.

* * *

DETERMINING TAP DRILL SIZES FOR METRIC THREADS

A short time ago, the writer was required to set the tap drill sizes for a number of different pitches of metric threads, international standard. In working out the sizes, it was assumed that about 75 per cent of a full thread would give commercially satisfactory results, and with this point settled, the following steps were taken:

Let D = outside diameter of thread;
DD = double depth of thread;
RD = root diameter of thread;
TD = diameter of tap drill;
p = pitch of thread in millimeters.

$$DD = p \times 1.29904$$

and

$$RD = D - (p \times 1.29904)$$

Hence:

$$TD = D - p \times 1.29904 \times 0.75$$

Taking an example, let us assume that we wish to know the tap drill size for an international thread, 10 millimeters in diameter with 1.5 millimeter pitch. Applying the formula:

$$TD = 10 - 1.5 \times 1.29904 \times 0.75$$
$$TD = 8.53858$$

The nearest metric drill which can be obtained for this is 8.5 millimeters.

After figuring out a number of tap drill sizes by this formula, it was apparent that $p \times 1.29904 \times 0.75$ in all cases was almost the same as p; and as metric drills can be obtained in millimeter sizes and tenths of millimeters, a small variation would be permissible. An inspection of the sizes obtained made it evident that all this multiplication to obtain tap drill sizes was unnecessary and that $TD = D - p$, or, taking the same example as that given previously, $10 - 1.5 = 8.5$ tap drill.

No simpler formula can be devised for tap drill sizes than that given, as the sizes can be determined by inspection. The same formula can be applied to tap drills for the U. S. form of thread. For example, taking a ¾-inch diameter thread with ten threads per inch (0.100 inch pitch), we would have $0.750 - 0.100 = 0.650$ inch TD. The size commonly used for this would be 41/64 or 0.6406 inch, which, it will be seen, is 0.0094 inch less than the size obtained by the formula method. This method is extremely simple and easily applied, and in a great many cases the sizes can be determined by a mental calculation. A. A. D.

* * *

VALUE OF TRADE-MARKS

BY EDWIN M. GILES[1]

Owing to a misconception of the functions of a trade-mark, many persons for a long time thought that a trade-mark was only an excuse for charging an exorbitant price. Yet the trade-mark law was created solely for the protection of the buyer; it guarantees to the individual buyer that he will receive the commodity he desires.

The trade-mark was a most powerful factor in overturning the once basic principle of barter and sale: "Let the buyer beware." It was once the accepted practice, as it still is in the Orient and many other parts of the world, to cheat the buyer if possible. When a person buys a so-called "staple" article, he must either analyze and test each purchase to ascertain its purity, or he must take the word of the seller for this. Frequently the seller is a middle-man and must take the word of the manufacturer. The purpose of a trade-mark is to save the purchaser the expense and effort of testing goods. A trade-mark is the manufacturer's guarantee of the purity of any article bearing that mark. Because of their advertised value, the owners of trade-marks dare not, from selfish interests, permit the trade-mark to be applied to goods of questionable character. As a result, the largest concerns are trending toward the purchase of trade-marked material exclusively. Their buyers select two or more brands, which they have found most suitable, of each material used and then obtain prices for these. The medical profession for many years held that to specify or prescribe a trade-marked article was unprofessional and savored of quackery. Today almost all physicians specify trade-marked pharmaceutical preparations. They do so in order to be certain that the patient obtains something with which the physician is familiar. In this way the physician guarantees both to himself and to his patient the purity of his prescriptions.

Manufacturers are rapidly learning that it is of little concern to them how much profit is included in the price of goods they purchase as long as they can purchase these goods as low as any competitor and providing the quality is the best for their purpose. This attitude of the big buyers has acted as an encouragement and an inspiration to the producers of trade-marked articles. For there is no incentive like profit. As a result, the manufacturer using these articles finds his cost of operation being constantly reduced, not so much by the lowering of the first cost of materials as by the improvement in their quality and economy of use.

[1] Address: Care of E. F. Houghton & Co., Philadelphia, Pa.

DIAMOND TOOTH FORM FOR ROLLER CHAIN SPROCKETS[1,2]

It is a fact patent to all who have had experience with chains and sprockets that the particular form of sprocket tooth so long in use has been found decidedly unsatisfactory, and has not met the reasonable requirements of high-grade steel roller chains as made today for the transmission of power. In many cases chain drives have been abandoned and other means of transmission substituted, because of noise or rapid wear, due solely to poorly designed sprocket teeth. Some two years ago

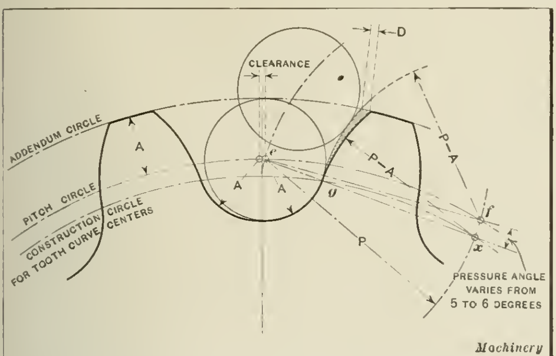


Fig. 1. Old Form of Sprocket Tooth with Pitch Line Clearance and Small Pressure Angle

it seemed to the Diamond Chain & Mfg. Co., Indianapolis, Ind., and a few others, that the time had come to apply scientific methods to the study of sprocket teeth, and to develop a tooth form that would be less noisy and more efficient than the old form. Accordingly its engineering department began a course of study and experimentation which has led to the development of the form herein described. Tests have ex-

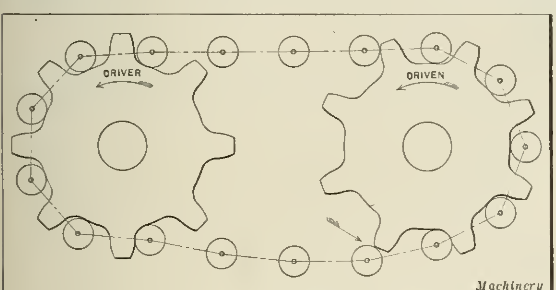


Fig. 2. Chain too Short and Action of Follower Impossible; Pitch Line Clearance a Little Greater than Necessary for Driver

tended over a period of nearly two years, and this firm is now regularly supplying sprockets and cutters of this design to its customers.

Every chain begins to elongate as soon as it is put into operation, and this elongation, due to wearing of the rivets

[1] Abstract of booklet entitled "Diamond Tooth Form for Roller Chain Sprockets," published by the Diamond Chain & Mfg. Co., Indianapolis, Ind.
[2] For additional information on the design of sprocket teeth and allied subjects published in MACHINERY, see also "Design and Construction of Sprockets," by B. D. Pinkney, January, 1916, and other articles to which reference was made at that time.

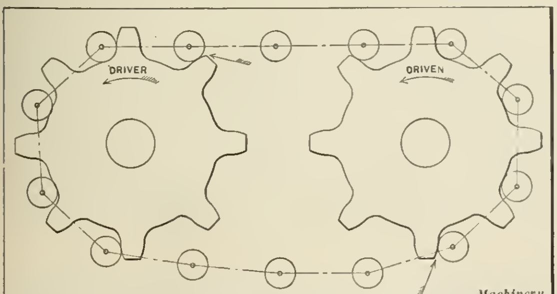


Fig. 3. Chain too Long and Clearance Insufficient

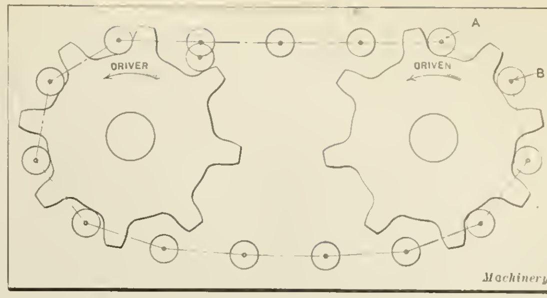


Fig. 4. Chain Elongated and Clearance Ample; when Roller A is released B will come against Tooth with Snap, making Motion of Sprocket Jerky

and bushings, continues as long as the chain is in use. To provide for this continual lengthening of the pitch, the old-style sprocket is cut with the clearance on the pitch line, thus allowing the rollers of an elongated chain to creep around the pitch circle without interference with the backs of the teeth. The Diamond chain sprocket tooth has only a slight amount of pitch line clearance, but the pressure angle is increased, so that as the chain elongates the rollers ride at higher points on the teeth, thus allowing the chain to adapt itself to its own proper pitch circle. A study of Figs. 1 to 6, inclusive, will make

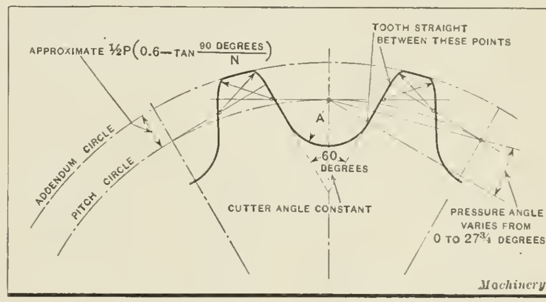


Fig. 5. Renold Form of Sprocket Tooth, with Uniform Space Angle of 60 Degrees, Variable Pressure Angle from 0 to 27¾ Degrees, and No Pitch Line Clearance

this perfectly clear. Clearance *D* at the end of the tooth was thought to be of chief importance, center *x* being so chosen that this clearance is always one-tenth of the roller diameter; and the radius of the tooth curve is equal to pitch *P* minus one-half the roller diameter, *A*. The last point of contact between the roller and tooth is at *g*, and the pull of the chain is in the direction *ex*. Hence the pressure angle is the angle included between *ef* and *ex*. This angle is about 5 degrees on a

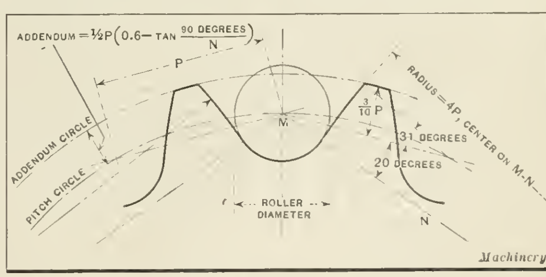


Fig. 6. Diamond Chain Sprocket Tooth Form, with Uniform Pressure Angle, Variable Space Angle, and No Pitch Line Clearance

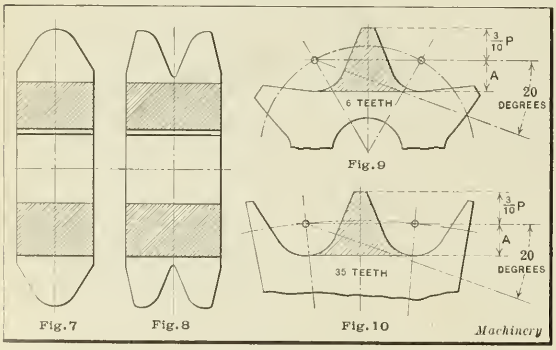
nine-toothed sprocket, and 6 degrees on a thirty-five-toothed sprocket. The pitch line clearance is usually about one-twentieth of the roller diameter; and when the pressure angle is only 5 or 6 degrees, this clearance is provided in order to allow space for the inactive rollers of a worn and elongated chain. After the chain has begun to wear, only one tooth will be in action at a time; and if this clearance were not provided, an elongated chain would tend to climb the teeth; but the small pressure angle would prevent this. See Figs. 2, 3 and 4.

In Fig. 5 is shown the tooth form used by Hans Renold, of Manchester, England, which has the merit of requiring only

five cutters for cutting six to eighty teeth, of providing a shorter tooth and a greater pressure angle, allowing an elongated chain to adapt itself to a larger pitch circle by running on a higher portion of the tooth. A reduction of noise and of wear is also conspicuous, and the load is divided among all the teeth in mesh, instead of falling entirely upon one tooth. The pressure angles vary as follows: for six teeth, 0 degrees; for seven teeth, 4¼ degrees; for eight teeth, 7½ degrees; for ten teeth, 12 degrees; for sixteen teeth, 18¾ degrees; for twenty teeth, 21 degrees; for eighty teeth, 27¾ degrees.

Fig. 6 illustrates the system developed by the engineering department of the Diamond Chain & Mfg. Co., which is said to have all the advantages of the Renold system, besides the following: Instead of making the angle of the tooth gap equal to 60 degrees for all sprockets, the pressure angle (or the angle formed by the line of action of the chain and a normal to the tooth outline at the point of contact) is kept constant and equal to about 20 degrees, thus following the well established principle used in connection with involute gear teeth. Sprockets with a greater number of teeth can be used, since we do not depend upon pitch line clearance to take up chain elongation, but upon the ease with which the chain adapts itself to a larger pitch circle. See Fig. 6. If cutters are used as shown in Fig. 7, five cutters will be required for cutting all numbers of teeth from seven to infinity. The range of pressure angles for any one cutter is 17½ to 22¼ degrees. In ordering cutters of this type, give pitch, roller diameter and range of teeth to be cut. Cutters are made for the following ranges: seven to eight teeth, nine to eleven teeth, twelve to twenty-seven teeth, eighteen to thirty-four teeth, thirty-five teeth and over. If cutters are used like that shown in Fig. 8, only one will be required for cutting any number of teeth for a given pitch and diameter of roller. This means that a complete stock of cutters for the various sizes of chains made in this country from ½ inch to 2 inches pitch would not exceed twelve in number. The pressure angle will be the same for every sprocket. This type of cutter cannot be used to cut teeth of the Renold type, since the contour changes for every change in the number of teeth to be cut.

An examination of Figs. 9 and 10 will show clearly the equality of tooth outlines in the Diamond type, and will explain why this great economy in cutter equipment can be effected. This type of cutter is known as the "Diamond universal sprocket cutter." In ordering, it is only necessary to specify the pitch and roller diameter, other dimensions, such as thickness, outside diameter, hole and keyway being standard. When this type of cutter is used it is recommended that the machine be indexed so that every other tooth will be cut first and the intermediate teeth afterward. This eliminates the tendency to produce a side thrust on the sprocket and thus spoil the accuracy of the indexing. To do this, use index gears for cutting half the given number of teeth. If the number of teeth is odd, either double the stop pawl number, if any, or double the number of teeth on one of the driving gears. Then when the blank has indexed through two revolutions, all of the teeth will be cut. If the number of the teeth to be cut is even, first cut half the teeth, then turn the blank through the space of one tooth (the manner of doing this depends upon the type of gear-cutting machine used), make a cut, and then



Figs. 7 to 10. Cutter Outlines and Sprocket Tooth Outlines

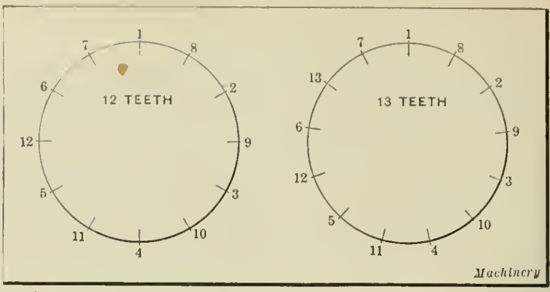


Fig. 11. Diagrams showing Methods of indexing for Even and Odd Numbers of Teeth

again index for every other tooth and cut the intermediate teeth. Fig. 11 shows the order in which the teeth are cut for a twelve- and thirteen-tooth sprocket, respectively.

Briefly, the essential differences between the Renold tooth form and that developed by the Diamond Chain & Mfg. Co. is that the former provides for a constant space angle and variable pressure angle, while the latter provides for a constant pressure angle and variable space angle.

To sum up, the Diamond chain sprocket tooth form has the following advantages over the form still largely in use: (1) The chain passes both on and off the sprocket teeth with greater ease; hence, less noise, less wear, and greater efficiency. (2) The pressure is distributed among all the teeth in mesh. (3) As the chain elongates, it adapts itself to a proportionately larger pitch circle, putting wear on a new part of the tooth, and thus reducing the tendency to "hook" the teeth. (4) The pressure angle is large. (5) The pressure angle is the same for all numbers of teeth. (6) An elongated chain will run as well on a sprocket with one hundred teeth as with twenty teeth. (7) Any number of teeth for a given pitch and roll diameter can be cut with a single cutter. (8) The length of tooth is so determined that the angular motion of the link between the pitch circle and the addendum circle is always the same (31 degrees).

The outside diameters for these sprockets are less than those usually tabulated. Instead of adding the roll diameter to the pitch diameter to obtain the outside diameter, the following formula is used:

$$\text{Outside diameter} = \text{pitch diameter} + P\left(0.6 - \tan\frac{90\ \text{degrees}}{N}\right)$$

The rule for calculating the outside diameter may be stated thus: Divide 90 degrees by the number of teeth and find the natural tangent of this angle. Subtract it from 0.6000 and multiply the difference by the pitch. Add the result to the pitch diameter.

* * *

USES FOR SHELBY TUBING

New uses for Shelby steel tubing are constantly being found. A 16-inch lathe was one of the two tools in the repair shop in a Pennsylvania lumber mill, and a lathe with a hollow spindle was badly needed. So the superintendent got a length of Shelby steel tubing and sent it to the nearest shop to be made up into a hollow spindle. This worked out very nicely and was as good as the spindles made of ordinary machinery steel which are frequently put in on a repair job where the work is not heavy.

Another use for tubing is found in milling-machine collars. It requires no turning at all, for the various sizes of holes to suit standard arbors are "stock," and practically any outside diameter can be obtained. Dealers should select tubes which have the holes a trifle small; it is then only necessary to saw off the lengths, run a reamer through them, and face the ends. In spite of the higher cost of tubing over cast iron, such collars can be economically made and are to be preferred—except where collars are made as a slack time "filler" or for the experience of apprentices. D. A. H.

* * *

Although both discovery and invention refer to new things, discovery consists in finding new truths in nature, while invention is the applying of these truths to some desired purpose.

TUNGSTEN LAMP MANUFACTURE

PROCESSES USED BY THE UNITED INCANDESCENT LAMP CO., BUDAPEST, HUNGARY

BY CHARLES EISLER [1]

THE processes used in the manufacture of tungsten lamps are of considerable interest. Owing to the fragility of the various materials used in the construction, the machines and fixtures must be so arranged that they will perform their functions in a minimum time and with little likelihood of breaking the parts. Practically every part of an incandescent lamp requires the most delicate handling, from the tungsten filament to the glass bulbs. The processes and machines described in this article are based upon the practice developed by the United Incandescent Lamp Co., Budapest, Hungary, and while this is not secret, the writer believes that this material has never been published in detail form in this country. The various steps which are taken in connection with the manufacture of the lamp from the swaging of the tungsten billet to the final testing of the finished lamp will be described in this article and the machines used will be illustrated.

Manufacturing the Tungsten Filament from the Slug

The powdered tungsten is first weighed and then poured evenly into a mold or die like that shown in Fig. 1, after which the mold is placed under a hydraulic press and compressed at a pressure of about 5000 kilograms per square centimeter. The die is made from high-grade tool steel, hardened and ground very accurately. The mold is usually made from 1/4 to 3/8 inch square and about 5 to 8 inches long. The depth of the die is considerably more than the slug is to be, in order to give the plunger *A* a good location in the die before the tungsten is compressed. After the bars have been compressed they are fragile and their handling requires skill. A hydrogen furnace is used to unite these bars, the temperature being about 2000 degrees C.

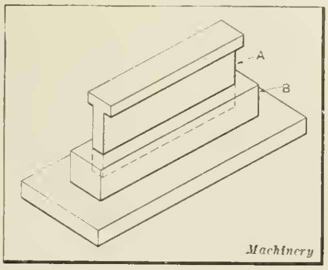


Fig. 1. Mold used for compressing the Tungsten Powder into Slug Form

Heating and Swaging the Slug

A special electric furnace such as that shown in Fig. 3 is used to heat the slug to a temperature of from 1200 to 1300 degrees C. in an atmosphere of hydrogen. Referring to Fig. 2, the various parts of the tungsten lamp will be seen, and the form produced on the tungsten slug by the first swaging operation can be noted at *A*. One end of the slug is formed for a distance of 80 or 90 per cent of the length, after which it is

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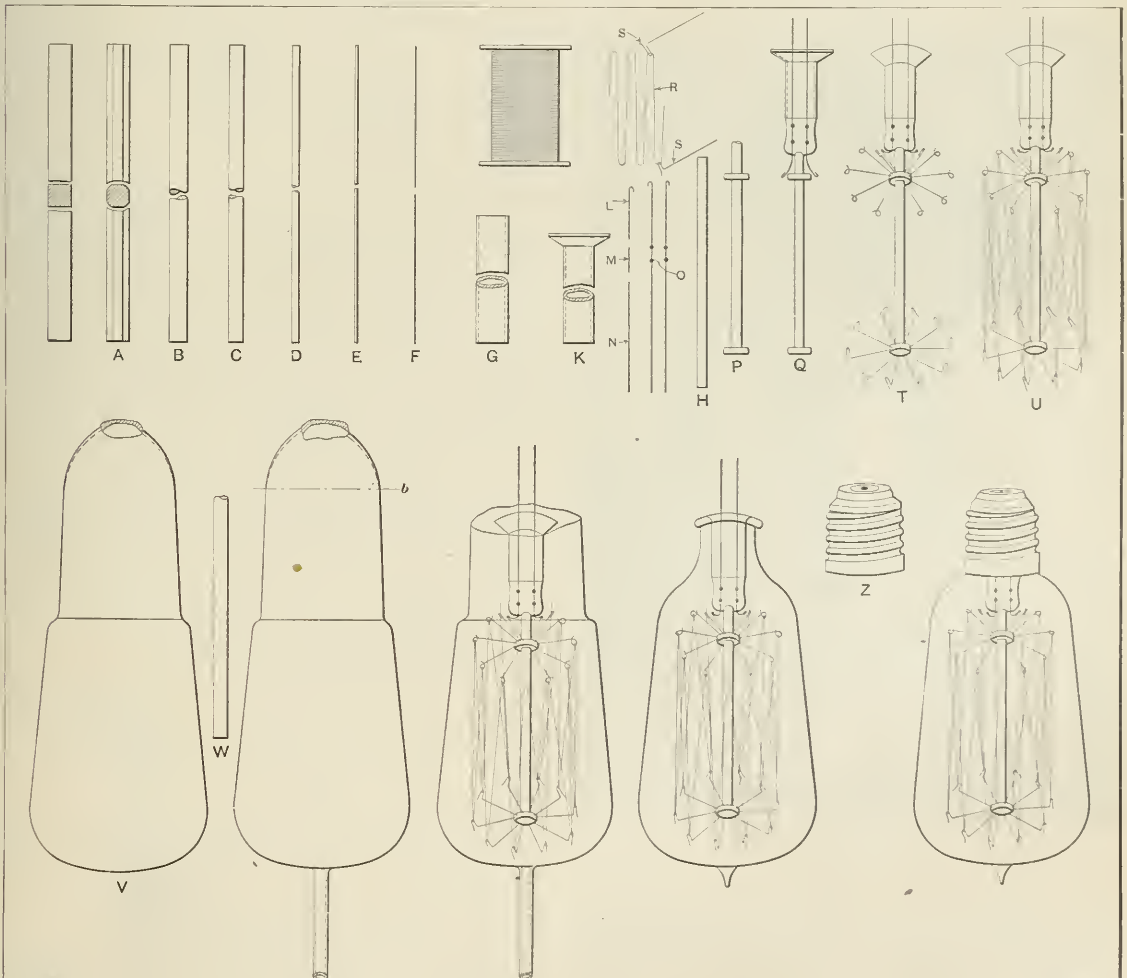

Fig. 2. Component Parts of Tungsten Lamps

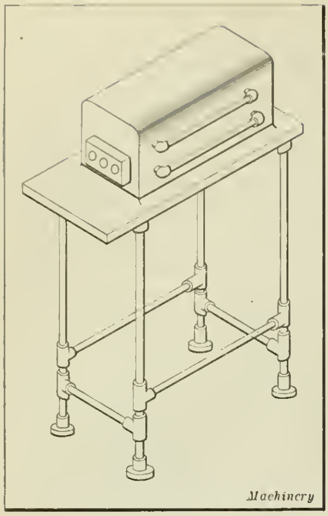

Fig. 3. Electric Furnace used for Slug Heating

reheated and the other end swaged to completion. The handling of the slug from the furnace to the swaging machine is done very rapidly in order to prevent the slug from oxidizing as far as possible.

Hot-swaging the Slug

After the slug has been heated to the proper temperature, it is removed by means of the pliers shown in Fig. 5 and transferred to the swaging machine for the first operation, which consists of forming it into octagonal shape. Fig. 4 shows a hot swaging machine built by the Langelier Mfg. Co., Providence, R. I. These machines are built in several sizes, the same principles being incorporated in the various machines, with the exception that in the case of the No. 1½ hot swager, there is an annular recess or chamber inside the machine head, through which a stream of cooling water is kept running in order to prevent the machine from heating unduly during the handling

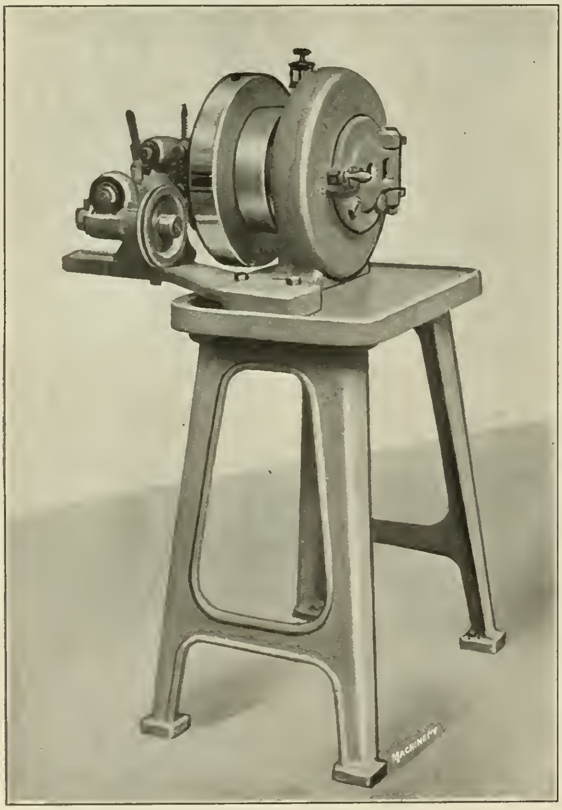

Fig. 4. Langelier Swaging Machine

of the hot tungsten wire. The sectional view shown in Fig. 6 is taken directly through the center of the spindle and shows the construction very clearly. The spindle is slotted across the enlarged end to receive a pair of hammer-blocks and dies *A* and *B*, the reciprocating action of which is in a radial direction. The spindle is driven by the pulley *C*, which has a heavy

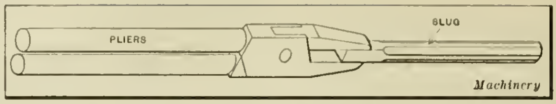

Fig. 5. Pliers for holding Tungsten Slug while swaging

rim and acts as a flywheel, producing a steadier movement. As the spindle revolves, the jaws are thrown outward by centrifugal force, so that the outer ends strike against the steel rolls *D*, which throw them back again toward the center. There are a number of these rolls on the inside of the cage so that the reciprocating action of the jaws is very rapid. This type of machine was described in detail in the January, 1914, number of MACHINERY on page 420.

Fig. 2 shows at *A*, *B*, *C*, *D*, *E* and *F* the various steps through which the tungsten slug passes in being swaged to the required size. The rods are swaged from 5/16 inch square to 1/32 inch round in steps of about 0.020 to 0.025 inch at a time. When the rod has been swaged to 1/32 inch, it is usually from

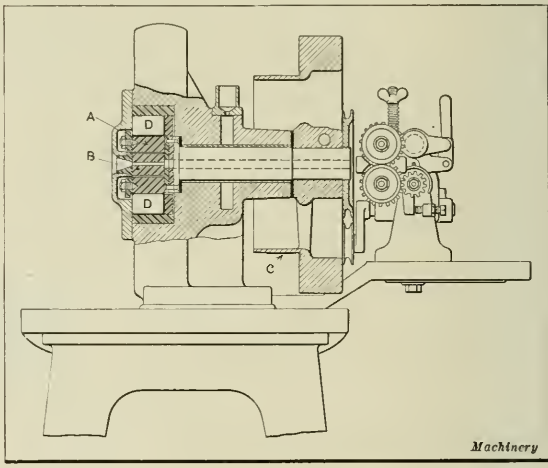

Fig. 6. Longitudinal Section through Head of Langelier Swaging Machine

75 to 100 feet long. From 1/32 inch, the wire is drawn at a cherry red through diamond dies by steps of 0.002 to 0.005 inch until it is about 0.003 inch outside diameter. For the smaller sizes it is drawn by steps of 0.001 inch down to 0.001 inch outside diameter, or even smaller if required. Wire has been drawn down to 0.0004 inch outside diameter and to lengths of from 10,000 to 11,000 feet.

Drawing Wire Through Diamond Dies

After the swaging operations have been performed, the wire is drawn through diamond dies as shown in Fig. 7. The drawing operations are performed on several sizes of machines.

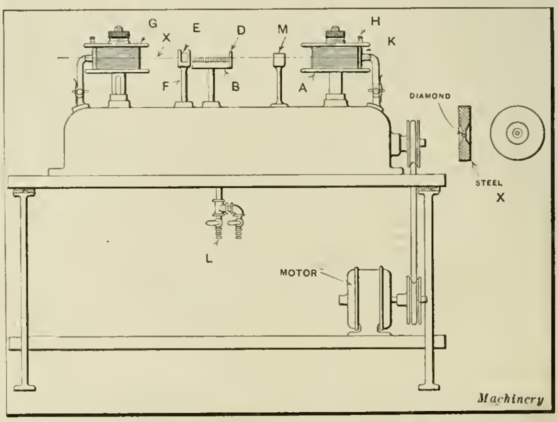

Fig. 7. Machine used for drawing Tungsten Wire through Diamond Dies

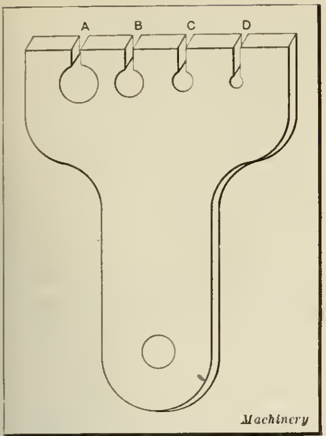

Fig. 8. Gage for Glass Tubing

according to the diameter of the wire. The wire is drawn at the rate of from 10 to 85 feet per minute, the speed depending on the size of the wire. The operation is as follows: The wire is placed on spool *A* and led through lubricator *M* and guide *D* over gas flame *B* and through die *E*. This die is held in a bracket *F* and the wire *X* is wound on the spool *G*. This spool travels vertically up and down a distance equal to the width of the spool, in order to distribute the wire evenly on it. The end of the wire is held on the spool by the screw *H*, and the protector *K* is provided to keep the wire on the spool in case it should break during the drawing operation. The wire is heated to a cherry red heat while being drawn, the gas and air mixers at *L* being provided for this purpose; these supply the gas for the burner *B*.

Cleaning and Flashing the Wire

The wire is now cleaned and annealed under hydrogen by the machine shown in Fig. 9. It is taken from a spool at

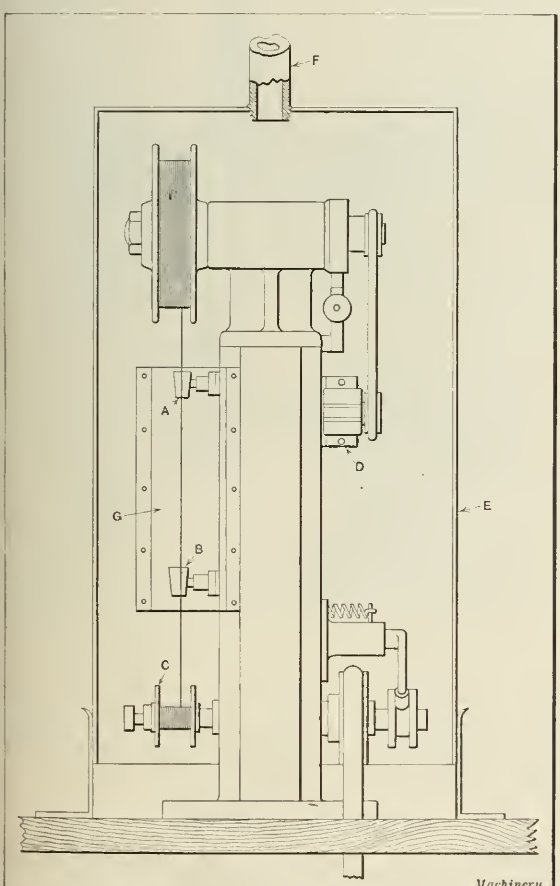

Fig. 9. Machine used for cleaning Tungsten Wire

the top, drawn through the mercury cups *A* and *B* onto the spool *C*, which is passed back and forth to allow the wire to be distributed evenly on its surface. A speed recorder *D* shows

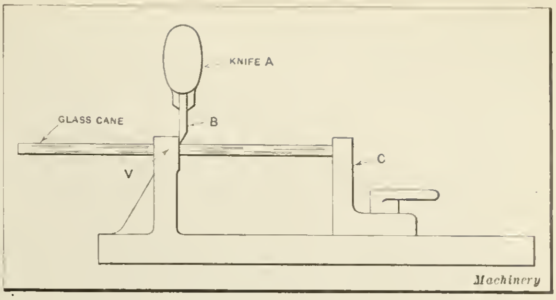

Fig. 10. Cutting Glass Tube on Hand Fixture

the number of meters which are run from each spool. The machine is covered by a hood *E*, which contains hydrogen gas and is provided with a mica window *G* so that the operator can observe the working of the wire.

The mercury cups *A* and *B* form the terminals through which an electric current passes which heats the wire in

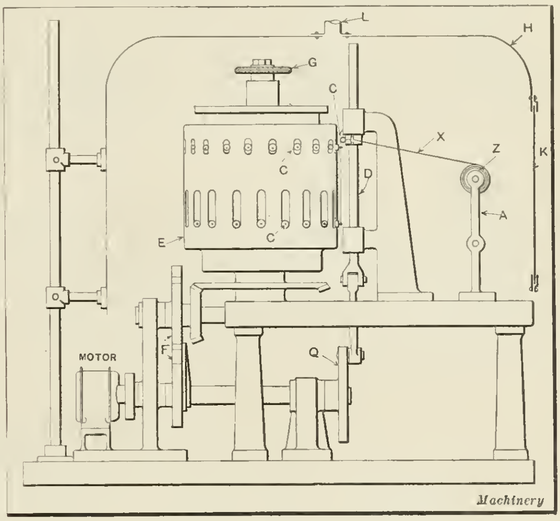

Fig. 11. Forming Zigzag Filament

transit, and while this is being done it must be run under hydrogen in order to keep it from becoming oxidized. This process of heating the wire electrically as it passes through the mercury cup is called flashing. The hydrogen is let into the hood by the inlet pipe *F*, and provision is made for raising and lowering the hood by means of a sprocket chain and handlever not shown.

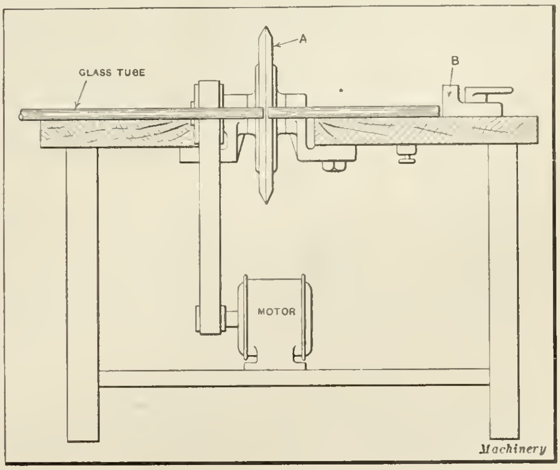

Fig. 12. Cutting Glass Tube with Emery Wheel

Forming the Zigzag Wire

A special forming machine shown in Fig. 11 is used to form the wire into zigzag shape after it has been cleaned as described in the previous operation. The process is as follows: The spool Z is filled with wire and placed on the bracket A. The wire X is bent over the pins C, which are adjustable for different lengths of the zigzag. The machine is driven by the electric motor shown through a stop motion of the Geneva type shown at F. The wire is drawn from the spool through a holder on the sliding rod D controlled by the eccentric shown at Q. Adjustment is obtained by turning the knurled nut G. The pins C are insulated to give the proper electrical contact, as the shape of the wire is formed while it is red hot. The mechanism is covered by a sheet metal hood H having a mica opening at K to permit the operator to see the work. The operation is performed under hydrogen as in the preceding case, the gas entering the hood at L. The tungsten wire is

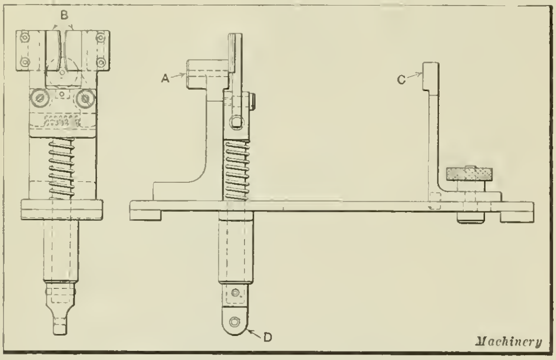

Fig. 13. Machine Fixture for cutting Glass Tube

shaped under the hydrogen hood in order to prevent the filament from oxidizing. The hood can be raised by means of a chain and handwheel.

Cutting the Glass Tube

Several methods of cutting the glass tubes are in vogue, but the operation of cutting is very simple. The tube shown at G in Fig. 2 is cut on an ordinary rotating wheel as shown in Fig. 12. A V-shaped carborundum wheel A is used and the tube held against the stop B, which is adjustable for various lengths. The operator can handle more than one length of glass when cutting by placing one on top of the other. It must not be understood that the glass is entirely cut through by the wheel, as it is simply nicked a little and then cracks off, due to the heating action of the wheel on the glass. The tubes are cut from lengths of about three or four feet, and with this method 2500 to 3000 can be cut per hour. The glass cane shown at H, Fig. 2, can also be cut by this method, but another device is used for the solid glass rods.

Fig. 10 shows a hand fixture used in cutting the glass rod H, the cutting in this case being done by a knife. The most common type of knife in use is that shown at A, although others are being used to some extent. The knives are made of special tool steel and hardened. When regrinding, they must be ground on stones under a stream of water, in order

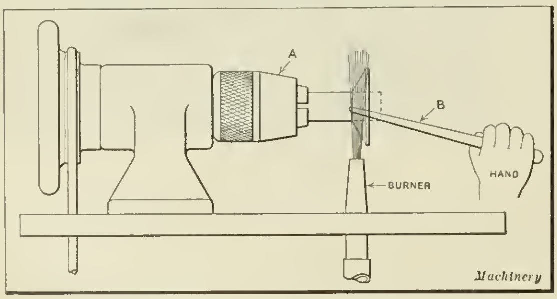

Fig. 14. Flanging Glass Tube to make the Flare

to guard against the temper being drawn in the slightest degree.

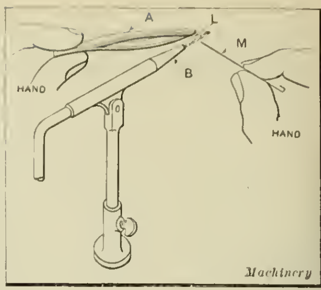

Fig. 15. Welding Tungsten and Platinum Wires

The knives shown at B in Fig. 13 are used in a fixture in which the glass rod is fed through the hole A and is held against the adjustable stop C. The knife blades are then pulled down by the plunger D by means of a foot-treadle not shown in the illustration. By this method the glass is scratched on both sides and then cracked off. From 2000 to 2500 pieces per hour can be produced in this way by a girl. In sorting, a regular snap gage is used such as that shown in Fig. 8. This work is done before the tubes or canes are cut to the required length. About eight or ten rods or tubes can be held in the operator's hand at one time and gaged very rapidly. At A, B, C and D are shown the slots for the different sizes.

Making the Flange

The glass tube G, Fig. 2, is heated in a special rotary chuck A shown in Fig. 14, and when the glass has been heated to the proper temperature it is flanged by the rod B to the shape K,

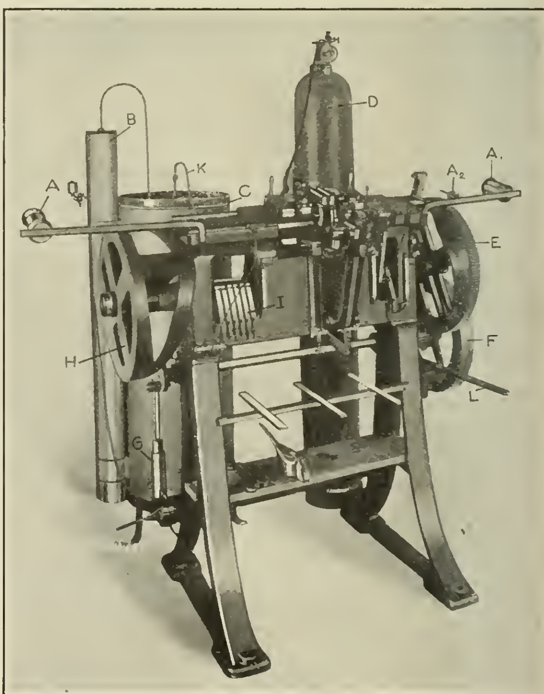

Fig. 16. Automatic Machine for welding Lead-in Wires

Fig. 2. In the majority of cases two or more rotary chucks are used so the maximum production will be obtained. When two chucks are used, one is being heated while the other is being loaded. The forming is generally done by hand, but may be done automatically if desired.

Making the Lead-in Wire

Referring to Fig. 2, L is a nickel lead-in wire of which one end is bent and clamped to the filament and welded to M, which is made from platinum or a substitute. This portion is usually 1/8 inch long and has a diameter of 1/64 inch approximately, depending upon the size of the lamp. Platinum is used because it has the same coefficient of expansion as the glass. N is a copper wire, the ends of which are soldered to

the base after the lamp is based. The wires L, M and N are electrically welded together as shown at O, and two are used in each lamp. It is an interesting fact that the majority of lamps of this kind contain platinum, and up to the present time it has been difficult to procure any substitute.

In making the welds on pieces L and M, the part L is held with a pair of tweezers A, as indicated in Fig. 15, while the part M is held by hand, and both ends are brought together over the needle gas burner B and welded. This operation looks difficult, but an operator with little experience can get a production of approximately 350 pieces per hour. The part N is handled in the same manner.

Fig. 16 shows a machine which is a standard product of a German manufacturer for welding lead-in wires. This machine is arranged to take three different kinds of wires and

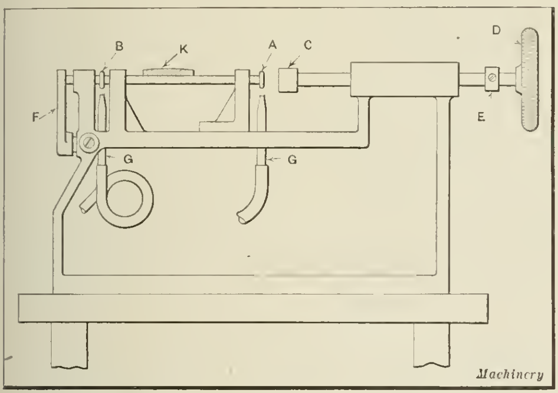

Fig. 17. Fixture for making Cane Rod Buttons

weld them into one complete unit, the production being in the vicinity of 2500 pieces per hour. It can be arranged to make hooks or tubes as desired. Referring to the illustration, A, A_1 and A_2 are, respectively, the copper wire roll, the nickel wire roll, and the platinum wire roll. The gas regulator and the gas tank are shown, respectively, at B and C, while the hydrogen bottle can be noted at D. The driving pulley and flywheel are shown at F, and the gear and cam by means of which the slides are operated are indicated at E. The gas compressor G is driven from the main shaft. The electrical contacts are at I. The movement of the slide is controlled by the cam wheel H.

Making the Cane Rod Buttons

The glass arbor or cane rod shown at H in Fig. 2 is cut to length and sorted to the proper size, as previously described. After it has been cut, the rod is inserted in the fixture shown

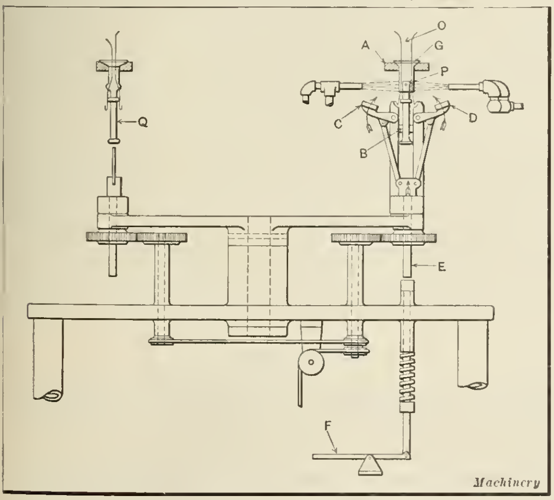

Fig. 18. Machine for making Stem

in Fig. 17, in order to make the buttons or enlarged ends as shown at P in Fig. 2. The glass rod is located in U-grooves and the flames G heat the part where the button is to be made. After sufficient heat has been applied, the end of the rod is pressed by hand by the knurled knob D and the anvil on the end of rod C. An adjusting collar is provided at E and another adjustment for the other end may be noted at F. While the rod is being heated, it is turned back and forth by a fiber turner K to form the button to the required shape. Other methods are used for doing this work, but the process shown produces good results and is inexpensive. Five or six arbors can be handled at one time, and the anvils can be arranged to be operated by a foot-lever if desired.

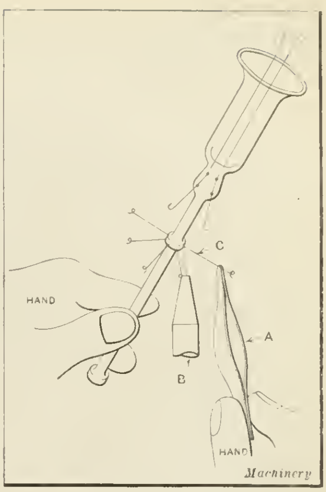

Fig. 19. Inserting Anchor

Stem Making

A complete stem consists of parts K, O and P, Fig. 2, which are assembled to make the piece Q. The flare, lead-in wires and arbor are inserted in a holder as shown in Fig. 18. The flare is held in a sort of nest and the arbor by the jaws shown at B. While the welding flames are softening the glass parts the head is rotated, and after the glass has been softened sufficiently the clamping is performed by the jaws C and D and the plunger E, actuated by the foot-lever F. Machines of this type frequently have from one to eight separate heads. After this operation has been performed, the stem is ready for the insertion of the filament supporting anchor.

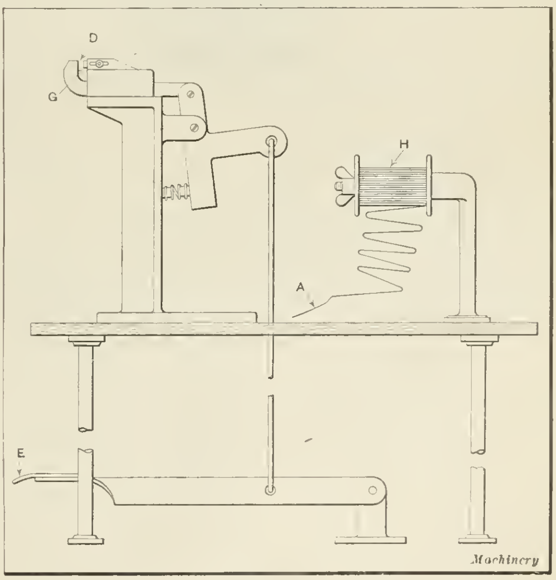

Fig. 20. Fixture for clamping Zigzag Filament to Lead-in Wires

Inserting the Anchor

The anchor is made of nickel wire and the end is coiled on a special machine at the rate of 5000 per hour, after which the wire is inserted in the stem as shown in Fig. 19. The flame from pipe B is directed against the button and anchor C while the nickel wires are set in place by tweezers A, a

needle burner being used for this work as previously described. A part of the hub and the short end of the anchor C are heated and inserted by hand, as indicated.

Mounting the Zigzag Filament

The zigzag filament shown at R in Fig. 2 is taken from a drum and mounted on hooks as shown at S; in addition, the two ends of the tungsten wire are clamped to the lead-in wires

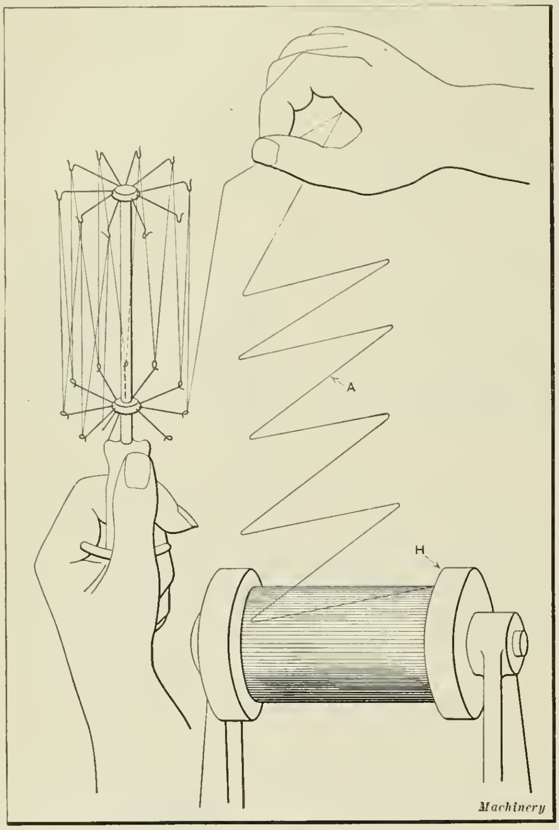

Fig. 21. Method of assembling Zigzag Filament

as shown at U. In this operation the zigzag wire is removed from the spool on which it has previously been wound, as indicated in Fig. 21, and hooked over the anchors by hand. After this has been done, the operator takes the end of the wire A and holds it in the hooked end of the lead-in wire while this is placed between the jaws D, Fig. 20. By pressing down on the lever E the jaws are moved together to clamp the wire in place. After one end has been clamped, the operator winds the zigzag on the hooks, clamps it and cuts off the end at the same time with a knife. During this operation the work is held at a slightly different angle. It will be noticed that the zigzag wire has already been wound on the spool H into the V-shape that it will have when mounted. This operation is done when the wire is taken off from the forming machine shown in a previous illustration. The spool H is conveniently accessible to the operator, so that the work can be done very rapidly. It will be understood that the work shown in Fig. 21 of pressing the zigzag filament on the anchors is done after one end of the wire has been clamped, as stated.

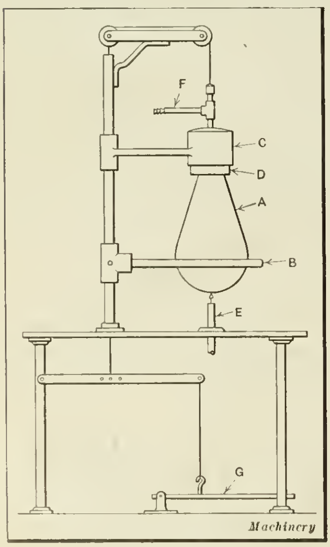

Fig. 22. Piercing Bulb

Operations on the Bulb

After the bulb shown at V in Fig. 2 comes from the glass molds, it is first washed. The piece shown at W is the so-called top tubing which has been cut and sorted to the proper size. This tubing is cut into three-foot lengths by the same process as was employed for cutting the glass canes.

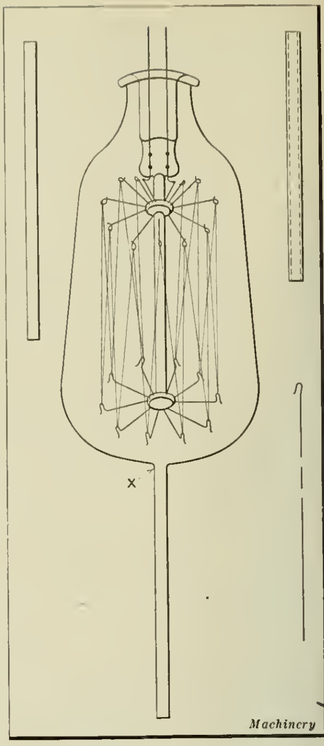

Fig. 23. Bulb with Tube and Stem assembled

Piercing the Bulb

Before the top tubing W is sealed on the bulb, it is necessary to pierce a hole as shown at X in Fig. 23. The method of piercing this hole is clearly shown in Fig. 22. The bulb A is placed in the nest B; the cap C is lowered, and the rubber ring D acts as a seal on the bulb. F is the air inlet to which a rubber tube is connected when in operation. The air enters the bulb while the flame heats the part where the hole is to be pierced. As soon as the glass has become soft from the gas flame E, an opening is caused by the air pressure,

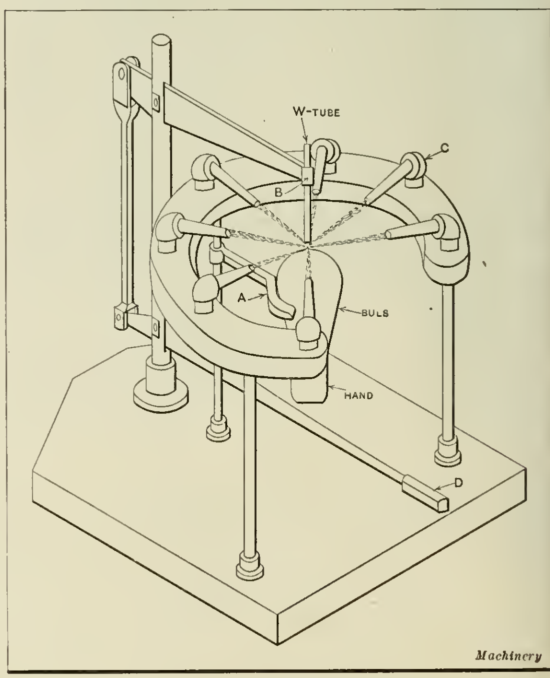

Fig. 24. Tubulating Bulb

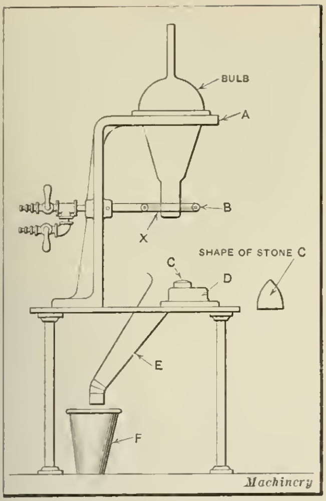

Fig. 25. Cracking off Collar

after which the cap C is raised by removing the pressure from the treadle G. The air pressure used is from 4 to 5 pounds per square inch.

Tubulating the Bulb

The tube is inserted in the bulb on a machine shown in Fig. 24. The bulb is held by hand in the nest or case A while the tube is held by a spring chuck B. The flames C must concentrate on the center of the bulb and on the end of the tube, and when both parts are heated to the melting point the tube W is pressed lightly against the bulb by the hand-lever D. This lever is connected with the burners C in such a way that as soon as the lever is touched the flames stop burning. During the course of the operation, the bulb is turned back and forth a little until it is sufficiently hot to make the seal.

Cracking Off the Collar

The apparatus used for cracking off the bulb collar is shown in Fig. 25. The bulb is placed in the fixture A and the part to be cracked off at X centers in a ring burner which heats the bulb all around. Then the bulb is removed and the end X is placed on a saturated stone such as that shown at C, or on any other substance which will hold moisture. As soon as the

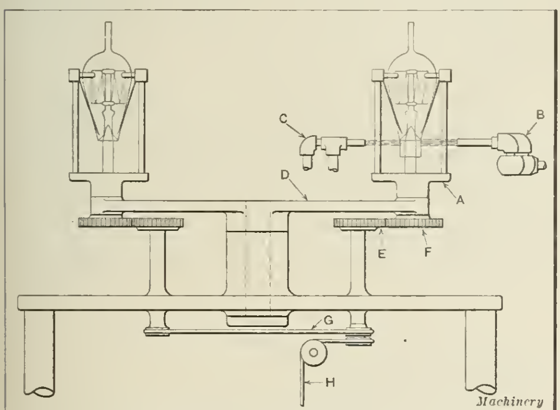

Fig. 26. Sealing Bulb

hot glass strikes the stone the collar breaks off, leaving a clean fracture. D is the water container intended to supply the moisture, E is a chute for scrap, and F is a scrap pail. In operating, the bulb is held on the stone C until it cracks off, the operator in the meantime having placed another bulb in the holder A, making the operation almost continuous. About twenty to twenty-five seconds is the time taken to perform this operation. The top tubing is used to locate the bulb during the operation of exhausting.

Sealing the Bulb

The bulb and stem are located in a rotating holder as shown at A in Fig. 26. While this is rotating, the two segmental fires (Bornkessel) B and C heat the bulb until both parts are melted together as shown. There are usually four or more arms or heads D, so that the bulb can be heated gradually and the finished bulb allowed to cool while one position is being finished. The holder or head A is rotated by the gears E and F driven by the belts G and H. The operator always remains in the same position in relation to the holder. When the work is completed, the operator simply turns the arm D by hand for the next position. Automatic attachments for indexing are also made for machines of this kind.

Exhausting the Lamp

The method of exhausting the lamps is shown in Fig. 27. The lamps B are inserted in the rubber tubes C, and the lead-in wires are wrapped around pins A through which an electric current passes. The tubes C are on a common manifold which is connected to the vacuum line D. After the lamps have been placed in their proper position, they are raised into the oven E which is kept hot by gas flames. The oven temperature is raised to as great a degree as the lamps will stand without damaging them, and they are left here for a short time, after

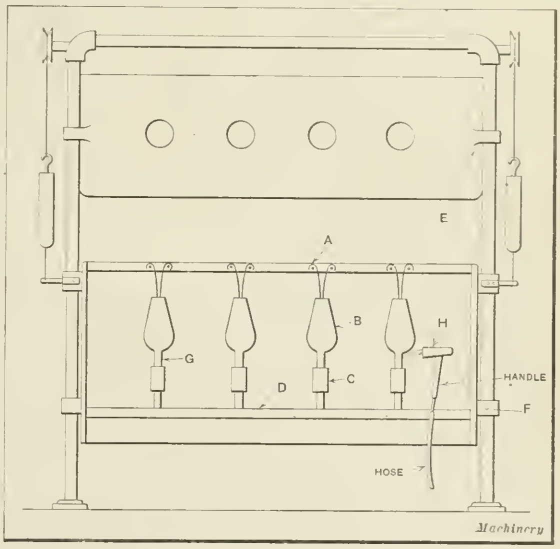

Fig. 27. Apparatus used for exhausting Lamp

which they are lowered again and burned at about 120 per cent rating for four or five minutes.

After this the lamps are tipped off, that is, the tube G is cut off with a hand torch as shown at H, and then removed for other operations. The vacuum obtained varies according to the size of the bulbs and the shape of the lamps. A high vacuum of 0.001 millimeter, mercury pressure, is obtained in some cases. In any event, the vacuum must be as perfect as is commercially possible.

Basing the Lamp

The bases shown in Fig. 2 at Z are filled with cement and placed on the bulbs, after which they are located in the basing fixture as shown in Fig. 28. There are two separate carriages

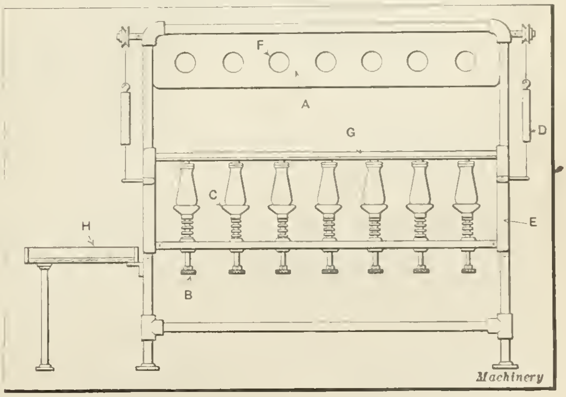

Fig. 28. Basing Lamp

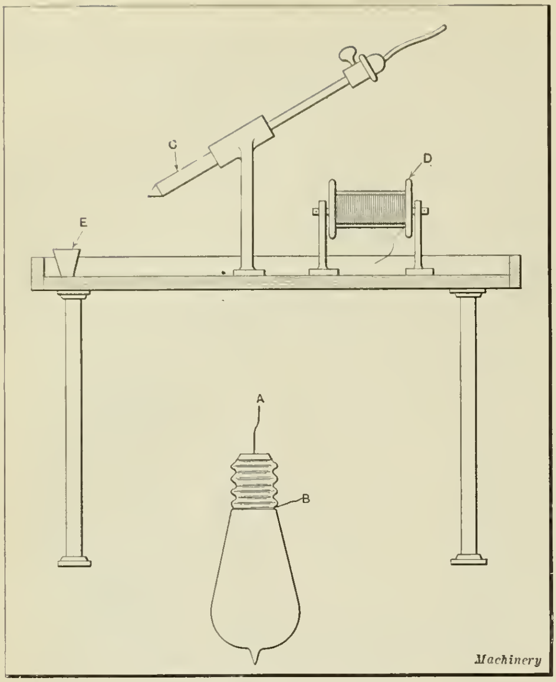

Fig. 29. Soldering Lead-in Wires

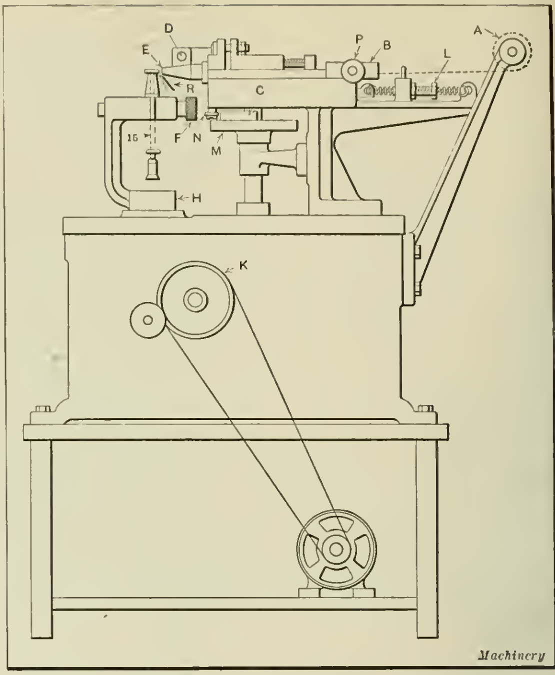

Fig. 30. Machine used for inserting Hook End of Nickel Wires

on which the bulbs are placed, only one of which is shown in the illustration, the other being in the gas oven shown above. It will be noticed that all the lamps are in a line, so that the operator can easily determine whether they are set up straight or not. In operation, the base and lamp are held by the plunger *B*, and the cone cup *C* is held in position by the coil spring shown. Weights are provided at *D* to balance the slide or carriage *E*. The oven is provided with holes *F* covered with mica so that the operator can see that the lamps are not being overheated. The portion *G* acts as a guide for the Edison bases, and *H* is the table on which the operator works while the lamp bases are backed on the lamps.

Soldering the Lead-in Wires

After the Edison sockets have been baked on the bulbs the lead-in wires project from the base as shown at *A* and *B* in Fig. 29. An electric soldering iron *C* is used for soldering these wires, the iron being stationary while the lamp is held in the correct position for both *A* and *B*. The solder is in wire form on a spool *D*, a soldering paste box being provided at *E*. After the soldering operation, the projecting wire is cut off by a special knife.

The socket is now polished on a regular polishing wheel in order to clean it perfectly, the polishing wheel being located very close to the soldering fixture.

Inserting the Hook End

The inserting of the hook end of the nickel wires is done by means of the special machine shown in Fig. 30. The wire is drawn from the spool *A* and straightened at *B*, being carried from the straightener by a slide. The forward movement of the slide is governed by the cam *C* and the roller *N*. On the return stroke, guide bushing *E* stops, and knife *D* cuts the wire, actuated by cam *M*. Bracket *H* rotates and stops at

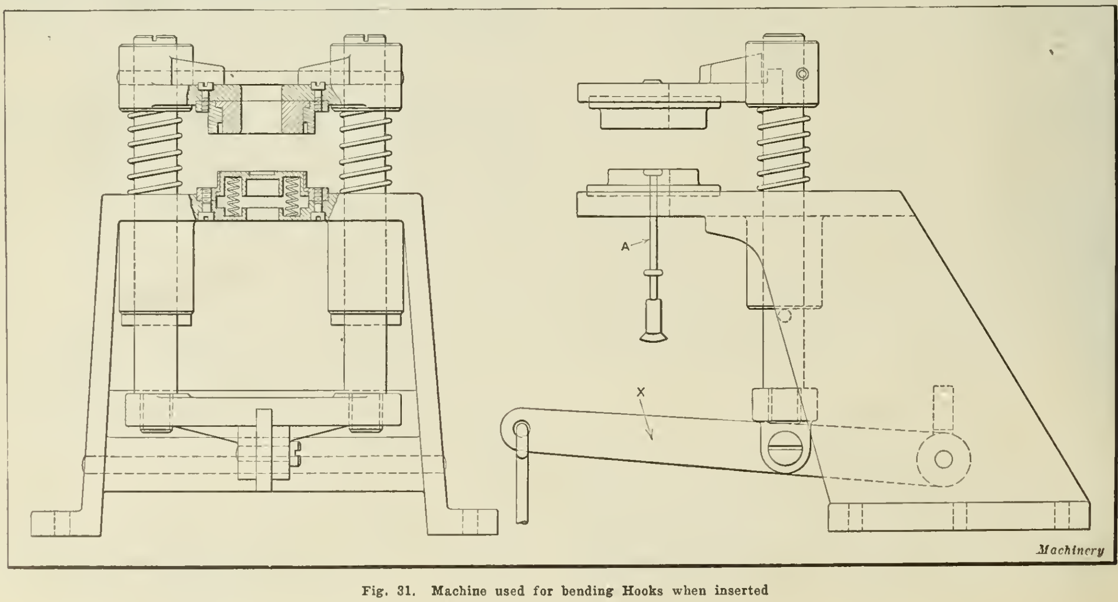

Fig. 31. Machine used for bending Hooks when inserted

ertain intervals to give the roper spacing for the hooks. 'his movement is effected by Geneva motion. The length f stroke can be regulated by he adjusting screw L while he straightener is regulated y the screw P. F is the humb-screw used to open the aws for loading and unloadig, and K is the driving pulay. The position of the eedle flame is shown at R. fter the hooks have been inerted they are bent by the xture shown in Fig. 31, the tem being inserted in the ending die as shown at A nd bent by pressure on the ot-treadle which is connectd to the arm X, thus operatig the plunger carrying the ie. A fixture of this kind is sed for bending wires from 010 to 0.014 inch outside dimeter. When the wires are om 0.003 to 0.005 inch outde diameter, a different type f fixture is used as indicated Fig. 32. The construction f the fixture is simple, and e operation will be aparent by reference to the lustration; it will be seen that the device is hand-operated.

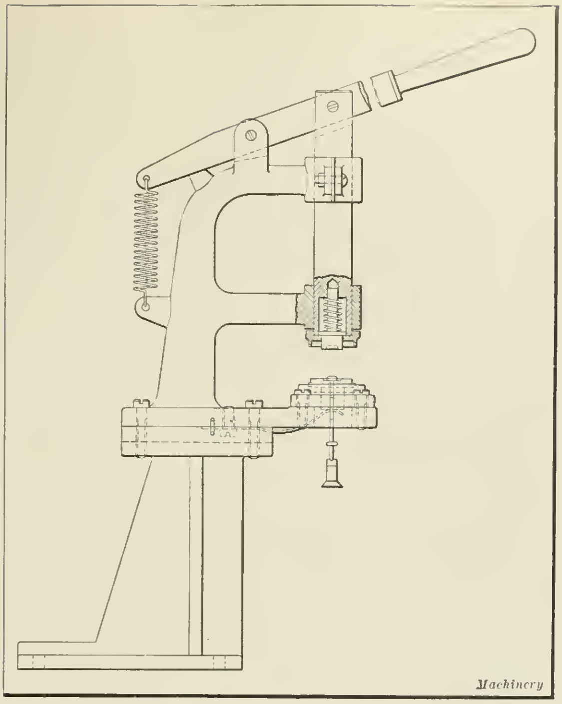

Fig. 32. Hand Fixture for bending Small Wires

Bump-testing Operation for Lamps

In order to see how long lamps will last under current hile being vibrated and knocked against, the lamps are given durability test so that it can be determined whether they e suitable for use on street cars or other vehicles having nsiderable vibration. Referring to Fig. 33, it will be seen at the lamp is placed in a regular socket on the rod A, rough which electric wires are passed to furnish the necesry current for lighting the bulb. The fixture can be turned to any position, being pivoted at F, so that the lamps can burned when they are tipped up, tipped down, horizontal at any other angle while burning or vibrating. The cam C volves at the rate of from 100 to 225 R. P. M. and causes the oe D to move up and down and to drop off the shoulder on e cam, thus allowing the rod A to fall until it strikes the ljustable stop E. The position of this stop determines the nount of "bump," and it is evident that various settings n be easily obtained. This is one of many methods used r testing the durability of lamps. After the stems and lamps ve been finished, they are loaded on special trays, as shown Fig. 34, which are made so that they can be placed on top each other and easily handled by the projecting ends B. e bulb and stem trays are of similar construction except

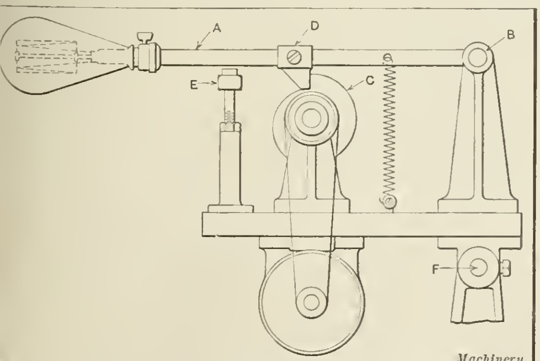

Fig. 33. Machine used for bump-testing Lamps

that the bulb trays are provided with holes as indicated, while the stem trays have fiber pegs as shown at C.

It will be seen from the foregoing description of the methods of manufacturing tungsten lamps that every operation which can be, is handled by an automatic machine, while for operations of such a nature that a machine is not practical, special tools or fixtures of many kinds are devised to make the lamp manufacturing cost very low. In addition to the operations mentioned, there are tests of burning the finished lamp, inspecting operations, etching, labeling, boxing, etc. Also in addition to the "bump" test mentioned in the article, the lamps are burned for "life" tests. The "bump" tests used are of different kinds; sometimes an entire box of lamps is rolled from the top of a three-story building to the basement, and if the lamps do not break under this severe test, it shows that they are suitable for use in street cars and other service of similar nature, and that they can be shipped with safety to any part of the globe. The output of the Hungarian factory in which these processes were developed is from 25,000 to 28,000 lamps of every kind per day.

* * *

A great deal of statistical matter has been published on the amount of iron ore known to be available, and it is generally believed that the United States Steel Corporation controls the greatest amount of tonnage available in the Western hemisphere. This is not true. The Nova Scotia Steel & Coal Co. owns the Wabana mine on Bell Island in Conception Bay, Newfoundland, in which it is estimated there is between 2,000,000,000 and 3,000,000,000 tons of hematite ore. The deposit is probably more than double the holdings of the United States Steel Corporation, which are estimated to be about 1,300,000,000 tons. The quality of the ore is very rich, averaging 51 to 53 per cent pure iron in the three seams worked. Bell Island is only two miles wide by six miles long, but mining operations are being carried on beneath the sea, the holdings of the company in fact being greater beyond the shore lines of the island than on the island itself.

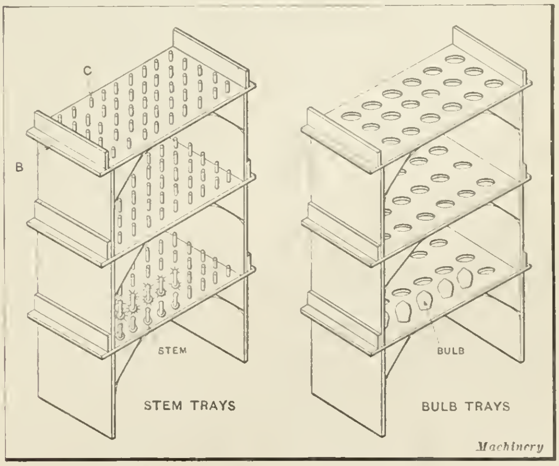

Fig. 34. Stem and Bulb Trays for Lamps

WHAT IS THE MATTER WITH THE MUNITIONS MAKERS?

FAULTS OF ORGANIZATION—LACK OF COOPERATION BETWEEN HEADS—EMPLOYMENT OF LABOR—WAGE DIFFICULTIES

BY FRED H. BOOART

THAT something is the matter with the munitions makers has passed the point of worth-while discussion. Twelve to fifteen months ago, the finger of pride was being directed from all over industrial America toward certain new corporations created for the sole purpose of handling contracts for munitions for foreign governments. Attention was drawn to them partly because they were, in most cases, backed by some of the largest and soundest manufacturing corporations in the United States (which was assumed to assure success in anything that should be undertaken), but more particularly because the contracts for war materials called for such rapid execution as to stagger all preconceived ideas as to what was possible of accomplishment in the creation of an organization, and the planning, building, equipping and manning of a plant for the mechanical production of such materials. Yet in every case this seemingly impossible task was just what was going to be accomplished.

In directing public attention to the stupendous money value of these contracts, to the name and character of the financial interests through whose hands the business passed to the manufacturers, and to the names and achievements of the manufacturers who had been awarded large orders, no opportunity was overlooked to center the public gaze on the miracle that must be performed to meet the deliveries agreed upon, and to emphasize the fact that such leading industrial organizations as had been selected alone had the size and breadth of organization and the financial stability to warrant undertaking the performance of such a miracle. And for a time it seemed that they were going to make good. Almost over night, acres of scrub farm land and boggy river meadows were cleared, leveled and covered with a network of tracks. Another week, and a continuous stream of freight cars loaded with foundation and building materials was being shunted in on those tracks and unloaded at high pressure. The manner in which many of the munitions plants grew from these materials and the speed with which the buildings, in every detail of equipment, were rushed to completion will long stand as a miracle of accomplishment. As soon as the buildings were completed, in some cases while they were incomplete, the installation of power equipment and machine tools began, and a few weeks later the public was informed that workmen were being hired and the plants were ready to begin active operations.

This marked the status of a majority of the big contractors somewhere between October 1, 1915, and January 1, 1916. To be sure, most of these manufacturers had announced some months before that actual delivery of finished product would be begun probably by November 1, and in no case later than January 1. However, certain uncontrollable conditions, known and appreciated by everyone acquainted with the machine tool market in 1915, had held back their equipment and had caused some delay; but this was of only momentary importance, as a sufficient factor of safety had been allowed in the purchase of equipment to permit of catching up with deliveries in a very short time when things were once under way.

Since then from ten to twelve months have passed in which no miracle of production has been accomplished by these new organizations. During this period millions of dollars' worth of war materials have been exported, but of this a comparatively small percentage has been ammunition or arms; and of the exports in these, the greater part has been produced by manufacturers who had had experience in the line of work contracted for and simply broadened an existing organization to cover the requirements of the new business, or by comparatively small manufacturers who were able to apply their mechanical experience in somewhat similar work to the problems of munition making with success. By the plants specially organized and equipped for the production of ammunition and small arms, comparatively nothing has been produced which is acceptable to the inspectors of the contracting governments, and which, in consequence, can be rated as salable product. On the contrary, very discreditable rumors have been leaking, first into the trade and lately to the general public, of gross inefficiency in their operation, of abuses and wastage in all departments of their organization, culminating, as one might expect, in a general accusation of mismanagement. The term "mismanagement" is the easiest in the world to apply to any organization from which the results are not up to promise or expectation, and as freely tossed about in casual conversation, it means absolutely nothing. Likewise, it is the easiest thing in the world for an outsider to view the result that to his mind is evidence of mismanagement and state what he would have done had the initiative been his. But such freely formed judgments amount to nothing unless they can be followed by a specific proof of error in judgment and a definite placing of responsibility for that error. It is a comparatively simple task to dig up proof of error in judgment in any concern, and even within the organizations of the munitions makers themselves it is an admitted fact that such errors have been and are being made; but the questions that come up at every conference on the matter, and the questions that must be correctly answered before the trouble can be remedied, are: "Where is the cause? Who is to blame?"

It is assumed at the outset that the trouble with these plants is in their mental equipment. Certainly the trouble is not due to the inadequacy of the plants, because in most cases they are ideal for the purpose and far advanced in details for small economies of manufacture over the average of the large American industrial plants. Neither is it due to poor or inefficient equipment, because the equipment, as a whole, is known to be of good construction and mostly new. Moreover, as every recent visitor to any of these plants will have observed, there is in nearly every department a large percentage of the equipment that has not yet been operated, or which is not being operated through lack of tools or operatives. This would seem to put the question squarely to the organizations to discover within themselves where the fault lies.

The suggestions submitted in the following paragraphs are the result of observations covering nearly a year spent in minor positions in the producing organizations of two of the large munitions plants. The constant migration of employes between these special plants and the relation of various experiences by these floating employes make it certain that internal conditions in these two plants are about on a par with the others of the group; this leads to the belief that the basic mistakes of all have been similar. These suggestions are not offered as an answer to the query heading this article, but are merely the logical conclusion of one viewing conditions from the standpoint of a common workman.

Organizations Based on Personality, not on Mental Efficiency

The point of vital weakness in these munitions organizations is that they are based on personality and not on mental efficiency. To place the blame for this would necessitate going far back and attributing to some human mind a foresight wellnigh supernatural. The big contracts for munitions fell into the hands of giant corporations because it was believed that they alone had the resources, the prestige, the driving power and the organization measuring up to the requirements necessary to get these gigantic industries into operation within the time limit. In the first three elements they were gaged correctly, and all three were needed to provide the material and mechanical equipment necessary to start production. But unfortunately for the ultimate success of these enterprises, the basis of organization of the parent plants was not suited to the demands of a manufacturing organization of such complex detail as is required to produce munitions to specifications.

It is a well recognized fact that, while some of our large industries, whose foundation dates back two generations, have grown into the class of big business, their organization is the same family affair that it was in the days when "the old man"

walked up and down through the shop in his shirt sleeves, calling everyone by his first name, and basing his driving power on the personal allegiance of his employes. Out of these old-time fellow-workers and friends, the department superintendents and foremen of today have been developed—every man familiar with his job because he has grown up in it and all with the idea of loyalty to the executive head firmly fixed as a principle of employment. It is obvious that such an organization owes its stability to its gradual development by the natural workings of the laws of selection, and that its producing power lies in each branch of the organization doing over and over the one or few things it has been trained to do.

The munitions contracts called for the manufacture of certain metal parts and composite devices generally unfamiliar to American mechanics, but for the production of which very complete and specific directions were given, down to the most trivial details. Obviously, it was a problem of detailed mechanical analysis requiring a mental organization based upon proved experience and efficiency, carefully designed and constructed to fit every requirement of the specifications. And because the task was of definite proportions and called for speed above everything, it required an organization in which previous faithfulness in other lines, personal friendships, inside pull, and all such qualifications played no part whatever.

In the specially organized plants, as they stand today, fully 50 per cent of the executive positions are held by men who, because of their previous success in handling departments in which they had grown up, or because they have exhibited commendable loyalty on occasion, or possibly for no other reason than that they "belonged," have been lifted out of the parent organizations and placed in positions requiring mechanical refinement as far removed from their previous line of work as a dividing head is from a threshing machine. If this 50 per cent had been a latent factor, merely reducing the mechanical effectiveness of the organization to what was represented by the remainder, the result would not have been so disastrous. But the habit of acquiring a personal following, which was the basic principle in the school of organization in which these men were brought up, followed them into the munitions plants and has proved their greatest drawback. It is the isolation of certain productive groups in these plants, headed by a leader whose power rests on service of a certain character to executives higher up, that has, from the moment these plants were ready to begin active operation, cut their productive capacity to such a small proportion of the normal expectation, considering the equipment used and the number of operatives employed, as to set even the executives themselves to wondering what all the wages had been paid for and what had become of the product.

Results Obtained by This Organization

The direct consequence of this grouping of forces, without regard to the laws of organization, has been three-fold: First, it has resulted in the development of so-called productive organizations without head or tail. From the top down there is no limitation of activity, no point at which an executive stops and leaves minor details in the hands of the proper subordinate; and from the bottom up there are no definite limitations of authority, no point beyond which a workman or minor official knows he may not go without passing the bounds of propriety and making himself liable to reprimand. On the contrary, high executives exercise authority down to detail instruction to operatives on machines, without intermediate knowledge or later notification; and these same operatives, not receiving "satisfaction" at the hands of their foremen, or superintendent, carry their troubles, in some instances, to the manager's office and get a hearing, if nothing more.

Second, the organization thus obtained has blocked every effort that has been made to work in at any point an effective productive sub-organization. In these large plants, an isolated organization, even if it is a perfect working unit, is helpless unless it has the cooperation of those coordinate units that are a necessary part of operation on a large scale. For instance, a foreman of a section of automatics might try to make a record in his department. He might clean house, get together some experienced men (if allowed to go so far), and be in shape to turn out a normal production. His actual output, however, will depend on how promptly the stores department supplies him with stock, how quickly his motor is repaired when it goes wrong, his belts mended when they break, his machines repaired in case they break down. In addition, he is absolutely dependent on the tool department for the special tool equipment required on his machines. It is here that nearly all the aspirants for production honors fail, because if any department foreman shows sufficient activity to attract particular attention, his supply of tools is usually purposely curtailed.

Finally, this organization has sidetracked the best mechanical experience and ability into a condition of practical inactivity, and substituted men of very limited mechanical experience, who have in some manner exhibited qualities that gave them the reputation of being "live wires." The very speed that was demanded on these munitions contracts has operated to the detriment of the qualified mechanic, and immensely to the advantage of the mechanical faker and grandstand player. The skilled mechanic, even though he may never have seen a shrapnel shell or a fuse component, knew after a few minutes' study of the detail prints that the production of such parts to such specifications was an extremely complex proposition. Such a mechanic, when any phase of the problem was presented for his solution, went at it with deliberation and painstaking thoroughness, because experience had taught that therein lay ultimate success. Immediately he was classed as a pettifogger and putterer, his "dawdling methods" were condemned as too slow, and eventually his effort and experience were set to one side to make way for the slam-bang production man, who could "make a showing." His "showing" will be found in various scrap piles representing an expenditure of several millions of dollars—monuments to high-speed production and the lack of mechanical refinement.

Familiarity with Product Preferred to Familiarity with Mechanical Construction

Another element in these munitions organizations that, in view of results obtained, would seem to be an error in selection is the employment in various responsible positions of men whose sole qualification is their familiarity with the use of munitions. It has been assumed, in other words, that because a man could sight a rifle or shoot a cannon, he necessarily must have had experience that would prove valuable in the manufacture of the materials familiar to his hands. In some few cases this familiarity has proved valuable; but in all departments producing exclusively machined metal parts to blueprints, executives so chosen have proved worse than useless. They have set up a line of experience counter to the specifications which is constantly at war with the requirements and the personal judgment of the foreign inspectors. A department superintendent, seeing the matter from a broader viewpoint than the majority, expressed himself in this manner: "I used to think I knew something about fuse work, but everything I attempt to do the way I think it ought to be done gets me into trouble. I have discovered that the only way to make headway in this work is to find out what the foreign inspectors want and then do it that way, whether I think it is right or wrong." This clear-cut statement, which is only another way of expressing a decision to adhere to the strict letter of the specifications, offers the key to the relations as they exist today between certain elements of the producing force and the representatives of the foreign governments. If such decisions had been so general as to create a definite policy in these plants, this relationship would be uniformly pleasant and cooperative. But a limited and ofttimes incorrect understanding of the function of certain parts has made it common practice to let down from the specified requirements whenever occasion offers, on the ground that such adherence to fine detail is nonsense in view of the manner in which the parts are to be used. Naturally, the practice has given rise to unending controversy over what one thinks is good enough and what the foreign inspector knows he must insist on.

Judging from the way this phase of the problem has worked out, it would seem that these specially equipped plants manu-

facturing munitions would be better off today and much farther advanced toward the satisfactory completion of the contracts if they had not known for what purpose the material being manufactured was to be used. These contracts for munitions were not a general specification to manufacture and ship so many rounds of ammunition or so many thousand rifles as per samples submitted. They were orders to produce, in American factories, certain war materials that were to be the exact counterpart of what had already been produced in various foreign countries for sufficient time to have developed their manufacture to a fine science. Every detail was specified in the most painstaking manner: the analysis of the materials used; the manner of examining and testing the materials; the dimensions of every component required, with the allowable variation from those dimensions; and the manner in which the parts were to be assembled, the various tests they were to be subjected to, and the basis of acceptance or rejection. Directions were given for everything—printed in a book, in fact—from the selection of the first pound of material to the manner of loading the finished product on shipboard for export. The only point in the whole contract requirements left to the discretion of the contractors was the choice of manner and method by which the specified parts should be produced. Reduced to its simplest terms, these contracts were an undertaking to manufacture a certain line of interchangeable parts to limits. This work is purely a problem in specialized mechanical engineering, and nothing more is demanded in its solution than the application of experience gained in the successful solution of similar problems in plants that have manufactured products of similar classification, though presumably for an entirely different purpose.

How many men with this sort of experience could be found in the munitions plants would be difficult to determine. It is certain that the percentage is very small, whereas the nature of the work and the record of the past year would indicate that, apart from the general business organization necessary to all such corporations, fully 75 per cent of the initiative should be in the hands of men of mechanical ability experienced in the production of small interchangeable parts.

Faults in Employment Methods Used

The two premises which have been set up and discussed in some detail are of vital importance, because they have their beginning in the foundation on which these organizations are based. If these premises are correct, dissection and discussion of minor faults and failures are futile, because it is reasonable to assume that they would all be corrected if the basic principles of organization were made sound and suited to the nature of the business. There is one outstanding feature of these munitions plants, however, that from the outset has been handled with a disregard for every principle of common justice and common sense.

For the conditions described, no single individual, probably no group of individuals, could be held accountable, as the organization of gigantic enterprises under new and strange conditions was a plunge into unknown territory, and naturally brought up problems which only time and a new line of experience could solve. But the administration of the employment departments of these plants reflects discredit on those that devised the system, and double discredit on those responsible for its continued use after it has proved inadequate, uneconomical, and susceptible to unlimited corruption.

In the creation of the labor departments of these plants, the same principle is applied to a minor department that governed the selection of the major organization. The identical methods of hiring, controlling, pricing, and paying employes that had operated successfully for the parent companies were in most cases installed at the new plants, without modification to meet the changed conditions brought about by the increased demand for labor. The necessity of grabbing up every applicant for employment to fill holes in the producing mechanism left no room for the exercise of judgment in their selection. The rule was to hire everybody, try everybody, and to hold on to everybody who possessed even a small percentage of the qualifications usually demanded of a desirable employe. Such a condition left no element of choice to the employer and gave the applicant the whip hand, because, secure in the knowledge that he would be employed for some purpose, he had everything to gain and nothing to lose by attempting to bluff himself into as well paid a position as possible.

Few if any of the plants have what, in the present state of industrial development, would be classed as an organized department of labor. Such organization as exists is represented by the assignment of certain functions of the department to an employment clerk and his assistants, to a chief timekeeper and a small army of subordinates, to certain designated superintendents, and finally to the manager himself. Applicants for employment present themselves at the outside employment office, and after giving certain personal facts are asked as to their experience, for purposes of "classification." The employment clerk has before him a schedule which reads somewhat as follows: Toolmakers, 45 to 60 cents; automatic operators, 35 to 50 cents and piece work; turret lathe operators, 30 to 45 cents and piece work; tool adjusters, 40 to 50 cents; machine operators, 25 to 35 cents and piece work; inspectors, 30 to 40 cents; laborers, 20 cents. The first figure is the minimum and the second is the maximum that a foreman or superintendent is allowed to pay new employes.

The existence of this schedule and, probably, the rates are well known to the applicant, because they had not existed for a month after the establishment of these plants before the system of classification was known for a radius of a hundred miles around every factory. Moreover, the applicant has probably been "tipped off" by some friend working in that plant, and has his "experience" learned by heart. The chief employment clerk may take this experience seriously, or he may question it. If the former, he fills in the classification and sends the man to the proper department to be placed and rated. If he questions the story the man tells, he sends the man to the department manager unclassified. But whether the man goes in classified or not makes little difference, as he tells the same story inside, and as there is no choice but to classify him, and no basis for judgment but his own story, he usually gets entered on the payroll at or very near his own estimate.

Under normal conditions, the rate will be fixed at the minimum for the classification and the rate card handed to the department timekeeper for recording. It may then pass successively to the department superintendent, the chief timeclerk, the general superintendent, and possibly the manager, to receive the official O.K.'s, and if it appears regular in every way, that is, if the rate fits the classification and the classification the department, it will probably be approved at every stage. Recommendations for a change in rate, or raises, go through a similar routine. The department foreman files a written recommendation giving reasons, and this passes through the same channels, requiring in some cases ten days to two weeks, during which time the employe is kept in doubt as to whether the increase is to be granted. Such, in brief outline, is the system of employment under which these munitions factories have developed their working force. If every applicant for a position were truthful as to his qualifications and every foreman to whom the authority is given to fix rates and classifications were honest in his service to his employer, the system would possibly meet every requirement. But the least desirable among the applicants for positions are the ones who have been informed as to the classes and rates paid, and these unblushingly represent themselves as experienced in the highest paid classifications. The foreman to whom they are sent knows perfectly well that they are falsifying, but to what extent he can judge accurately only by trial. He has been told to hire men. Such applicants will not lift a finger until they are classified and rated on their own terms, so the foreman, no matter how good his intentions may be, has no choice but to take the man at his own valuation.

It will be apparent that such a system of classification is open to abuse by dishonest or negligent foremen. There is no limit to the point to which the classification of any new employe may be boosted, so long as employes of that class are used in that particular department. In certain of the plants the departments are large, the department organizations are constantly expanding, and it is the easiest thing in the world to classify for any rate without any questions being asked as

to whether such men are actually needed. The result is just what might be expected. Departments are top-heavy with favorites classified and rated to the limit, and in a majority of instances men with mechanical experience are doing all the hard work, while others less worthy are getting the pay. If this meant merely the carrying of a few deadheads on the payroll of each department, its effect would not be serious, but every man in the department is "wise," and the net result is a what's-the-use-of-trying spirit not conducive to the highest productive efficiency.

It will be noted that there is no provision made in this system to detect "repeaters." All applicants must pass the employment clerk, but he is personally not on duty all the time and his force of assistants is constantly changing. This makes it possible, as is actually happening all the time, for men leaving the plant for better jobs elsewhere to come back in a few days and be hired again, often at a higher rate than before; for men to quit in one department and be hired in another where the rate for certain work is higher, or where it is possible to secure piece work; for men that were discharged for cause to be hired in another department in a few days, either under their own or an assumed name; for men to get themselves fired from a low-price job and be hired in a few days, in the same department, at a higher classification and rate. The ease with which men may be hired repeatedly by the same company has caused another abuse of authority to grow up, which in some cases is worked to good purpose. The difficulty of getting raises put through, due to the many O.K.'s required before the chief time-clerk can make them effective, was the means of losing a great many good men until the foremen hit upon a scheme of beating the raise check to it. Their plan now is to discharge good men on Friday afternoon or Saturday morning and hire them back on Monday, when they are reclassified and rerated. Where a raise had been refused and the reasons given for the refusal were not satisfactory from the foreman's viewpoint, it has been customary to double the increase over the recommended raise, just to add an element of humor to the situation.

However, in dollars-and-cents value, all the abuses described and imaginable under the fixed-rate-per-hour system are as nothing compared with the money being thrown away in these plants on piece work. There seem to be two separate causes for the almost inconceivable wages certain classes of men have been able to draw from these plants: First, the setting of piece-rates before jobs were developed. Primarily, this was due to lack of experience. Many of the men placed in charge of lathe operations, such as boring, turning, facing, etc., had no experience on which to base judgment as to how fast such operations ought to be done. Consequently, they started the operations with machines in a low state of efficiency, tools (often of carbon steel) that were of crude form and poorly hardened, and from the first output under such conditions they made production tables and fixed piece-rates. The result was that, when these same jobs reached a condition approaching normal operation, the earning power under the piece-rate granted often totaled from two to four times what a fair wage for the work would have been. The second cause has been the laxity of inspection from operation to operation. This has made it possible for piece-workers to crowd through defective work, which would be credited them, paid for, and lost sight of in the general scramble, before the defects would become apparent. To see some of these highly paid piece-workers in action, and to watch their sledge-hammer methods of gaining speed of output without regard to the life of the equipment, would drive the average mechanic into a state of nervous collapse.

The examples cited and the weaknesses disclosed are more than sufficient to condemn this whole employment system as a relic of a former industrial period, entirely inadequate to meet the requirements of present-day conditions. It takes no flight of the imagination, moreover, to picture what a legacy of industrial unrest and distorted values will be handed down to the "legitimate" manufacturing industries by these gigantic special plants—in which, in the course of their existence for the purpose for which they were organized, there might easily be employed upward of a hundred thousand mechanics—unless there is effected by the munitions makers, and this very promptly, a revision of method that will bring about normal conditions of employment and wages.

Remedies for These Faults

Such a general disclosure and discussion of some of the faults of the munitions plants would hardly be complete if it failed to be constructive to some degree. Yet to point out what is necessary to be done in such circumstances to correct every evil is no simple task. There is such a clearly defined operation of the law of cause and effect between some of the salient features of these organizations and the inefficiency that has resulted from their administration that certain corrections suggest themselves. These organizations should have been based solely on experience and efficiency. To what extent the established principles of scientific management could be used in the development of such an organization could be determined only by careful analysis; but it must be borne in mind that the filling of these contracts was in the nature of a 100-yard dash, while the side organization necessary to the operation of scientific management, and the investment involved in its installation, makes it better adapted to a two-mile run.

In whatever form such an organization might be worked out, there are two essential elements required to get results which will be found to characterize every effectually organized force, whether its basis be "scientific" or just sound business sense: First, the organized initiative must be capable of being plotted; that is, there must be a definite structure indicating the radiation of authority from the chief executive to every department head and subordinate, and this distribution of authority must follow a consistent line of descent from subexecutive to subordinate, with no doubling-up and no loose ends. Second, there must be no overlapping of authority, but definite limits set, above which minor officials may not go and below which high officials will not directly interpose. The principle that "a man cannot serve two masters" is as much a law of business organization as of ethics, and wherever one finds smooth-working efficiency of operation, he will find every man with one boss and with no uncertainty as to who it is.

It is well within the limits of probability that if some of the scrambled organizations in the munitions plants, as they are constituted today, were reconstructed with these two principles in mind and adhered to, their efficiency, with the same personnel intact, would be increased 100 per cent. The weak spots and leaks in the labor organization are not so complex, and it seems nothing short of criminal negligence that these have been allowed to continue so long. All that the circumstances require is the adoption of all or even a part of the features of a half dozen modern systems of employment in use in American factories, and of which the details are commonly known.

This matter of employment and wages assumes tremendous importance, because of its influence on such a large proportion of the workmen available for the mechanical industries and the effect this influence is to have when these special plants have completed their contracts and turned the men loose on a normal labor market. The success or failure of these plants, whether they make the tremendous profits they expected or sink their earnings in ineffective operation, is not a matter for general public interest. But the fact that their methods are heading tens of thousands of young men toward social bankruptcy, through the establishment of false standards of values and expensive personal habits that cannot be maintained when conditions return to normal, is a matter for deep public concern.

* * *

PRECISION GEAR CENTER GAGE—CORRECTION

In the description of the use of the "Precision Gear Center Gage" which appeared in the October number an error appeared relative to the required dimensions of the graduated collars. The graduated collars for measuring a center distance of 5 inches would, of course, require a radius of 3 inches and 2 inches, respectively, instead of diameters of 3 inches and 2 inches, as stated, in order to measure a center distance of 5 inches.

AREA OF SEGMENT OF CIRCLE

BY J. J. CLARK [1]

The mathematical formula expressing the area of a segment of a circle is simple in form and is easily derived. Thus, referring to the accompanying illustration:

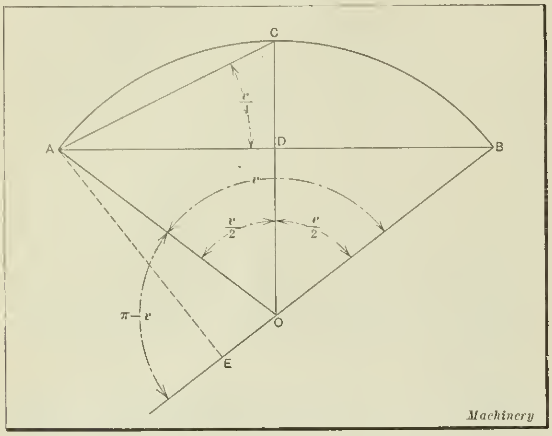

Diagram illustrating Method of calculating Area of Segment of Circle

Let $ACBDA$ be any segment;

A = area of segment;
v = central angle AOB;
r = radius $OA = OC = OB$;
c = chord AB;
h = height of segment = CD;
l = length of arc ACB.

Then, when angle v is expressed in radians:

$$l = rv$$

Area of sector $AOBC$ is:

$$AOBC = \frac{rv \times r}{2} = \tfrac{1}{2} r^2 v$$

Area of triangle AOB is:

$$AOB = \frac{OB \times AE}{2} = \frac{r \times r \sin(\pi - v)}{2} = \tfrac{1}{2} r^2 \sin v$$

Therefore, area A of the segment is:

$$A = \tfrac{1}{2} r^2 v - \tfrac{1}{2} r^2 \sin v = \tfrac{1}{2} r^2 (v - \sin v) \qquad (1)$$

To apply Formula (1) when v and r are known, and v is expressed in degrees, minutes and seconds, reduce the minutes and seconds to a decimal of a degree and then multiply this number of degrees and decimal of a degree by 0.01745329252, using one more significant figure than there are significant figures in the number denoting the angle. Except when exact results are required, the number of decimal places in the angle should not exceed three or four at the most. For instance, 43 degrees, 19 minutes, 32 seconds = 43.326 degrees, very nearly, and 43.326 × 0.0174533 = 0.75618 radian. If, however, the chord and height of the segment are given, which is usually the case in connection with shop problems, then (referring to the illustration):

$$\text{Angle } CAB = \text{one-half angle } COB = \frac{v}{4}$$

$$\text{Tan } CAB = \tan \frac{v}{4} = \frac{CD}{AD} = \frac{h}{\tfrac{1}{2}c}$$

$$\text{Tan} \frac{v}{4} = \frac{2h}{c} \qquad (2)$$

Formula (2) gives one-fourth the angle, and this multiplied by 4 gives angle v, from which may be found the number of radians in this angle; its sine may then be looked up in a table of natural trigonometric functions. The radius r is:

$$r = \frac{\tfrac{1}{2}c}{\sin \frac{v}{2}}$$

It may also be calculated from the formula:

$$r = \frac{c^2 + 4h^2}{8h} \qquad (3)$$

Numerous approximate formulas have been published for finding the area of a segment; but many are incorrect for very large angles when they give good results for small angles, and *vice versa*. In any case, if results are desired that will be correct to, say, five significant figures, the calculation is quite laborious and chances of making mistakes are numerous. Hence, the writer has calculated a table presented in this connection, by means of which the area of any segment may easily be found. This table gives values of constant k in the formula:

$$A = kch \qquad (4)$$

The columns headed m contain values obtained by dividing height h by chord c; that is, $m = \frac{h}{c}$.

The columns headed k contain values corresponding to m in the preceding column. The columns headed d contain values to be used in finding k when the value obtained for m is not found in the table. For example, let m be the value obtained by dividing h by c. If this value is not contained in the table, note the next smaller value (which we will call m_0) and the corresponding value of k, which we will denote k_0. Let k denote the value sought; then:

$$k = k_0 + (m - m_0) d \qquad (5)$$

In Formula (5), d is the value in the column headed d that falls midway between k_0 and the next succeeding larger value, k_1. Suppose h = 10 5/64 inches and c = 32 3/8 inches:

Then m = 10 5/64 ÷ 32 3/8 = 0.31129;

m_0 = 0.310 (see table);

k_0 = 0.71541;

d = 0.302.

VALUES OF CONSTANTS USED IN CALCULATING AREA OF SEGMENT

m	k	d	m	k	d	m	k	d	m	k	d
0.000	0.66667	0.002	0.125	0.67493	0.132	0.250	0.69890	0.254	0.375	0.73655	0.350
0.005	0.66668	0.008	0.130	0.67559	0.140	0.255	0.70017	0.254	0.380	0.73830	0.356
0.010	0.66672	0.014	0.135	0.67629	0.144	0.260	0.70144	0.260	0.385	0.74008	0.358
0.015	0.66679	0.018	0.140	0.67701	0.148	0.265	0.70274	0.266	0.390	0.74187	0.360
0.020	0.66688	0.024	0.145	0.67775	0.154	0.270	0.70407	0.268	0.395	0.74367	0.366
0.025	0.66700	0.030	0.150	0.67852	0.158	0.275	0.70541	0.274	0.400	0.74550	0.368
0.030	0.66715	0.034	0.155	0.67931	0.162	0.280	0.70678	0.278	0.405	0.74734	0.372
0.035	0.66732	0.040	0.160	0.68013	0.168	0.285	0.70817	0.282	0.410	0.74920	0.376
0.040	0.66752	0.046	0.165	0.68097	0.172	0.290	0.70958	0.288	0.415	0.75108	0.378
0.045	0.66775	0.050	0.170	0.68183	0.180	0.295	0.71100	0.290	0.420	0.75297	0.382
0.050	0.66800	0.054	0.175	0.68273	0.182	0.300	0.71245	0.294	0.425	0.75488	0.386
0.055	0.66827	0.060	0.180	0.68364	0.188	0.305	0.71392	0.298	0.430	0.75681	0.388
0.060	0.66857	0.066	0.185	0.68458	0.192	0.310	0.71541	0.302	0.435	0.75875	0.392
0.065	0.66890	0.072	0.190	0.68554	0.198	0.315	0.71692	0.306	0.440	0.76071	0.394
0.070	0.66926	0.080	0.195	0.68653	0.202	0.320	0.71845	0.310	0.445	0.76268	0.398
0.075	0.66966	0.082	0.200	0.68754	0.206	0.325	0.72000	0.314	0.450	0.76467	0.400
0.080	0.67007	0.086	0.205	0.68857	0.212	0.330	0.72157	0.318	0.455	0.76667	0.404
0.085	0.67050	0.094	0.210	0.68963	0.216	0.335	0.72316	0.322	0.460	0.76869	0.408
0.090	0.67097	0.098	0.215	0.69071	0.220	0.340	0.72477	0.326	0.465	0.77073	0.410
0.095	0.67146	0.102	0.220	0.69181	0.224	0.345	0.72640	0.328	0.470	0.77278	0.414
0.100	0.67197	0.110	0.225	0.69293	0.230	0.350	0.72804	0.334	0.475	0.77485	0.416
0.105	0.67251	0.114	0.230	0.69408	0.234	0.355	0.72971	0.336	0.480	0.77693	0.418
0.110	0.67308	0.118	0.235	0.69525	0.240	0.360	0.73139	0.340	0.485	0.77902	0.422
0.115	0.67367	0.122	0.240	0.69645	0.242	0.365	0.73309	0.344	0.490	0.78113	0.426
0.120	0.67428	0.130	0.245	0.69766	0.248	0.370	0.73481	0.348	0.495	0.78326	0.428
0.125	0.67493		0.250	0.69890		0.375	0.73655		0.500	0.78540	

Machinery

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Consequently, $k = 0.71541 + (0.31129 - 0.310) \times 0.302 = 0.71580$.

The area A of the segment is:

$$A = 0.7158 \times 32\ 3/8 \times 10\ 5/64 = 233.55 \text{ square inches.}$$

This result is found by substitution in Formula (4).

If the chord c and radius r are given, first calculate the value of height h by the formula:

$$h = r - \tfrac{1}{2}\sqrt{4r^2 - c^2} \qquad (6)$$

If the height h and the radius r are given, first calculate chord c by the formula:

$$c = 2\sqrt{2rh - h^2} \qquad (7)$$

The following formula expresses the value of k very accurately:

$$k = 0.66667 - 0.00127m + 0.5545m^2 - 0.11563m^3 - 0.077m^4 \qquad (8)$$

Thus, for $m = 0$, $k = 0.66667$; for $m = 0.1$, $k = 0.67196+$; for $m = 0.2$, $k = 0.68755-$; for $m = 0.3$, $k = 0.71245-$; for $m = 0.4$, $k = 0.74551+$; for $m = 0.5$, $k = 0.78540+$. Note how closely these values correspond to those given in the table; in fact, by substituting this expression for k in Formula (4), we obtain the most accurate formula for the area of a segment that the writer has ever seen.

$$A = (0.66667 - 0.00127m + 0.5545m^2 - 0.11563m^3 - 0.077m^4)ch \qquad (9)$$

If m is greater than 0.500, the segment is greater than a semicircle. In such case, find the area of the other segment having the same base (chord) and whose height is $2r - h$; then subtract this area from the area of the circle, and the remainder will be the area of the segment sought.

The formula used for calculating values of k in the table is:

$$k = \frac{v - \sin v}{8m \sin^2 \dfrac{v}{2}}$$

* * *

ANNUAL MEETING OF A. S. M. E.

The annual meeting of the American Society of Mechanical Engineers will be held in New York City, December 5 to 8, inclusive, the Engineering Societies Bldg. being the headquarters. The president's address on the relation of education to engineering, by Dr. D. S. Jacobus, will be delivered Tuesday evening. On Wednesday morning, following the regular business of the session, there will be memorial exercises in memory of John E. Sweet, past-president and founder of the society. The technical papers to be presented follow:

"The Proportioning of Surface Condensers," by George A. Orrok.

"The Testing of House-heating Boilers," by L. P. Breckenridge and D. B. Prentice.

"Water for Steam Boilers—Its Significance and Treatment," by Arthur C. Scott and J. R. Bailey.

"The Utilization of Waste Heat for Steam Generating Purposes," by Arthur D. Pratt.

"Graphic Methods of Analysis in the Design and Operation of Steam Power Plants," by R. J. S. Pigott.

"Power Plant Efficiency," by Victor J. Azbe.

"Heat Transmission through Various Types of Sash," by Arthur N. Sheldon.

"Accurate Appraisals by Short Methods," by J. G. Morse.

"Productive Capacity a Measure of Value of an Industrial Property," by H. L. Gantt.

"A Gas Producer for Bituminous Coal," by O. C. Berry.

"Commercial Sampling and Gas Analysis," by P. W. Swain.

"An Investigation of the Internal Combustion Engine as Applied to Traction Engines," by A. A. Potter and W. A. Buck.

"The Ratio of the Specific Heats and the Coefficient of Viscosity of Natural Gas from Typical Fields," by Robert F. Earhart.

"Illustrated Review of the Werkspoor Marine Diesel Engines," by Thomas O. Lisle.

"The Impact Tube," by Sanford A. Moss.

"Heat-treatment of Wrought Iron Chain Cable," by F. G. Coburn, W. W. Webster and E. L. Patch.

"The Flow of Air and Steam through Orifices," by Herbert B. Reynolds.

"Clasp Brakes for Heavy Passenger Equipment Cars," by T. L. Burton.

"Mechanical Design of Electric Locomotives," by A. F. Bachelder.

"An Analysis of the Working Parts of Safety Valves Met with in Marine Practice, with Suggestions for Repairs and Improvements," by E. F. Maas.

"The Talbot Boiler," by Paul A. Talbot.

The machine shop session will be devoted to discussion of papers on the standardization of machine tools and on a classification of machine shop practice and a proposed plan of work of the sub-committee on machine shop practice. On Friday afternoon and Saturday morning there will be a public hearing by the boiler code committee.

* * *

APPRENTICES' SHOP PROBLEMS

BY JOHN G. BRUEGGEMAN [1]

When apprentices, while getting their shop training, receive, as well, a training in the principles of mechanics and the fundamentals of science and mathematics applying to their trade, it is remarkable how changed is their manner of approaching their work. Their interest is stimulated and their outlook broader, but particularly is their insight keener into the why and the how of their work.

The high school in Springfield, Vt., has a cooperative, or part-time, course in conjunction with the Fellows Gear Shaper Co., the Jones & Lamson Machine Co., and other machine builders of the city. During the last year of their four-year course, after they have had a grounding in mechanics, science and mathematics, the boys are required to submit, each time they are at school, several shop problems taken from their own or fellow-workers' experiences. The problems they dig up show what use they make of their training in analyzing methods and processes.

A problem that was submitted not long ago caused considerable discussion. The boys had about completed their course and were doing some good work in the shops. A boy who was operating a radial drilling machine in the special tool department was given a tool-block and a drawing, Fig. 1, showing a bolt hole to be drilled at 15 degrees to both the front and side faces of the block. Having received instruction in orthographic projection, he knew that if that bolt-hole were to appear as it did in the drawing, at 15 degrees to the front and side of the block, it would not be correct to tip the block 15 degrees both ways and drill. So, using a bevel protractor, he found the position in which the block should be placed so that the drilled hole would appear to make angles of 15 degrees with both the front and side faces of the tool-block. Then he brought the problem to school for a mathematical solution.

Several solutions were worked out in class. The simplest was by triangulation. The diagrams in Fig. 2 and the views in Fig. 3 will aid in making the solution clear. AB, A_1B_1, and A_2B_2 are front, side, and top views, respectively, of the hole through the block, which was 5 inches thick. According to trigonometry, $BC = 5 \times \tan 15 = 1.34$ inch. Obviously, B_1C_1 is the same as BC, so that the angle which B_2C_2 makes with B_2B must be 45 degrees. This is one angle through which the block must be revolved. As

$$\overline{B_2C_2}^2 = 1.34^2 + 1.34^2$$
$$B_2C_2 = 1.89 \text{ inch}$$

Therefore, a right triangle with AC (or A_2C_2) as the long leg and B_2C_2 as the short leg may be formed. The hypotenuse of this triangle will represent the hole through the block in its true position and length. The angle this line (A_2B_2 in the diagram) makes with AC (or A_2C_2) is the angle through which the block must be tipped vertically after being revolved horizontally through 45 degrees. This is the angle α in Figs. 2 and 3. The tangent of angle α is $1.89 \div 5 = 0.37800$. From a table of tangents it is found, therefore, that the angle α is 20 degrees, 42 minutes.

The table of the radial drilling machine on which this job was done could be revolved about a horizontal axis running through the center line of the table bracket, as well as horizontally about its own center. The tool-block could, therefore, have been clamped to the table with its front side parallel to the horizontal axis of the table; the table revolved horizontally through 45 degrees and then tipped in a vertical plane through 20 degrees, 42 minutes, and the hole drilled.

Not all the problems submitted originate with the boys; some are given to them by the older hands. For instance, one of the boys was given a piece to turn down to 12 inches diam-

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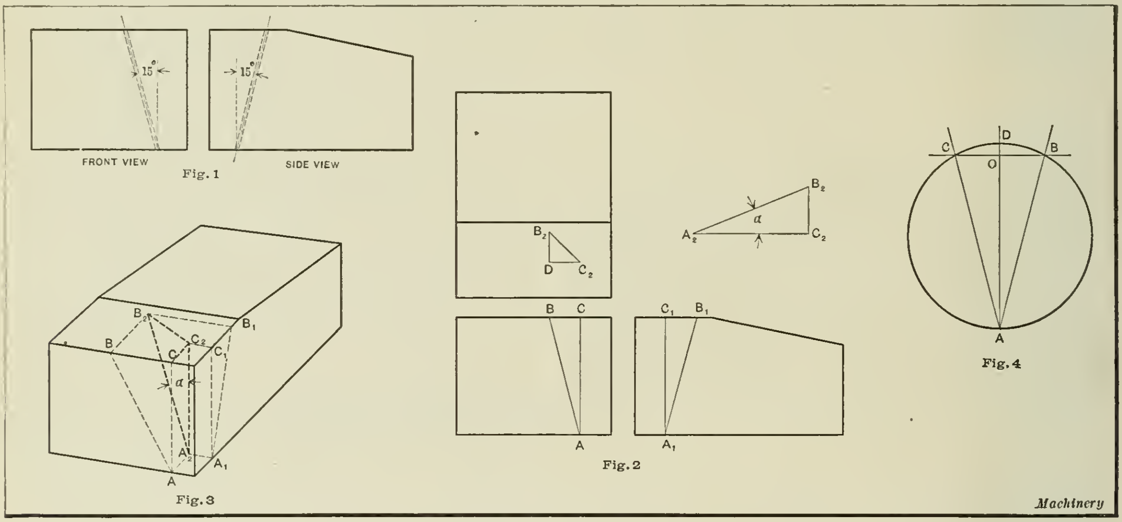
eter. As he had to know, in thousandths, how much stock remained for his finishing cut—since 12-inch micrometers were the largest available—he used the method of measuring the work and the geometric solution shown in Fig. 4. His foreman was responsible for the method of measuring, but the boy worked out his own results.

From a point A on the work he measured, with his 12-inch micrometer, to the two points B and C on opposite sides of the work. Then he measured the chordal distance BC, which was found to be 1 1/2 inch. The amount of over size was calculated from these measurements as follows: DA is the perpendicular bisector of the chord CB; BOA is then a right triangle with $OB = 3/4$ inch and $BA = 12$ inches. As $(OA)^2 = 12^2 - 3/4^2$, $OA = 11.977$ inches. Knowing that: "If through any point two secants are drawn to a circle, the product of the distances from the point to the two intersections on one secant is equal to the product of the distances from the point to the two intersections on the other," and reducing this to shop English: $OC \times OB = OD \times OA$, or $3/4 \times 3/4 = OD \times 11.977$. $OD = 0.047$ inch; therefore, $OD + OA = 12.024$ inches, the diameter of the piece, so that there still remained 0.012 inch on the radius to be removed.

Not all of the problems have a direct application to the work in hand; some spring, rather, from a wholesome curiosity of the boys. About the time that the class in mechanics was discussing forces and the principle of work, one of the apprentices, doing some chuck work on a turret lathe, and pulling quite hard on the end of a chuck wrench, became interested to know what he was putting on his piece of work in the way of compressive force to keep the work from turning in the chuck. Looking up the data on the three-jaw scroll chuck with which his machine was equipped, he found that the spiral scroll had a lead of 1/3 inch, while it took twelve turns of the wrench to turn the scroll once. As he was a husky lad, he thought that he must have been pulling about 100 pounds on the end of a 12-inch lever to turn the chuck screws. So, applying the mechanics' principle of work, he found 100 pounds $\times$ 12 inches $\times 2 \times 3.1416 \times 12$ turns $= F \times 1/3$ inch. Taking a short-cut by using 22/7 for 3.1416 and transposing, this gave $F = 100 \times 12 \times 2 \times 22/7 \times 12 \times 3 = 271{,}543$ pounds, where F is the force on each jaw of the chuck. Of course, the other two jaws had to push back with an equal force between them in order to keep the work from being pushed sideways; that is, to hold the work in equilibrium, so that the force F was the total compressive force to which the work was subjected. This is, of course, the theoretical load; what the actual force was is extremely difficult to say, as the power absorbed in friction in the chuck is difficult to determine exactly. The boy took the safe assumption, however, that about two-thirds of the 100 pounds was wasted in friction. Thus, the force F would be a third of the calculated force, or 90,500 pounds.



Figs. 1 to 4. Mathematical Solutions of Shop Problems

CASEHARDENING BRONZE FOR DIES

The bronzes which possess the greatest hardness lack the requisite properties for chasing and sinking fine intricate designs. It is, however, possible to obtain a hard face on a bronze by a process analogous to the casehardening of steel, and this is practiced with some bronze dies. The method is that of coating the surface of the die with pure tin, and then heating to a low red heat in order to alloy the tin with the surface of the bronze. As is well known, copper and tin unite in all proportions, and with from 20 to 30 per cent of tin the alloy becomes quite hard. The surface of the die to be casehardened is cleaned from grease by soaking in a strong hot potash solution and then immersing in a pickle or dip of acid to remove the oxide. A suitable pickle, which works more rapidly if hot, is made with five parts of water and one part oil of vitriol, and the die is allowed to soak in it for several hours until clean. It is then taken out and brushed, and the surface coated with a strong solution of chloride of zinc to act as a flux. The surface is then covered with pure melted tin. The tin may be melted on the surface by a soldering-iron, but by far the best method is to use a torch or a blowpipe. The tin is melted over the surface only, and as little as possible put on, as the fine detail of the die must not be filled up. The die is then washed in water to remove the excess of chloride of zinc flux, and the surface examined. If there are any portions which are not covered with tin, the process is repeated. The next operation is to heat the die to a red heat, preferably in a muffle, though a blowpipe or torch may be used. To prevent the surface from oxidizing, it is advisable first to cover it with a strong solution of boracic acid. The boracic acid is dissolved in hot water and the solution lightly brushed over the surface. A light coat only is necessary. The die is placed on an iron plate to keep it from breaking when heated, as tin-bronze becomes brittle at a red heat, and it is heated to a low red heat and allowed to remain in this condition for ten or fifteen minutes. The plate is then removed from the muffle and the die allowed to cool. The boracic acid is removed by soaking in hot water and afterward pickling if necessary. After the foregoing operations the surface of the bronze is quite hard and difficult to cut with a file. Dies hardened by this method can be used for stamping leather, soft metals, paper and similar work, as they can be made originally soft enough for chasing or sinking with ease, and then hardened without destroying the design. The best results are obtained by using a rather soft bronze mixture with as little lead as possible. Such a bronze, high in copper, is not likely to give trouble by softening or cracking during the heating. A mixture recommended for this work is: Copper, 88 pounds; tin, 8 pounds; zinc, two pounds; and lead, two pounds.—*Foundry Trade Journal.*

LETTERS ON PRACTICAL SUBJECTS

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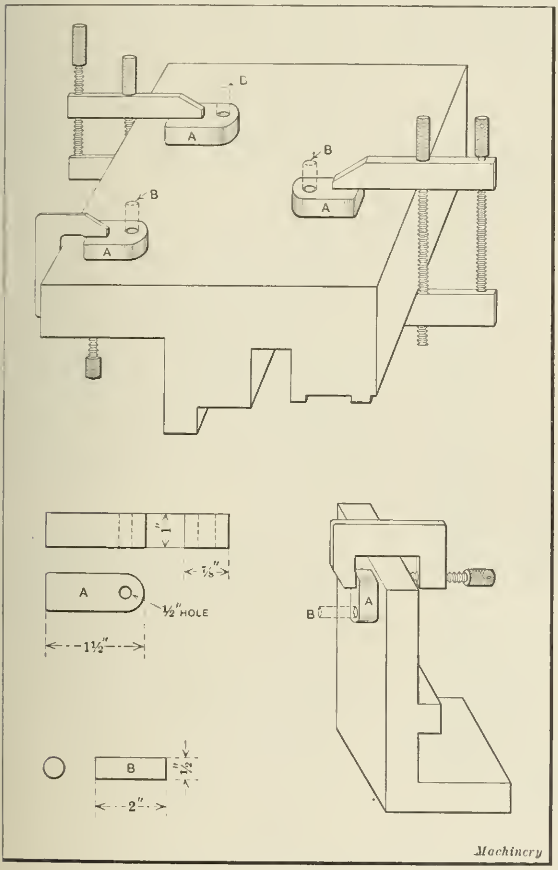
LOCATING HOLES IN JIGS AND FIXTURES

The accompanying illustration shows a time-saving method of locating holes in jigs and fixtures. Before this method can be used, however, it is necessary to make up a number of tool-steel blocks *A*, being careful to have both surfaces of each block exactly parallel, and the half-inch hole lapped to size and absolutely square with both surfaces. Then an equal number of pins *B* must be made up and ground to fit snugly in the holes in the blocks; also a number of bushings with



Locating Blocks and Pins for locating Holes in Jigs and Fixtures

various size holes, preferably varying by 1/64 inch down to 1/64 inch.

In use, the blocks are clamped lightly to the piece in which it is desired to locate the holes, with C-clamps or toolmakers' clamps, as shown, and the pins are inserted in the blocks. Measurements are taken across the pins with a micrometer, or an indicator from the surface plate, as the case may be, and the blocks are adjusted until the proper locations are found. The blocks are then accurately clamped, the pins removed, and the piece is taken to the drill press where the holes are drilled, using the blocks as drill guides. If the holes to be drilled are smaller than the holes in the blocks, the proper size bushing should be inserted; if the holes are larger, a half-inch hole should be drilled, the blocks removed from the piece, and the holes rebored with a pilot counterbore.

The blocks illustrated are for medium size work, but blocks should be made of the proper size to fit the needs of different work. Of course, this method cannot be used in all instances, but enough work can be found for it to effect a considerable saving. It is sufficiently accurate for more than 80 per cent of the jig work done in the average tool-room. In fact, its accuracy seems to be limited only by the expertness of the toolmaker. The writer has located, drilled and reamed three holes within a limit of 0.001 inch in 11 inches. If a set of correctly made blocks and pins is available, together with a flat drill properly ground and a micrometer of the proper size (or a dial indicator for surface plate work), it is an easy matter to keep the dimensions within a limit of 0.0005 inch. A properly ground flat drill having a round shank ground to fit the bushing is preferred for this work, as it does not have the same tendency to run off center as an ordinary twist drill has. A three-corner reamer is essential, too, for reaming the holes with the utmost precision.

Moline, Ill. H. W. JESPERSEN

MAKING 50,000 WASHERS IN AN HOUR

To make 50,000 stampings in an hour from one die seems almost impossible, yet it is easily done. Few people realize what a punch press can do when properly tooled and handled. There are hundreds of punch presses in operation today with makeshift, unhandy, inefficient tools that, with little change and slight expense, could be made to turn out considerably more work at no higher cost for operating. In one of Detroit's largest automobile factories, there are two presses working at 500 and 600 pieces an hour that could easily be made to turn out 2500 and 3000 an hour.

The die that turns out 50,000 washers in an hour is a sub-press die of the compound type with about a 3-inch ram laid out to cut five washers and their holes at each stroke. These washers are about 7/32 inch in diameter with a hole suitable for a No. 4 or No. 6 screw. The material is half-hard brass, No. 22 or No. 24 B. & S. gage, which is fed in rolls 1 5/16 inch wide and about 150 feet long. These rolls are made by running the regular roll sheet brass, which is 6 inches wide, through a set of gang slitters which cut the whole roll into strips 1 5/16 inch wide. The die is laid out to cut the first, third and fifth washers in the first row and the second and fourth washers in the third row back. This is done simply to avoid getting the five holes too close together, thus weakening the die and reducing its life.

The press used is a regular No. 3 punch press, but the stroke is reduced from 1 1/2 inch to 3/4 inch in order to reduce friction and to prevent the sub-press from overheating, which would be likely to occur were the longer stroke used. The No. 3 presses are designed to run at 100 to 125 revolutions per minute, but shortening the stroke makes it possible to use a very large pulley on the driving shaft and run the press at 190 revolutions per minute. Although this speed is excessive for a press of this size, in the present case it handles the work smoothly and easily. A double roll feed with 1/64 inch adjustment is used to feed the stock through the die; and as the strip comes out, it is rolled up on a reel. Later, the handy-man removes the washers by see-sawing the strips over a 3/8-inch rod placed in a box for this purpose. The center punching, or slug as it is often called, is punched through the die in the blanking operation; consequently no slugs are mixed with the washers. While $190 \times 5 \times 60 = 57,000$, which is the number of washers it would be possible to make in an hour should every stroke be caught, in the starting of each roll of stock there is a small loss of time, so that only about 50,000 washers are produced.

This sub-press die will cut about 1,000,000 of these washers without grinding, though sometimes more than 3,000,000 may be cut. The same die will cut half as many steel washers.

The dies do not deteriorate as fast as the ordinary progressive blanking die, neither do they cut at as fast a speed, because in blanking this size of washer in a progressive die (single blanker) a small No. 1 press with a standard stroke of 1 1/2 inch, running at 175 to 200 revolutions per minute, would be used. This means that the ram of the press or the punch is traveling at the minimum rate of 262 inches per minute. On the sub-press die the press has a stroke of 3/4 inch and makes 190 revolutions per minute, so the punch travels but 142 1/2 inches per minute. As a result, while the cutting speed is slower, the production is greater, and there is less wear on the sub-press die than on the common die. The reduced wear is due to the material being pressed back into the strip instead of being pushed through the die.

Ypsilanti, Mich. A. E. Sanford

PLANER AND SHAPER GAGE

The accompanying illustration shows an L. S. Starrett planer and shaper gage to which I have added a vernier reading to 0.001 inch, which does away with the necessity of setting the gage with a micrometer and saves a considerable amount of time when numerous settings are required. I graduated a gage in this way by first tinning the edge with solder, after which the gage was set at 0.500 inch; a line A was then scribed on the slide and a line B on the base, a Brown & Sharpe vernier height gage being used for this purpose with edge C held vertical. The gage was then set at 1.500 inch and line D scribed to coincide with line A. Readings of the height gage were kept for both lines, and the difference was found to be 3.162 inches, which corresponds to 1 inch vertical movement of the slide. Distance BD was next divided into ten equal parts, and each of these subdivided into four equal spaces, making a total of forty divisions, each of which is:

$$3.162 \div 40 = 0.07905 \text{ inch.}$$

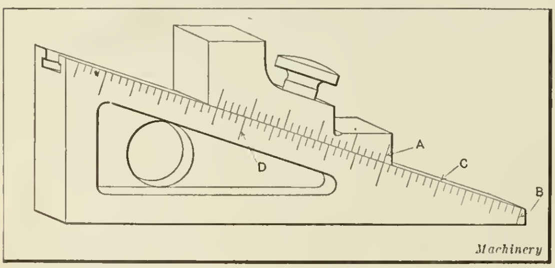
Twenty-five divisions on the vernier occupied the same space as twenty-four divisions on the scale, so that each vernier division is:

$$\frac{24 \times 0.07905}{25} = 0.07589$$

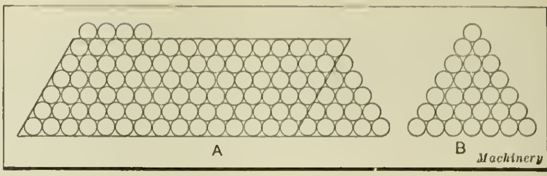
$$0.07905 - 0.07589 = 0.00316 \text{ inch.}$$

From the preceding, it will be evident that a movement of the slide of 0.00316 inch corresponds to a vertical movement of 0.001 inch on the slide. This is explained by the fact that the angle of the gage is 18 degrees, 26 minutes, and the sine of this angle is 0.3162, *i. e.*, a right-angle triangle with one angle of 18 degrees and 26 minutes and a hypotenuse 1 inch in length has an opposite side 0.3162 inch in length. To find the hypotenuse of a similar triangle with an opposite side 1 inch in length, divide 1 by 0.3162, which gives 3.162 inches. This verifies the preceding calculation. Frederick W. Snyder

Williamson School, Delaware County, Pa.



L. S. Starrett Planer and Shaper Gage provided with Vernier Scale



Rapid Method of counting Tools

METHOD OF COUNTING TOOLS RAPIDLY

In the May number of Machinery, J. H. Crary presented a table for rapidly determining the number of shells or billets in a pile without actually counting them. His method may be rapid, but I believe my method is faster, as it is but a formula and can be computed mentally in an instant without referring to a table or blueprint. The method is as follows: Multiply the number of shells or tools in the top row by the number of rows, which gives the number contained in the parallelogram shown at A. To this result add the number of odd tools, if any, on top of the pile and the product of one-half the number of rows multiplied by one less than the number of rows in the pile. This gives the number of tools shown at the right of the parallelogram. This rule can be stated as a simple formula, as follows:

$$N = TS + \frac{S}{2}(S-1) + O$$

in which

N = number of tools;
T = number of tools in top row;
S = number of tools in side row;
O = number of odd tools on top.

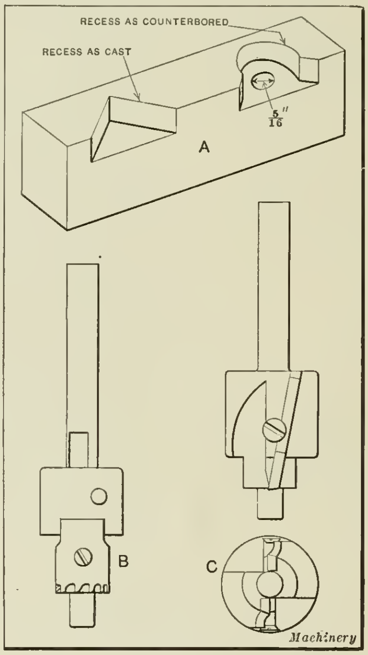
For example, in the case shown at A, $T = 15$; $S = 6$; and $O = 4$. Inserting these values in the formula and solving, the number of tools is found to be

$$15 \times 6 + \frac{6}{2} \times (6-1) + 4 = 90 + 15 + 4 = 109.$$

Should the pile have only one tool on top, as at B, add 1 to the number of rows, then multiply one-half of this sum by the actual number of rows; or, in the form of a formula, $N = S\left(\frac{S+1}{2}\right)$. Substituting in this formula the value of S shown at B, or 7, and solving, the number of tools is found to be

$$7 \times \frac{7+1}{2} = 7 \times 4 = 28.$$

Cleveland, Ohio. L. N. Frost



Heavy-duty Counterbores for Use on Castings and Steel

HEAVY-DUTY COUNTERBORES FOR SMALL WORK

Two counterbores which stood up remarkably well under severe service are shown in the accompanying illustration; both of these have removable cutters made of high-speed steel. A piece of work before and after being counterbored is shown at A, from which it will be seen that there is a triangular-shaped recess cast in the piece which is subsequently counterbored. A small hole is required in the work, and advantage is taken of this fact to use a pilot to help support the tool. With the exception of the recess, each casting is finished all over before being drilled, and for certain reasons it was not found advisable to cut the recess from solid metal, even though the counterboring could have been more easily done in that way. The unbalanced condition of the tool, the blow which occurs as each tooth strikes the metal once during every revolution, the sand which remains in the corners after the castings have been pickled and tumbled, and the spotting on unbroken casting surfaces combine to make exceptionally

severe service conditions which the counterbores are required to meet.

Tool *B* is made with a carbon steel shank which extends right through the cutter and forms a hardened pilot, to which previous reference has been made. The driving head is fastened to the shank by a taper pin and transmits power direct from the chuck to the cutter. A drill press is used for the performance of this operation, which is fitted with a Hartford chuck, the two jaws of which extend beyond the body and engage the driving pins used on this counterbore. The cutter is made of a small piece of high-speed steel, which is flattened to fit into a driving slot in the head, where it is held by a small set-screw, the only function of which is to prevent the cutter from falling out. Owing to the uneven character of the cut, small teeth are used, which are spaced 1/8 inch apart, and these teeth are maintained throughout the life of the cutter by re-grinding them with a saucer-shaped wheel when they become worn down too low for sharpening. In order to maintain the diameter of the counterbored hole, the body of this cutter is turned straight on the outside, but the teeth have a slight clearance ground on them. One of these cutters averages 17,000 holes before it is completely worn out; and satisfactory results are obtained when running at 65 revolutions per minute.

Tool *C* was designed for use in counterboring 11/16-inch holes to a depth of 1/4 inch, the material being cold-drawn steel. It will be seen that this counterbore is furnished with two 1/8- by 3/8-inch blades and two screws to hold them in place; the body of the tool is made of machine steel with the pilot end casehardened. The two blades were made from pieces of a discarded milling cutter. This counterbore has unusually free cutting properties, and has successfully overcome trouble of any kind when used under severe conditions of service. D. A. H.

RECESSING TOOL

A recessing tool that I recently designed for performing a certain piece of work may prove of interest to readers of MACHINERY, as the same idea might be successfully employed in the construction of recessing tools for many different classes of work. This tool is used in a drill press, and collars *A* and *B*, Fig. 1, are adjusted so that the recessing operation starts when collar *B* comes into contact with the top of the work. The portion of the tool extending below collars *A* and *B* is a free fit in the hole to be recessed, and forms a bearing for cross-bar *C* that supports the recessing tool. This cross-bar has spiral gear teeth cut in it which mesh with rack teeth cut in *D*.

In operation, the tool is entered into the hole in the work and fed down until collar *B* comes into contact with the top of the work, which retards further downward movement of the sleeve supporting bar *C*. The shank of the tool and bar *D* carried by it continue their downward movement, which results in the spiral rack teeth giving bar *C* the necessary transverse movement to bring the recessing tool into operation. At the same time, this tool is being revolved by the drill press to enable the recess to be cut. After the machining has been finished, the tool is withdrawn by raising the drill spindle, and in so doing the shank and rack *D* are raised, to provide for withdrawing bar *C* and the cutter from the recess, so that the entire tool can be lifted from the work.

Moline, Ill. H. W. JESPERSEN

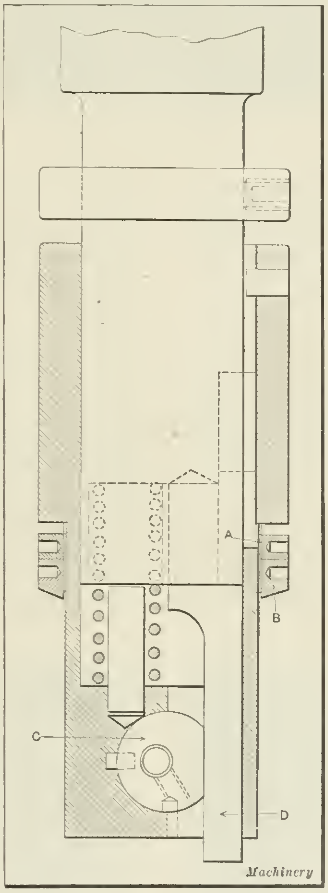


Fig. 1. Design of Efficient Recessing Tool that is used in Drill Press

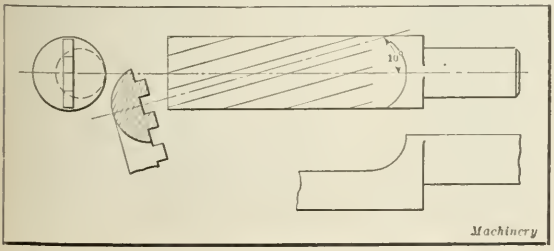
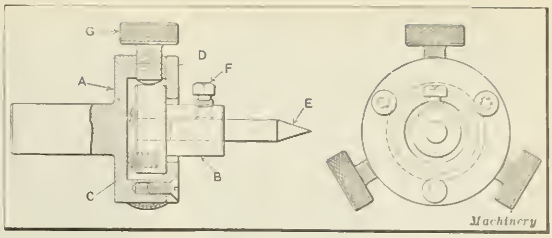


Fig. 2. Detail of Feed Bar D, showing Rack Teeth that engage with C to feed Recessing Tool

LOCATOR FOR HOLES TO BE BORED OR DRILLED



Construction of Locator for center-punching Work to be bored or drilled

Drill jigs are often laid out to scale measurement with surface gage and dividers. By using a magnifying glass, keeping the scriber points well sharpened, and exercising a moderate amount of care, lines may be placed with great accuracy. But getting even a very small center-punch mark exactly on the intersection of two scribed lines, especially on cast iron, is a difficult task, as anyone who has tried will admit. To strap a jig to a lathe faceplate, position a punch mark with a "wiggler" indicator, and counterbalance the job is a lengthy and provoking task, especially if the jig is large and of irregular shape or has holes much off center. With the aid of the tool shown, however, such work can be more accurately, easily and quickly done on a milling machine, or even on a drill press having a screw feed table.

The tool has few parts and requires no particular care in its construction. The body *A* has a shank at one end, while the other end is recessed to contain the pointer holder *B*. Holes are drilled in one end of pointer holder *B* for the three coil springs *C*, which keep it in constant contact with a retainer plate *D*. The pointer *E* is of casehardened cold-rolled steel, with a taper ground truly round to a sharp point, but not necessarily concentric with the straight part. It is held in the holder by the set-screw *F*. The pointer is set in position by means of the knurled-head fine-pitch screws *G* that bear against the enlarged end of holder *B*.

A universal chuck on the machine spindle serves to hold drills, boring tools and locator. The taper point *E* is trued up with an indicator for each hole to be located. The indicator should be of the block type, such as the Boulet, as it may then be held in place on the work or machine table by a weight. The indicator must be applied as low on the taper as possible and the machine spindle turned by hand while screws *G* are being adjusted. After the adjustments are made, the setting should be tested by running the machine a few revolutions by power before the indicator is removed. Of course, the extreme point is the only part required to run true. The line intersections must not be center-punched when this tool is

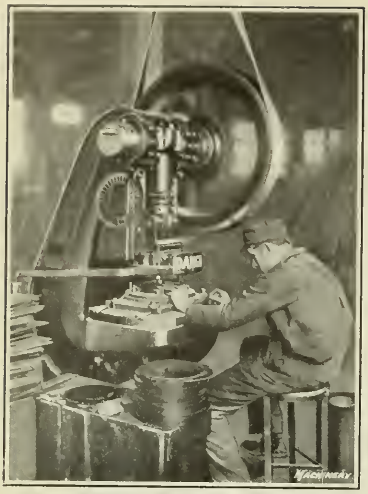


Fig. 1. Punch Press equipped with Safety Device

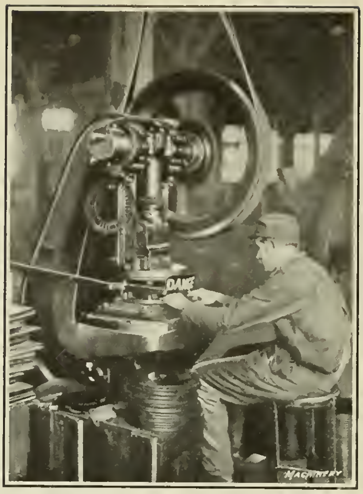


Fig. 2. Operation of Safety Guard shown in Fig. 1

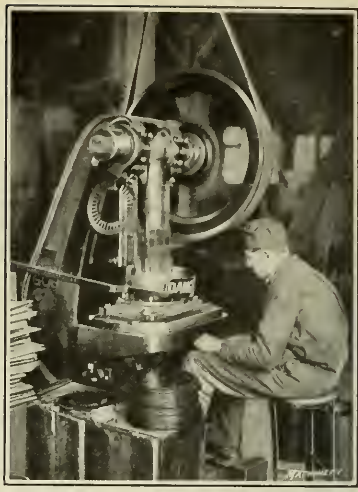


Fig. 3. Position of Guard when Punch Press is in Operation

used, as by bringing the work very near the point, the tool may be set practically on the exact intersections of the lines. With a little practice, the truing up of the pointer E can easily be done in from one-half to one minute.

Anderson, Ind. LEROY M. CURRY

SAFETY APPLIANCES

The accompanying illustrations show some appliances suggested in one of the many safety-first campaigns that have been made in most of the manufacturing plants and machine shops. These guards can be attached to almost any machines of the same nature. In Fig. 1 is shown a punch press used, in this instance, to make the punchings for an electric motor. This press is equipped with a safety guard that is attached direct to the foot release and drops a little before the punch, as shown in Fig. 2. In this way it prevents injury to the operator's fingers, as it strikes them if they are in a dangerous position and completely covers the opening between both parts of the press. In Fig. 3 is shown the position of the guard when the press is in operation. In Fig. 4 is shown a 200-pound drop-hammer. A foot-release drops the hammer, but the hammer cannot strike the work unless the blocks of wood are withdrawn. This can be done only by using both hands, as shown in Fig. 5.

St. Louis, Mo. J. C. GRINDELL

FIXTURE FOR FORM-MILLING FLAT CAM

The flat cam illustrated at A is one that would ordinarily have been handled on a profile milling machine, but owing to the large amount of work that had to be handled on these machines it was placed on a plain horizontal milling machine equipped with the fixture shown. One edge I of this cam was to be milled round and to form. The rounding was done by a concave cutter E, and the form was obtained by milling in the usual manner when the work was held in the fixture.

This fixture consists of four principal parts: a base H, a slide B upon which the work is held, a slide C that carries a

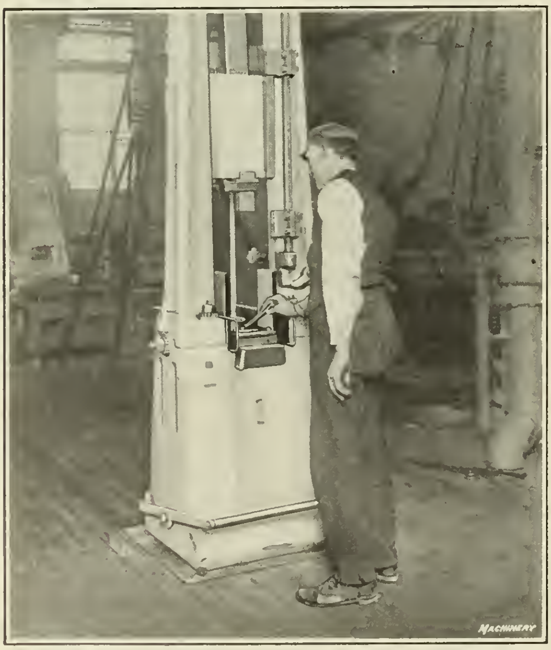


Fig. 4. Power Hammer with Safety Blocks in Position

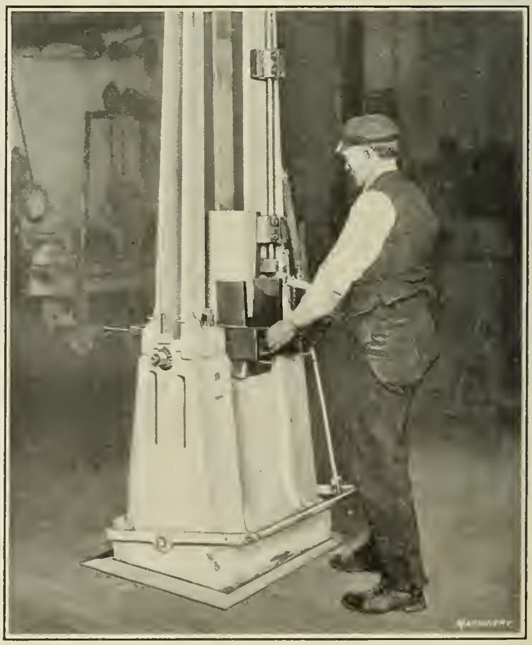
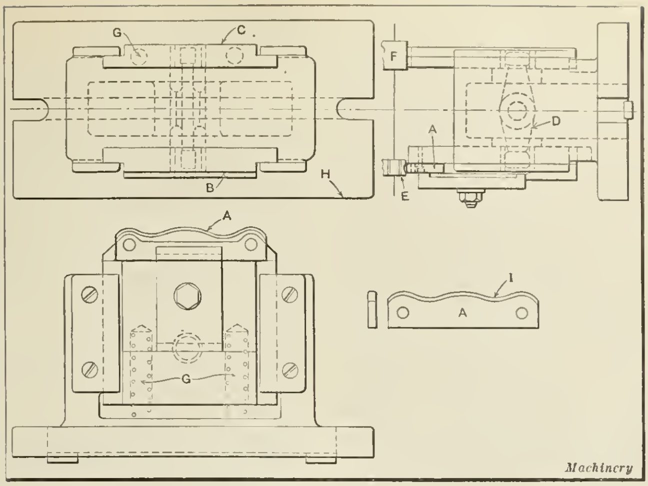


Fig. 5. Power Hammer in Operation

master cam, and a lever *D* that connects the two slides *B* and *C*. The concave cutter *E* and a ball-bearing roll *F* are mounted on an arbor, which is held in the spindle of the machine. When the cam is being milled, the roll rides along the master cam on the fixture, which is held against the roll by the springs *G;* this causes the work to be raised or lowered under the cutter by the action of lever *D*. To obtain good results with a tool of this type, the slides must be rugged and well made, as any looseness will cause chattering, and the springs that cause the master cam and slides to follow the roll on the arbor must be stiff enough to prevent the cutter from hogging into the work.

F. Server



Flat Cam and Fixture for milling

WHY THE SCALES DIDN'T WEIGH CORRECTLY

The lathe that wouldn't turn correctly with a weight on the floor near it, mentioned in the September number of Machinery, had nothing on the coal scale that wouldn't weigh a ton when the wagon was filled to overflowing. After the platform had been taken up and the adjustments and leveling checked, the only source of trouble left was the rod that ran up through the floors to the beam in the office. This was all right, the owner insisted, and he didn't want any time spent examining that, for he said no one ever went in between the floors and the rod ran through unobstructed space. However, one of the boys sneaked in there with a pocket flash lamp and found a barrel of lime resting against the rod. D. A. H.

FORGING MACHINE PARTS

In looking over working drawings one often sees the words, "Smooth-forge this piece"; but sometimes no great advantages are obtained by making certain parts from forgings. When the part is quite regular in shape and is made of machine steel, the cost of the forging greatly exceeds the cost of machining and the extra cost of the steel removed by the machinist. Although it is impossible to eliminate forgings for machine parts, careful consideration should be given the work before specifying that parts that are not of a very irregular shape should be forged before machining. Sometimes the part must be extra tough to withstand excessive strains. In such cases, it has been found cheaper to use a better grade of steel and machine the part direct than to use a forging; of course, the part must be symmetrical in form.

One case of this kind was where a large and expensive oval tapered broach used in the manufacture of production parts was forged, and after machining was sent to the hardening shop. It was heat-treated under the supervision of a good practical man and sent back to the machine-room in what might be considered good condition. After being ground to size, it was put to work, but broke under the pressure of the first production part. Upon examination, the piece was said to have been "cracked in hardening." A second broach was then made. This was machined direct from the stock, so as to get it out more quickly, as the blacksmiths were very busy and the production output was retarded for want of the piece. This broach has broached many thousand pieces and is still in good condition. Probably the steel taken from stock was more homogeneous than the forging. In large plants this plan of making parts direct from stock should not be overlooked, as one may find many cases where it is much cheaper to produce the required machine part from stock than by smooth-forging.

New Haven, Conn. Eric Lee

LARGE COUNTERBORE FOR SPOT-FACING

The tool shown in Fig. 1 was designed by the writer for spot-facing and cutting clearance on a large steel casting and was used on a horizontal boring mill. It is mounted on a heavy boring-bar and is clamped by means of two set-screws on the hub. The cutter extending beyond the outside diameter of the body and one just like it in the opposite block (not shown) cut a clearance on a projecting part of the casting. These have the form shown at *A*, Fig. 2; the form of the thirty-four other cutters is shown at *B*. When the cut reaches the face of the work the feeding must be slow and the cutting steady to a depth of from 1/8 to 3/8 inch, according to the variations in the casting. These variations, which are common evils in steel castings, were the cause of the operation, the object of which was to

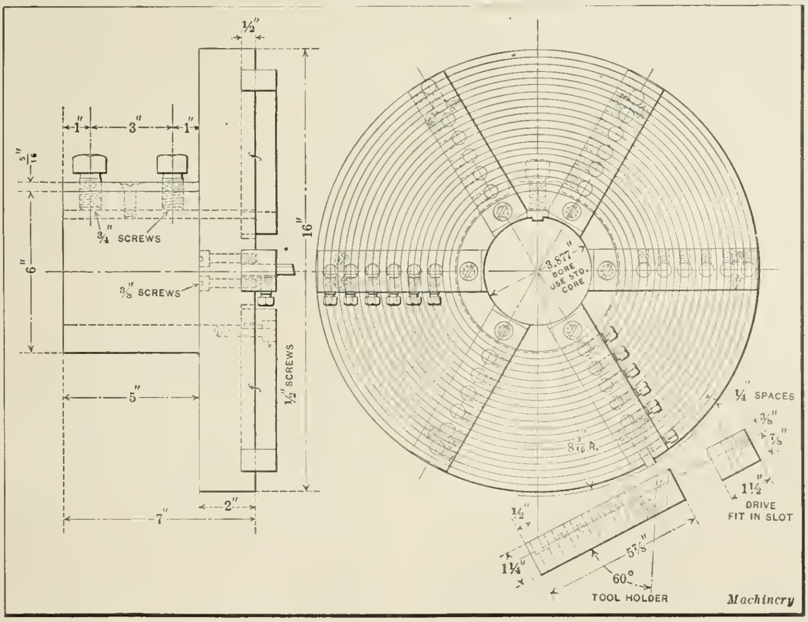


Fig. 1. Counterbore for spot-facing

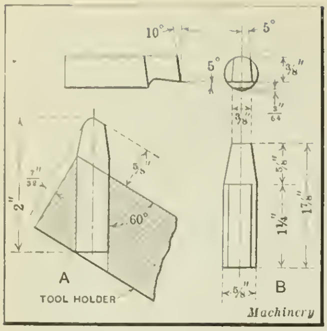


Fig. 2. Forms of Tools used in Counterbore

give proper clearance to a gear.

The cutters were set in such relation to each other on the face of the body that the entire surface was covered with a generous allowance of lap to insure that no ridges were left on the finished surface. A fine finish was not necessary, and a saving of 75 per cent of the time required for this operation when using a single-point tool was effected. The upkeep of this tool was not excessive, the cutters being made of high-speed steel and of such shape that they could be ground the same as a milling cutter, all being mounted in rows with their cutting faces in a straight line. The bearing face proper was finished in the ordinary manner with a sweep tool to an exact dimension. The only remarkable thing about this tool is the large surface covered in an unusual manner.

Columbus, Ohio. OTTO R. WINTER

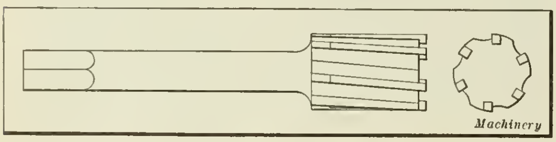
HIGH-SPEED CHUCKING REAMER OR CORE DRILL

Before the outbreak of the European war, few shops thought of making their own core drills. However, we found not long ago that it would take six weeks to have a four-fluted carbon-steel twist drill made to be used in a jig, so we decided to make it ourselves. The one made is shown in the accompanying illustration. It was used for machining ninety-eight holes, 1 15/16 inch in diameter and about 4 inches deep, in split boxes. There were two to each casting, and the distance between centers had to be very accurate and all the castings interchangeable.

The body of the drill was made from machine steel; the blades were made of "Rex AA," the cutting ends being located to a high heat and hardened in water. The blades were 2 inches long and projected 5/16 inch beyond the body. They were fitted with a disk grinder in 5/16-inch slots inclined at an angle of 10 degrees in the body. The front edge of the slot was radial on the front end of the body. The diameter of the cutting end of the drill was 0.002 inch larger than the other end. This drill worked so well that the boxes were reamed, with a 1/8-inch split between the box and the cap, in less than one-half the time that would have been required had a carbon core drill been used, and the cost was just about the same. As a result, another drill of this design but of a different size has since been made, and we will probably make all our large-size rose chucking reamers, for in this way properly tempered high-speed chucking reamers will be obtained for about the price of carbon reamers.

One twist-drill company had almost the right idea when it made a chucking reamer with the high-speed blade welded in, but the tool had three faults: The blade was backed off, so that it cut sidewise and followed untrue holes; the blades were too thin—they would not have had enough wearing surface had they not been backed off; and the blades were set parallel with the body, thus giving no rake for cutting. Milling cutters that have no rake are scrapers, not cutters, and end-mills made with spiral grooves give the end cutting edges a negative rake that is intolerable. But these homemade reamers make reasonably true holes out of rough bored holes, and do it rapidly. Distillate is used to lubricate them.

Los Angeles, Cal. S. B. WELCOME



Reamer or Core Drill with Inserted High-speed Steel Blades

PATCHING CONCRETE FLOORS

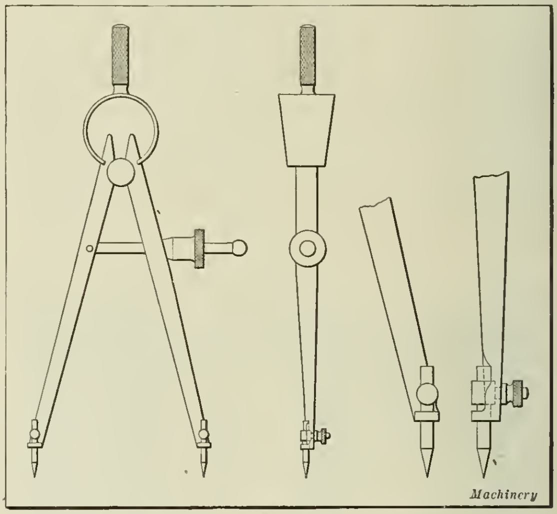
The item "Patching Concrete Floors" in the August number of MACHINERY seems to have created an entirely erroneous impression among some readers, so much so that the chief engineer, Ernest McCullough, of the Portland Cement Association has called it to the attention of W. P. Anderson, president of the Ferro Concrete Construction Co., whose experience was quoted. Mr. Anderson did not imply that deep holes or large areas could be successfully patched by the use of a mastic material, but somehow this impression seems to have been created. Inasmuch as this method of patching concrete floors is of considerable value when rightly used, we would very much appreciate your publishing a correction somewhat as follows:

> In "Patching Concrete Floors," recently published, it should have been stated that the use of a mixture of asbestos fiber and rubber gum is not applicable to the repair of deep holes or large areas. Such patches are quickly made and give excellent results when confined to patches about 1/8 inch thick and where truck loads do not exceed 1½ ton, but when used on deep holes or on large areas they will not stand up and give satisfactory service.

Boston, Mass. WALTER B. SNOW AND STAFF

VICTOR TALKING MACHINE NEEDLES USED AS DIVIDER POINTS

The accompanying illustration shows how Victor talking machine full-toned needles may be used in the drafting-room



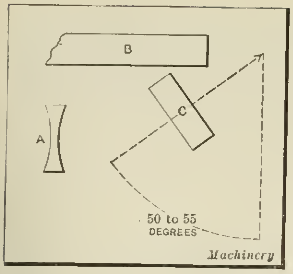
Dividers with Talking Machine Needles for Points

and the machine shop. They make good divider points, and are economical to use, as the cost is only five cents a hundred and they do not require grinding.

Cleveland, Ohio. FRED C. LATIMER

PIVOT DRILLS

One day, in about the middle of my apprenticeship—and I am not nearly old enough to be a Civil War veteran—the "boss" brought into the shop and exhibited as a great curiosity a twist drill, the first any of us had seen. Not till many years later did I see one in use. At that time chucking drills, "hog noses" and a few other drills for special uses were made in a lathe, but the ordinary everyday tool was the plain hand-forged flat drill. In shops too small to employ a blacksmith, every man made his own tools, unless he could shift the job on to the "cub." We should have been surprised to learn that flat drills were ever made in any other way than by forging out the end of a piece of round stock, shap-



Making Pivot Drills

ing it with hardy and file, then hardening and tempering.

A few years later, however, I was employed in a trade where the process was entirely different, the steel being hardened and tempered and then brought to size and shape by grinding in the lathe. These were the small tools, from 0.005 to perhaps 0.020 inch, which the watchmaker calls "pivot" drills, and the forging method was obviously inapplicable for their manufacture. Nowadays these drills are usually bought ready made, but some of the older watchmakers prefer to make their own, and workmen who are far from tool stores have to make a few, now and then.

The raw material is drill rod, Nos. 66 or 67 being often chosen because it fits the No. 8 chuck which is 0.8 millimeter in diameter. This rod is cut into inch lengths, which are hardened and then "let down" by holding one end in the flame of an alcohol lamp until the other end, which is to be the working part of the drill, becomes the proper straw color. The blank is then put into a split chuck in the lathe and from 1/8 to 1/4 inch of the end is reduced to the diameter of the finished drill by a wheel carried by the pivot polisher, a near relative of the machinist's toolpost grinder. Theoretically, it is considered best practice to set the wheel spindle at an angle of about one-half degree to the lathe axis, so that the drill will taper back, or be a fraction of a thousandth inch larger at its tip, but this hair-splitting refinement is by no means universally adopted. Next, the lathe spindle is locked by the sixty-hole index plate on the cone pulley, and the sides of the drill are ground, using the periphery of the wheel which gives the shape shown at *A*. Now the spindle is turned forward until the drill lips are horizontal and is then indexed three holes (or 18 degrees) farther, after which the wheel is passed over the lips as shown in the illustration, where *B* is the drill blank and *C* is the grinding wheel. This completes the job, and though the process may seem long from the description, a dozen drills can be made very quickly when the lathe is once set up. Each operation, of course, is performed on the whole dozen before the set-up is changed.

The continued use of the flat drill is not, as some people think, the result of hide-bound conservatism. In the sizes below No. 80, one has no choice, as the manufacture of twist drills of such minute dimensions is not an attractive commercial proposition, and in larger diameters the flat form is superior for certain classes of work. It manifests no tendency to draw in, and many good workmen believe that in lathe work on the softer metals it makes a smoother, straighter hole than its modern competitor.

New London, N. H. GUY H. GARDNER

CASTING BRASS NUTS ON FEED-SCREWS

In the October number of MACHINERY T. M. complained of the unsatisfactory service given by the brass nuts on the cross-feed screws of the cutting-off lathe, and asked for information concerning the casting of the nuts on the screws. While the writer has not done exactly the work mentioned by T. M., he has had considerable experience along that line, and would say that probably the reason the brass feed-screw nuts are not giving satisfaction is that yellow stick brass is used. Besides, this kind of casting is often poured from the metal in the bottom of the ladles or from metal which is unfit for other work. In addition, the molds are so simple that they are made by the cheapest help or by apprentice boys. Out of 150 bars of this material that the writer examined, only about 10 per cent was fit for use where hard service was required.

An analysis of yellow brass generally shows that it is 70 per cent copper and 30 per cent zinc; the slight variations are usually due to impurities such as a small amount of lead, tin or iron. This metal has a total strength of from 28 to 32 tons per square inch and an elongation of from 22 to 28 per cent; its scleroscope hardness is about 20. An alloy containing from 82 to 86 per cent copper, 10 to 14 per cent tin, 1 to 3 1/2 per cent zinc, and a small percentage of lead would give better results. The physical properties will be about the same, but the elongation will be slightly less, indicating greater hardness. A good dense metal is produced by melting at a temperature no hotter than necessary, taking care to prevent oxidation by covering the molten metal with charcoal. If zinc is used, it should be melted in a separate crucible, as it oxidizes readily and there is a great difference between its melting point and that of copper. The tin can be added to the copper just before it is to be poured, and the molten zinc can be added immediately afterward.

Casting a nut on a feed-screw can be done, but it would require experimenting, because few foundries are familiar with this class of work. A better way would be to cast the stick metal in a chill. All brasses and bronzes give off a certain amount of gas, so the sooner these metals are solidified the smaller are the areas containing the gas or gas holes. If these metals are kept molten a long time, the gases will find their way out; but as they are generally cast before this is possible, the gases are entrapped and holes result. An examination will show that chilled cast metal has a finer and closer grain than that cast in other molds, so that chilling will produce better results than ordinary methods.

In casting brass nuts on feed-screws, care will have to be taken to support the screw so as not to crush the mold. If the outside diameter of the nut is not large, thus giving a small area of metal, when the mold is poured the interior will solidify and the nut will shrink onto the screw. If the nut has a large cross-section, the metal which is solidified will be heated and a looser fit will result. In all cases, the nut should be removed from the screw as soon as possible. The shrinkage of brass is greater than that of iron or steel. It might be well to use a screw a few thousandths inch larger than the one on which the nut is to be used, so that when the nut is cold it will be near the correct size and have sufficient clearance. The threads will shrink on the sides, giving plenty of clearance, but the nut will bind on the outside and root diameter. If there is not sufficient clearance, a light cut may be taken, but this will remove some of the chilled metal.

When a green-sand mold is used, if the feed-screw is heated the mold is likely to crumble unless the metal is cast immediately. This causes trouble in handling in the foundry, because the work is then a special and not a production job. A better way is to run the metal through the mold. By this plan the screw is heated, and so dense a metal will not be produced as when it is cast on a cold screw. But this may be necessary to produce a sound casting, due to the small area of the thread. When the shaft or screw becomes cold, the nut will be easily separated on account of the shrinkage of the shaft. A dry-sand or skin-dried mold can be used if it is desired to use a heated screw. Besides producing a denser casting, this will do away with all danger of the screw crushing the mold.

A screw may be coated with seal oil into which has been stirred foundry facing (graphite), but the oil must be thinly and evenly applied. Plain graphite can be rubbed on, but it is not so efficient. Care must be taken to see that there is no rust or moisture on the screws, or gas holes will result. When the screw is coated with oil, the heat decomposes the oil, which gives off a film of gas; this makes removal of the nut from the screw quite easy.

However, results would have to be very discouraging before the writer would attempt to cast the nuts on the screws, because it is an impractical way at best. If the correct mixture is used, he thinks that casting a bushing in a chill with a straight metal core of approximately the right diameter and machining afterward would be preferable. Even in sand-cast material, a core should be used; a closer-grained metal will then result. The metal should be poured from the bottom of the mold, and a reasonable amount from the top of the stick should be scraped, as it will contain all the impurities.

G C R.

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

GRINDING CHILLED CAR WHEELS

H. C. V.—I have about twenty chilled cast-iron car wheels with flat spots to be repaired. I know that they can be ground, but would like to know if they could not be turned in a lathe.

A.—It is not commercially feasible to turn chilled cast-iron car wheels in a lathe, and it is seldom, if ever, done. Powerful lathes of special design are required for turning chilled iron, and no ordinary engine lathe could be used for turning chilled wheels. The flat spots, if not too deep, may be removed by grinding in a car wheel grinding machine.

ALLOWANCES FOR FITTING PARTS FOR BRAZING

W. G. Co.—Will you advise us what allowance should be made in the fitting of a steering wheel shaft in a socket of the worm when it is to be pinned and brazed? The diameter of the socket is one inch.

A.—The socket should be bored or the shaft should be turned to make a light drive fit when preparing for pinning and brazing the parts together. It is generally conceded by braziers that two parts to be brazed together cannot be fitted too closely. When the parts are heated and spelter is applied, the melted spelter will penetrate into the interstices of the closest fitted joint, and the brazing will be much stronger under such conditions than if the joint is loosely fitted and the spaces filled with spelter. In general, then, in fitting parts to be brazed, fit them closely and use as little spelter as possible. Wide open spaces are not favorable to sound brazing, and should always be avoided.

HIGH-SPEED STEEL

H. S. H.—What is the meaning of the term "high-speed" as applied to steel? I have believed that it referred to the cutting quality only and not to the composition of the steel in question. I know that most of the present high-speed steels contain a certain percentage of tungsten, but understand that tungsten is not absolutely necessary. Must a high-speed steel conform closely to a given chemical analysis, and is tungsten a necessary element?

A.—A high-speed steel is not necessarily one conforming to any given analysis, nor is tungsten a necessary element. Most high-speed steels contain tungsten, but other elements, such as molybdenum, confer the red-hardness characteristic. We would define a high-speed steel as one that cuts metals at a much higher rate of speed than ordinary carbon tool steel. A high-speed steel should continue to cut when the point of the tool becomes heated to a dull red temperature because of the red-hardness characteristic conferred upon it by tungsten, molybdenum or other alloys.

LOGARITHM OF 0

B. D. K.—What is the logarithm of 0? In one set of tables, I notice a dash is printed; in another set, it is recorded as 0; in MACHINERY'S HANDBOOK, it is printed inf. neg.

A.—The logarithm of 0 is designated by $-\infty$, read minus infinity. That this is correct will be readily apparent from the theory of exponents. If n represents any number greater than 1, any positive number may be represented by n^a, the value of a being different for different numbers. Here a is called the logarithm of the number to the base n, and if a is positive, n^a is greater than 1; but if a is negative, $n^{-a} = \frac{1}{n^a} =$ some number less than 1, but greater than 0, or, in other words, a decimal fraction. When a becomes infinitely great, the value of $\frac{1}{n^a} = \frac{1}{n^\infty} = n^{-\infty}$ becomes infinitely small; that is, it becomes 0. Consequently, $\log 0 = -\infty$, which is the value printed in MACHINERY'S HANDBOOK, the abbreviation inf. neg. standing for infinite negative. J. J.

MACHINING MONEL METAL

M. A. M.—Can you give me information regarding the working of monel metal in the machine shop, especially with respect to drilling and shearing in dies. I would also like to know the cutting speed, angle of rake and clearance of cutting tools, and the best lubricant to use when drilling or turning.

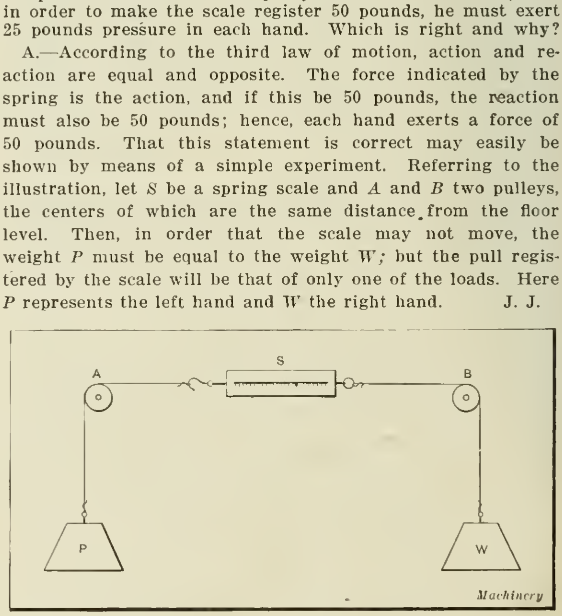
Answered by the International Nickel Co., Bayonne, N. J.

A.—Monel metal machines with a long tough chip, resembling copper in many respects, but requiring more power. Rolled or drawn monel and mild steel require practically the same power for machining. Cast monel requires somewhat more power to machine than the rolled metal. It has a tensile strength of about 65,000 pounds per square inch, and rolled or drawn monel has about 80,000 to 100,000 pounds per square inch tensile strength. Our usual practice in machining is to cut the metal dry at a speed of about forty feet per minute. We have taken a cut 1/4 by 1/20 inch feed at a speed of 150 feet per minute forty inches long without the tools breaking down. In this case we used a cooling compound. On our cutting-off machine we use a mixture of lard oil, borax and aquadag for cooling with good results. On our milling machines we use a mixture of "Oakite" with satisfaction. High-speed steel cutting tools are essential in machining monel. Our experience has been limited in drilling monel, but we know that some difficulties are presented, as the metal forms a tough chip like copper and tends to stick to the drill. It is also harder and requires more power to drill, being comparable to high carbon steel. We consider that "Oakite" would be a good lubricant for drilling and recommend that high-speed steel drills be used.

SPRING SCALE PROBLEM

J. E. F.—"A" claims that if he holds a spring scale in his hands and makes it indicate 50 pounds, he has exerted 100 pounds of energy; that is, he must resist 50 pounds with one hand while pulling 50 pounds with the other. "B" claims that the pull and resistance are equally divided in each hand; and, in order to make the scale register 50 pounds, he must exert 25 pounds pressure in each hand. Which is right and why?

A.—According to the third law of motion, action and reaction are equal and opposite. The force indicated by the spring is the action, and if this be 50 pounds, the reaction must also be 50 pounds; hence, each hand exerts a force of 50 pounds. That this statement is correct may easily be shown by means of a simple experiment. Referring to the illustration, let S be a spring scale and A and B two pulleys, the centers of which are the same distance from the floor level. Then, in order that the scale may not move, the weight P must be equal to the weight W; but the pull registered by the scale will be that of only one of the loads. Here P represents the left hand and W the right hand. J. J.



Spring Scale Illustration of Third Law of Motion

NUMBER OF BALLS THAT CAN BE PLACED IN A CYLINDER

M. F. W.—Referring to the August number, page 1084, suppose the box had been a cylinder instead of a cube; how many balls of equal and maximum size could be placed in the cylinder around the large ball?

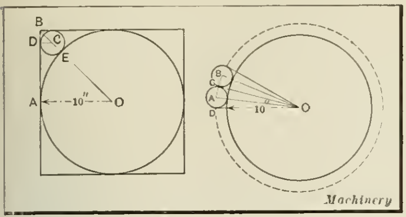


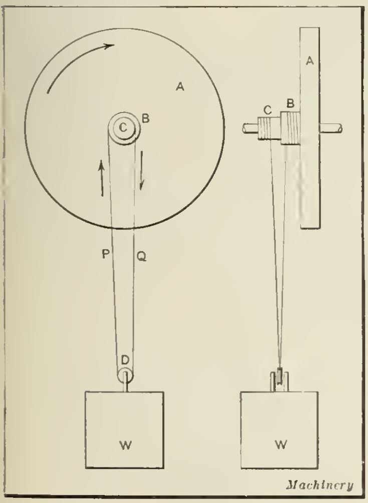
Diagram for calculating Number of Balls that can be placed in a Cylinder around a Large Ball

A. — The figure at the left of the illustration represents a vertical section through the centers of the large ball and one of the small balls. $OB = 10\sqrt{2}$, and $BE = 10\sqrt{2} - 10$. Letting r = radius of small ball = CD, $BC = r\sqrt{2}$. Hence, $r\sqrt{2} + r = 10\sqrt{2} - 10 = BE$; or, $r = \dfrac{10\sqrt{2} - 10}{\sqrt{2} + 1} = 1.715729$ inch. The figure at the right of the illustration represents a top view with the top of the cylinder removed. Assuming that the balls touch, they will lie so that their centers will be in a circle whose radius is $10 + r$, and BOC will be a right triangle, right-angled at C. Sin $BOC = \dfrac{r}{10 + r} = \dfrac{\sqrt{2} - 1}{2\sqrt{2}}$, after substituting the value of r as found above. Log sin $BOC = \bar{1}.1656793$, from which BOC = 8 degrees, 25 minutes, 15.81 seconds. This angle is evidently equal to half the angle $BOA = COD$. Hence, the number of balls in the top layer is equal to 360 degrees $\div$ 2 $\times$ 8 degrees, 25 minutes, 15.81 seconds = 180 $\div$ 8.42106 = 21.37 +, since 25 minutes, 15.81 seconds = 0.42106 degree. The number of balls is therefore 21 on top and 21 on the bottom, or 42 in all. J. J.

THE CHINESE WINDLASS

F. H. E.—I enclose a sketch of a hoisting device. Suppose that the diameter of the wheel A is 42 inches, and that the diameters of the drums B and C are 10 inches and $8\frac{1}{2}$ inches, respectively; how large a weight can be lifted if a force of 40 pounds is applied at the circumference of the wheel? What is this apparatus called?

A.—The apparatus is called a Chinese windlass; some writers on mechanics call it a compound wheel and axle. The principle of virtual velocities (see MACHINERY for June, page 897) applies here as in the case of any other machine, *i. e.*, the weight multiplied by the distance through which it moves equals the power (force) multiplied by the distance through which it moves. Let R, r, and r' be the radii of A, B, and C, respectively, and suppose A to make one revolution; then the distance moved by the power will be $2\pi R$. At the same time, B and C make one revolution also. As the part P of the rope winds on drum B an amount equal to $2\pi r$ and rope Q winds off drum C an amount equal to $2\pi r'$, the rope is shortened an amount equal to $2\pi r - 2\pi r' = 2\pi(r - r')$. The weight W is raised only one-half this distance, however, since it is divided equally between P and Q, D being a movable pulley. Hence, the distance W moves is $2\pi(r - r') \div 2 = \pi(r - r')$. Therefore, $P \times 2\pi R = \pi(r - r') \times W$; from which $W = \dfrac{2PR}{r - r'}$. Substituting the values given in this formula, $W = \dfrac{2 \times 40 \times 21}{5 - 4\frac{1}{4}} =$ 2240 pounds. A mechanism of this kind ought to have an efficiency of at least 0.90; whence, the weight lifted ought to be at least 2240 $\times$ 0.90 = 2016 pounds. J. J.



Chinese Windlass, or Compound Wheel and Axle

DISCHARGE OF AIR INTO THE ATMOSPHERE

W. M.—Please let me know a formula that will give the cubic feet of free air that will flow through an orifice of known size into the atmosphere, the gage pressure in the tank being anywhere from 5 to 50 pounds per square inch.

A.—Let T = absolute temperature of air in tank in degrees F. = 460 + temperature indicated by thermometer; let p = absolute pressure in tank = gage pressure + pressure indicated by barometer in pounds per square inch; p_1 = pressure of atmosphere as indicated by barometer; and V = velocity of flow through orifice in feet per second. Then the theoretical velocity of discharge is:

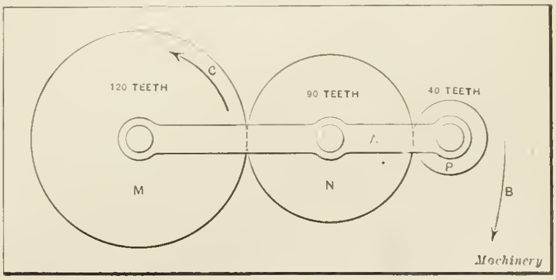
$$V = 108.67\sqrt{T\left[1 - \left(\frac{p_1}{p}\right)^{0.2907}\right]}$$

If you have no barometer, you may assume that $p_1 = 14.7$ and p = gage pressure + 14.7. The actual velocity will not be so great as calculated by the formula, because it will be affected by the size and shape of the orifice, practically the same conditions obtaining as in the case of the discharge of water. If the discharge is through a short tube the length of which is two or three times the diameter of the orifice, the actual velocity of discharge may be taken as $0.98V$. It is also assumed that the pressure in the tank remains constant. Assuming that the pressure in the tank is 10 pounds, gage; that the temperature is 70 degrees, and that the diameter of the orifice is $1\frac{1}{2}$ inch, $p = 10 + 14.7 = 24.7$, $p_1 = 14.7$. $T = 460 + 70 = 530$; then, $\left(\dfrac{14.7}{24.7}\right)^{0.2907} = 0.85996$, and $1 - 0.85996 = 0.14004$; whence, $V = 108.67\sqrt{530 \times 0.14004} = 936.2$ feet per second. The discharge is at the rate of $\dfrac{0.7854 \times 1.5^2}{144} \times 936.2 =$ 9.126 cubic feet per second = 547.56 cubic feet per minute. The actual discharge may be taken as 0.98 $\times$ 547.56 = 536.61, say 537 cubic feet per minute. J. J.

A PROBLEM IN EPICYCLIC GEARING

A. M. S.—Referring to the diagram, M has 120 teeth, N has 90 teeth, and P has 40 teeth. If the arm A makes fifty revolutions per minute in the direction indicated by the arrow B, and gear M makes thirty-six revolutions per minute in the direction indicated by the arrow C, how many revolutions per minute will gears N and P make and in what direction?

A.—Gearing of this kind belongs to the general class known as epicyclic trains. The best method known to the writer for attacking all such problems is that described on page 703 of



Epicyclic Gearing

MACHINERY'S HANDBOOK. Applying this method to the present case, suppose all the gears are locked and that the whole mechanism is turned around in the direction indicated by the arrow *B* fifty times; then imagine the gears to be released and the arm *A* stationary, and that gear *M* makes thirty-six turns in the direction indicated by the arrow *C*. Calling rotation in the direction of *B* positive or +, and that in the direction of *C* negative or —, the following results are obtained:

	M	*N*	*P*	*A*
Wheels locked	+ 50	+ 50	+ 50	+ 50
Arm stationary	— 36	$+\frac{120}{90}\times 36$	$-\frac{120}{40}\times 36$	0
	+ 14	+ 98	— 58	+ 50

It will be seen that gear *N* makes 98 revolutions per minute in the direction of arrow *B*, while gear *P* makes 58 revolutions per minute in the direction of arrow *C*. Gear *N* is an idler and so has no influence on the motion of *P*, except to change its direction of turning; the number of revolutions *P* makes is determined solely by gear *M* and the rotation of the arm *A*. When the arm *A* is stationary, the gears act as in an ordinary train. J. J.

SOLVING EQUATIONS FOR SPIRAL GEARING BY TRIAL

H. A. T.—I have met with some difficulties in trying to solve the equation given on page 674 of MACHINERY'S HANDBOOK:

$$R\sec\alpha + \operatorname{cosec}\alpha = \frac{2CP_n}{n}$$

Would you kindly indicate how equations of this kind are solved by trial?

A.—Equations of the form given above are solved by trial by selecting an angle assumed to be approximately correct, and inserting the secant and cosecant of this angle in the equation, adding the values thus obtained, and comparing the sum with the known value to the right of the equals sign in the equation. An example will show this more clearly. Using the problem given on page 675 of MACHINERY'S HANDBOOK, as an example, $R = 3$; $C = 10$; $P_n = 8$; $n = 28$.

Hence, the whole expression

$$\frac{2CP_n}{n} = \frac{2\times 10\times 8}{28} = 5.714,$$

from which it follows that:

$$R\sec\alpha + \operatorname{cosec}\alpha = 5.714.$$

In the problem given, the approximate spiral angle required is 45 degrees. The spiral gears, however, would not meet all the conditions given in the problem, if the angle could not be slightly modified. In order to determine whether the angle should be greater or smaller than 45 degrees, insert the values of the secant and cosecant of 45 degrees in the formula. The secant of 45 degrees is 1.4142, and the cosecant, 1.4142. Then,

$$3\times 1.4142 + 1.4142 = 5.6568.$$

The value 5.6568 is too small, as it is less than 5.714, which is the required value. Hence, try 46 degrees. The secant of 46 degrees is 1.4395, and the cosecant, 1.3902. Then,

$$3\times 1.4395 + 1.3902 = 5.7087.$$

Apparently an angle of 46 degrees is too small. Proceed, therefore, to try an angle of 46 degrees, 30 minutes. This angle will be found too great. Similarly 46 degrees, 15 minutes, if tried, will be found too great, and by repeated trials it will finally be found that an angle of 46 degrees, 6 minutes, the secant of which is 1.4422, and the cosecant, 1.3878, meets the requirements. Then,

$$3\times 1.4422 + 1.3878 = 5.7144,$$

which is as close to the required value as necessary.

In general, when an equation must be solved by the trial and error method, all the known quantities may be written on the right-hand side of the equals sign, and all the unknown quantities on the left-hand side. A value is assumed for the unknown quantity. This value is substituted in the equation, and all the values thus obtained on the left-hand side are added. In general, if the result is greater than the known values on the right-hand side, the assumed value of the unknown quantity is too great. If the result obtained is smaller than the sum of the known values, the assumed value for the unknown quantity is too small. By thus adjusting the value of the unknown quantity until the left-hand member of the equation with the assumed value of the unknown quantity will just equal the known quantities on the right-hand side of the equals sign, the correct value of the unknown quantity may be determined.

MOMENT OF INERTIA OF A RECTANGLE

S. W.—Will you please explain how $\frac{bd^3}{12}$ is equal to the moment of inertia of a rectangle?

A.—Referring to the illustration, let *MNPQ* be a rectangle with a breadth *b* and a depth (altitude) *d*, and suppose the rectangle to turn, or tend to turn, about *X'X* as an axis, *X'X* passing through the center of gravity. By definition, the moment of inertia *I* is the sum of the products obtained by multiplying each elementary area by the square of its distance from the axis. Let *p* be a differential area—a square the sides of which are *dx* and *dy*, the coordinates of the center being *x* and *y*; then, by the definition, $I = \int_{-\frac{d}{2}}^{\frac{d}{2}}\int_0^b y^2dydx = \frac{bd^3}{12}$.

Weisbach gives a demonstration without the use of the calculus, substantially as follows: Let *AB* be a narrow strip cut off by two vertical lines; draw two horizontal lines cutting off from the strip the small rectangle *C*, the center of which is at a distance *z* from *X'X*. Dividing the entire strip in this manner,

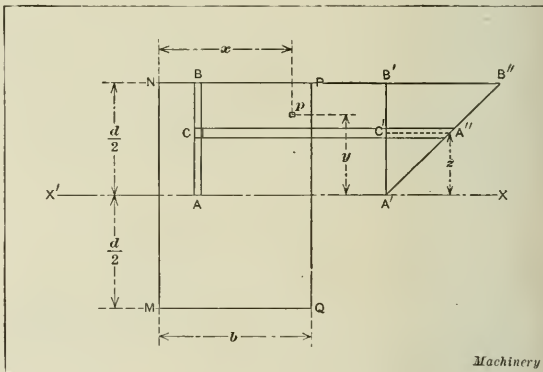


Diagram showing how Moment of Inertia of Rectangle is found

the moment of inertia of the strip is $I = a_1z_1^2 + a_2z_2^2 + a_3z_3^2 +$ etc. $= a_1z_1\times z_1 + a_2z_2\times z_2 + a_3z_3\times z_3 +$ etc., in which a_1, a_2, a_3, etc., are the areas of the small rectangles and z_1, z_2, z_3, etc., are the distances of their centers from *X'X*. Produce *NP* to *B''*, draw *A'B'* perpendicular to *X'X*, lay off $B'B'' = A'B' = AB$, and draw *A'B''*; then $A''C' = AC = z$. The product *az* may be regarded as the volume of a prism with the base *a* and the altitude $C'A'' = z$; and the moment of the prism with respect to *X'X* is $az\times z$. The sum of all these small prisms is a triangular prism, the base of which is *A'B'B''* and the altitude is the width of the strip $AB = b'$. The volume of this prism is $1/2b'\times A'B'\times B'B'' = 1/2b'\left(\frac{d}{2}\right)^2 = 1/8b'd^2$. The distance of the center of gravity from $X'X = 2/3A'B' = 2/3\times 1/2d = 1/3d$. The moment of this volume is $1/8b'd^2\times 1/3d = \frac{b'd^3}{24}$. Since this last expression is equal to the expression for *I* that was obtained above, the moment of inertia of the strip is $\frac{b'd^3}{24}$. Since the sum of the strips is one-half the area of the rectangle, the moment of inertia for one-half the rectangle is $I = \frac{bd^3}{24}$, and for the whole rectangle, $I = 2\times\frac{bd^3}{24} = \frac{bd^3}{12}$. J. J.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

ANDERSON VERTICAL TAPPING MACHINE

In working out the design of a vertical tapping machine which has recently been placed on the market by the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn., provision has been made for varying the cutting speed without affecting the time per operation, *i. e.*, to have the reverse speed compensate for a slow cutting speed, and to apply an efficient motor drive in such a manner that practically the full amount of power is transmitted to the tap. This high driving efficiency is obtained by direct connection between the motor and spindle and by the use of S.K.F. ball bearings, the combination being such that it is possible to run the machine on an electric lighting service wire without undue disturbance.

The spindle is made of high-carbon steel, turned and ground to size, and S.K.F. radial ball bearings are used at both the top and bottom. In each case the inner ball race, in which the spindle moves endwise, has been increased in length by forcing into it a sleeve 1½ inch long, which is made from high-carbon steel and accurately fitted to the spindle. Spindle frictions have been designed to secure good results, and owing to the spherically faced disk on which these operate, tendency to slip has been eliminated. The face of the friction driving disk is spherical, and this disk is mounted on the armature shaft of the motor, thus eliminating the use of intermediate transmission mechanism. A spring at the upper end of the spindle can be adjusted to counterbalance the spindle weight, and this spring is enclosed to eliminate chance of accidents. The motor is of standard design, having two special brackets or lugs for attachment to the machine, so that any specified motor may be employed, provided it does not exceed 6 inches in diameter. This allows the purchaser to make his own selection.

Fig. 1. Anderson Vertical Tapping Machine on which Decrease in Forward Speed is compensated for by increasing Reverse Speed to maintain Constant Rate of Production

A circular work table is provided which is 7 inches in diameter and has a movement of 1¾ inch on two way-rods, spaced far enough apart to insure rigidity and give an easy movement. Adjustment of 3 inches is provided for the way-rods and table, giving ample space between the chuck and table for a fixture and lugs. A spring under the table can be adjusted to counterbalance the weight, thus making movement to and from the tap very sensitive, which is a valuable feature where small taps are used. A foot-treadle is provided for operating the table, and this can be easily removed by simply loosening one screw. The connection from the floor to the machine is adjustable, and is provided with a safety spring so that the lead of the tap cannot be disturbed by sudden application of pressure on the treadle.

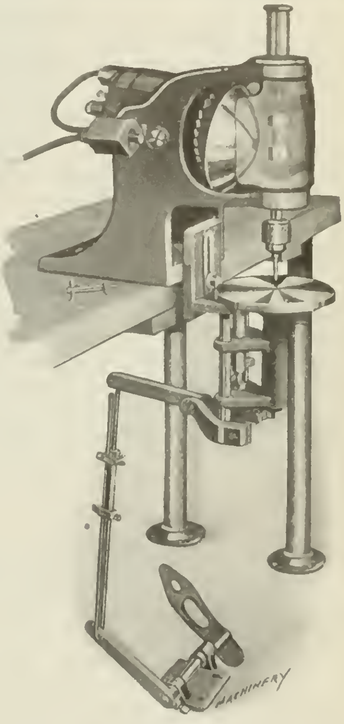


Fig. 2. View of Anderson Tapping Machine, showing Treadle and Springs to take up Inequality of Foot Pressure and counterbalance Weight

The column or body which supports the table is hollow to provide a chamber that can be filled with oil, so that when tapping work where the tap can go through it will dip into the oil, which results in lubricating the tap and washing off the chips so that they will not injure the thread when the tool is backed out. As the chamber becomes filled with chips, the oil level is maintained until exhausted or displaced by chips, and the chips can be removed by taking out the plug at the bottom of the chamber.

The motor is pivoted in the frame of the machine at the center of the spherical face of the friction driving disk which, it will be recalled, is mounted on the armature shaft. By tilting the motor, various cutting and return speeds may be secured. It will be evident that if the speed is reduced in either direction, it will be increased in the opposite direction. For instance, if the motor is so placed that the spindle runs at the same speed in both directions, say 1000 revolutions per minute, this gives a combined figure of 2000. The motor can then be changed to secure a speed of, say, 500 revolutions per minute in the forward direction and a reverse movement at the rate of 1500 revolutions per minute, thus maintaining the same combined figure. With one type of motor commonly used on these machines, two amperes of current are used at 110 volts, making the cost of power per hour, at six cents per K.W.H., 0.0132 cent. A switch of special design, a reinforced cord and attachment plug, and the necessary wrenches for

making all adjustments form part of the regular equipment.

Chucks may be furnished of the form shown in the illustrations, but unless otherwise specified, the machine is regularly equipped with a two-jawed positive drive chuck, which is considered best for general classes of work. Guards are provided to protect operators from injury and to prevent oil from being thrown. The principal dimensions of the machine are as follows: distance from spindle center to slide, 4 inches; diameter of spindle, 3/4 inch; diameter of table, 7 inches; maximum vertical adjustment of table, 3 inches; and weight of machine, 115 pounds net. The capacity of the machine is for tapping holes in cast iron from 1/16 to 1/4 inch in diameter, and for tapping holes in steel from 1/16 to 3/16 inch in diameter; and holes up to 1½ inch in depth may be tapped for all classes of work.

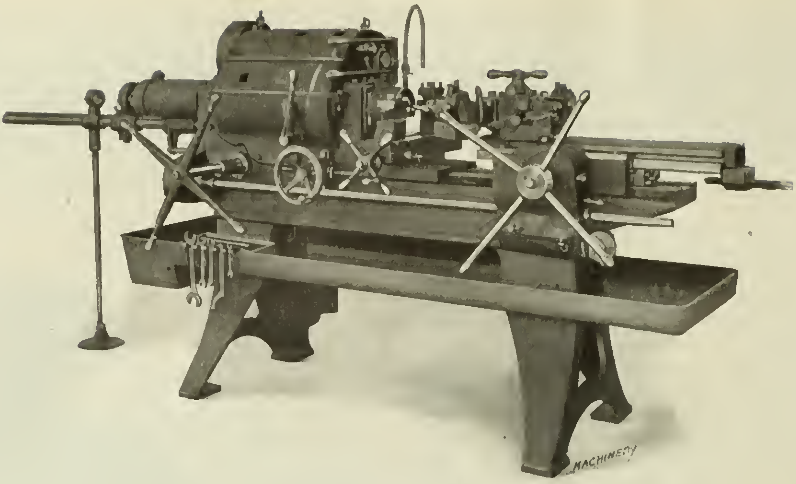


Fig. 1. Foster No. 5 Screw Machine with All-geared Head and Bar Equipment

TOOL EQUIPMENT FOR FOSTER NO. 5 SCREW MACHINE

The efficiency and productive capacity of a screw machine depend to a large extent on the quality of the tools employed. Not only can the production on what is commonly regarded as screw machine work in its narrow sense be increased to a considerable extent by the use of better designed and more rigid tools, but by means of additional equipment, the range of work which can be handled to advantage on the screw machine can be greatly widened and be made to include almost all kinds of chucking work.

The Foster Machine Co., Elkhart, Ind., has designed and is now building a complete new line of tools for the No. 5 screw machine. This machine has recently undergone several changes of design, and is now being built in two different styles, *viz.*, the back-geared cone head type and the all-geared head type. The latter is illustrated in Fig. 1, and the new bar equipment is shown mounted in place.

Bar Tools

Perhaps the most widely used of all screw machine tools is the one that is commonly known as a roughing box-tool or single cutter turner, a new design of which is shown at *A*. Two features of this tool that stand out prominently are its extreme rigidity and convenience of operation. As shown, the cutter is held in a manner to insure maximum economy of high-speed steel. The two roll jaws are independently adjustable and rigidly secured to the tool body by means of a bolt, the body being split for this purpose. The cutter-slide is equipped with a release to prevent marring the work when withdrawing the tool, which is operated by means of the bent handle in front of the tool. This handle also serves the purpose of binding the cutter-slide rigidly to the tool body. For convenience of setting, the slide operating screw is equipped with a graduated dial.

The multiple cutter turner shown at *B* is also noteworthy for its rigidity. This tool is shown equipped with two double tool-holders, enabling four cuts to be taken simultaneously, and one roller back-rest. The tool can, however, be equipped with three double tool-holders for taking six cuts simultaneously, and two roller back-rests. One important feature of this tool is that shoulders only ¼ inch apart can be turned with it. The pointing tool *C* is different from the two former tools in that it is provided with a shank for holding in the turret holes. The roller back-rest jaws are independently adjustable and interchangeable with those of the single cutter and the multiple cutter turners. In addition to the pointing cutter, tool *C* is designed to carry a centering drill. At *D* is shown a new design of adjustable hollow-mill. This is a cheap tool of great rigidity, and can be used to advantage on short work where much stock is to be removed rapidly.

Miscellaneous Tool-holders and Adapters

Simplicity of design and rigidity were striven for in designing the center drilling tool *E* and the knurling tool *F*.

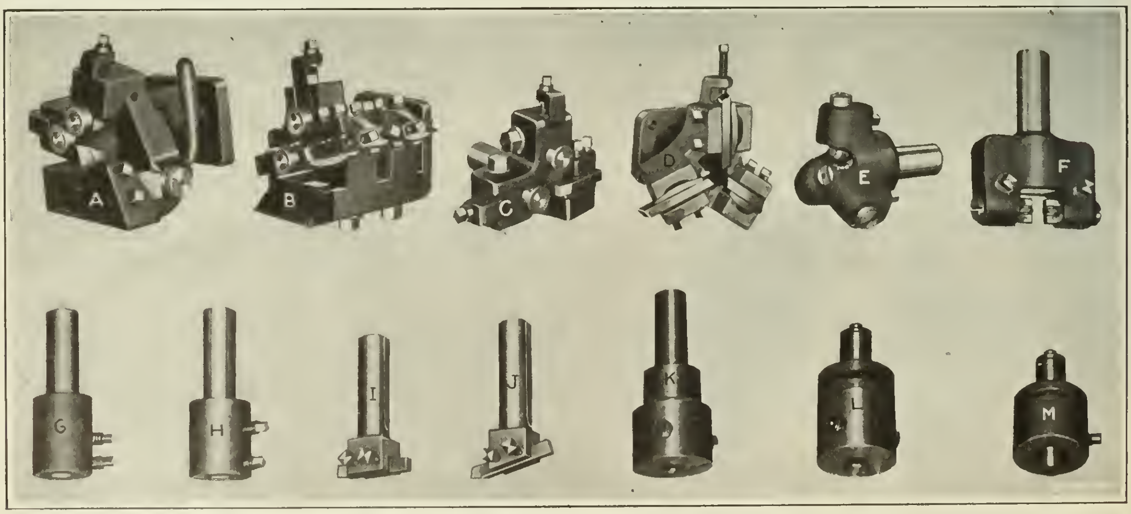


Fig. 2. A, Roughing Box-tool; B, Multiple Cutter Turner; C, Pointing Tool; D, Adjustable Hollow-mill; E, Center Drilling Tool; F, Knurling Tool; G to J, Tool-holders; K, Drill-holder; L, Tap-holder; M, Die-holder

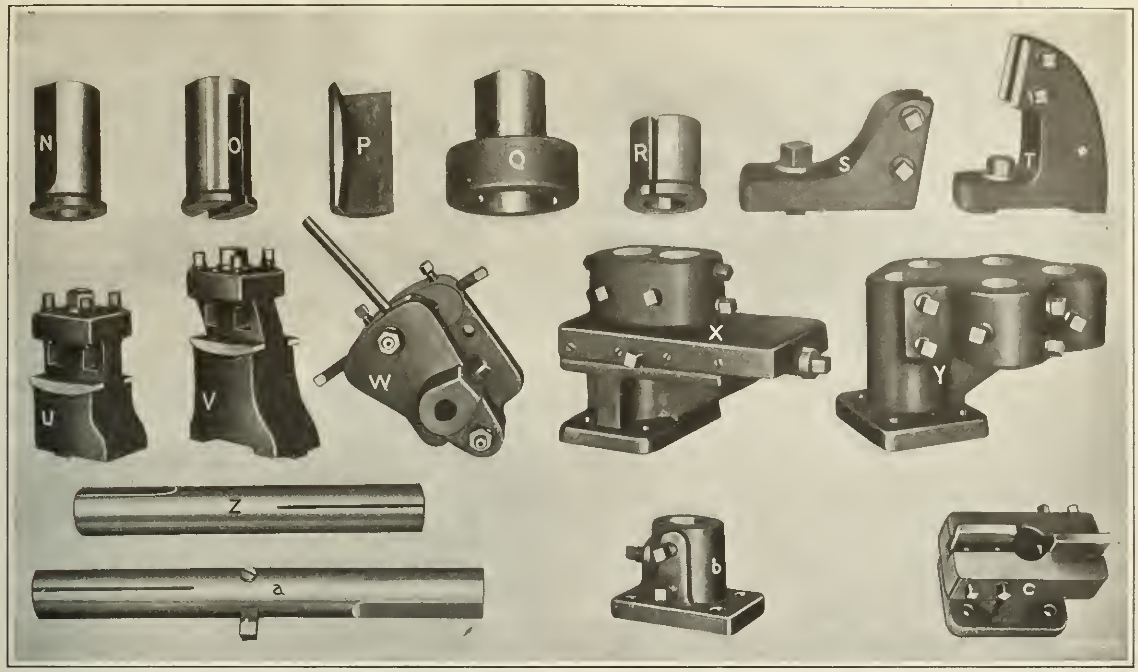


Fig. 3. N to R, Adapters; S and T, Forming Tool-holders; U and V, Double Tool-holders; W, Recessing and Back-facing Tool; X, Tool-slide for Use in recessing and back-facing; Y, Multiple Turning Head; Z, Pilot Bar; a, Boring-bar; b, Adapter; c, Facing Tool

The working principles of these tools can be readily comprehended by reference to the illustrations. From *G* to *J* are shown the tool- and cutter-holders that go with the equipment, and attention is called to the holder *G* that has a floating device which compensates for any error of alignment between the hole in the work and the center of the turret, thus preventing the reamer or other tool carried in it from cutting over size. The drill-, tap-, and die-holders, *K* to *M*, inclusive, are of standard and approved design. The spring die adapter *Q*, Fig. 3, is made to fit die-holder *M*, and adapters *N* to *R* are made to fit any of the tool-holders and also the turret hole.

Tool-holders for Cut-off Slide

The four holders *S* to *V* are furnished in addition to the regular cut-off slide tool-holders provided with all standard screw machines. The two forming tool-holders, one for the front and one for the rear, are of the dovetail type, and are split for the purpose of clamping the forming tool to the holders by means of two screws on the side. The double holders enable two cuts to be taken or two shoulders to be necked simultaneously, and are equipped with rocker wedges for adjusting the height of the cutter point.

Chucking Tools

Chucking work, as a rule, is not considered to fall within the scope of work for which the screw machine is peculiarly adapted. However, with a three-jaw scroll chuck and a complete line of chucking tools, a large and varied range of work belonging to this general class can be handled to advantage in small as well as large lots. The tool shown at *W* has been found to be peculiarly well adapted for recessing, back-facing and also for boring work in small quantities. The tool-carrying member swings around a pivot underneath the cutter and is operated by a handle. The two radial screws seen in the illustration provide adjustment and also act as stops for gaging the depth of cut. The tool-slide *X* is intended for the same general type of work, but is more rigid and has a much larger range of work; it can be used to advantage for back-facing hubs of gears and similar operations.

The multiple turning head *Y* is intended for the general run of turning and facing work. A pilot bar *Z*, carried in the center hole of the turning head, runs in a bushing held in the spindle and supports the tool against chatter. The cutter-holders *I* and *J* are primarily intended for use in this turning head. For simultaneously boring and turning, a boring-bar *a* can be held in the center hole and brought into action at the same time as a cutter-holder held in either of the other holes. The holder *b* is for adapting either of the tool-holders or the boring-bar to the turret. By means of the rocker adapter and the two set-screws on the top of the holder, a forged cutter can be adapted to the holder and adjusted for diameter.

ANDERSON DIE FORMING MACHINE

In the October, 1915, number of MACHINERY a description was published of the die forming machine which had just been placed on the market at that time by the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn. It will be recalled that the machine described at that time was equipped with electric motor drive. Recently this firm has introduced a belt-driven machine of essentially the same design to meet the requirements of shops in which electric power is not available, or where for any reason belt drive is preferred.

MOORE & WHITE HIGH-SPEED FRICTION CLUTCH

With the growing use of anti-friction lineshaft hangers and of machine tools designed for high-speed steel tools, there has come a general tendency to use higher speeds for factory shafting. Aside from metal working machinery, other machinery, such as grinding and polishing machines, wood-working machines, fans and electric motor drives, have always called for high speeds; and the necessity of having friction clutches especially adapted to high-speed conditions has become apparent. The clutch here shown was especially designed for speeds at which the ordinary wood block type of friction clutch will not operate successfully. It is of the metal-to-metal type, having bronze disks alternating with cast-iron. The disks are lubricated, but do not run in an oil bath. They are fully enclosed, and all important parts are machined all over so that the clutch is perfectly balanced. The engaging mechanism is such that there is no tendency to grab or drag when the clutch is released. A very accurate adjustment can be had.

This clutch is made in loose pulley and cut-off coupling types. From the following description of the loose pulley type, the cut-off coupling type will be understood. In the sectional view, Fig. 3, hub *A* is keyed to the shaft and drives or is

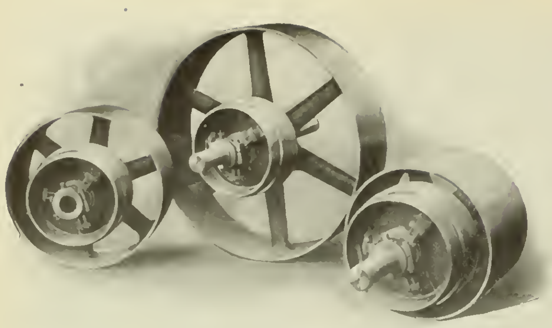


Fig. 1. High-speed Friction Clutch Pulleys equipped with Moore & White Clutches

driven by the cast-iron disks *B* through a series of pins *C*, which slidably connect the hub and the follower *D*. This follower is bored to pass over lugs cast on the pulley sleeve *E*. Between the hub and follower is a threaded adjusting ring *F*. The operating levers *G* and *H* are attached to the hub, and act against the adjusting ring when the spool *I* is forced into the position shown. The adjusting ring is thus forced to the right, carrying with it the follower, and the hub is forced to the left, thereby engaging the disks.

The bronze disks *J* are slotted and slide on the lugs of sleeve *E*, thereby communicating power to the latter. Springs *K* free the disks when the clutch is released. Sleeve *E*, carrying the loose pulley, runs on the divided bronze bushing *L*, which

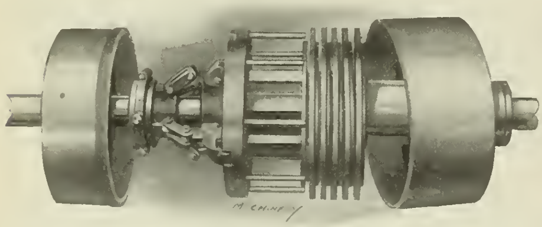


Fig. 2. Moore & White 21-inch High-speed Friction Clutch Pulley partially disassembled

is keyed to the shaft and grooved to distribute oil. The central space holds oil, and feeds it by gravity to the running surface as long as any remains. The oil retaining collar *M* is attached to the sleeve, not to the shaft, and is therefore not affected by centrifugal force. This lubricating arrangement is of the utmost importance at high speeds, as it holds the oil where it belongs and protects both the running surfaces and surrounding objects which might be damaged by flying oil. In the cut-off coupling the extended sleeve is omitted and a small bushing is used to hold the two shaft ends in line.

The clutch is made in sizes from 5 to 25 inches diameter of bronze disks. Each size has from one to six disks, according to the capacity desired. The smallest size can be run up

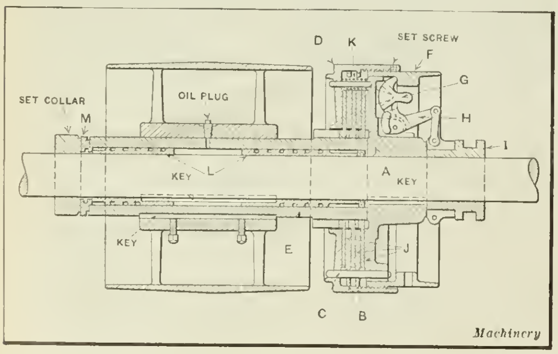


Fig. 3. Sectional View of Moore & White High-speed Friction Clutch

to 3000 revolutions per minute and the largest size up to 750 revolutions per minute. Powers transmitted are up to 630 horsepower. In sizes from 5 to 13 inches the clutches can be fitted directly on an extended hub of the pulley, gear or other member. These clutches are recommended for use with alternating-current motors when required to start under load, also for group drives to high-speed machinery and individual drives to wood-working and other heavy high-speed machines. They are made by the Moore & White Co., 2707-2737 N. 15th St., Philadelphia, Pa.

QUICK-OPERATING CUTTER

When it is necessary to make an additional hole in a cabinet to accommodate a piece of conduit or to make a hole in a

Fig. 1. Arrangement of Chuck, Feed Spring and Ratchet Wrench

metal locker or to do other work of this kind, considerable trouble is often experienced in finding a tool that will handle the job satisfactorily. Recently a tool has been developed for this purpose that can be used for cutting all sorts of metal, fiber and slate, and it can be adjusted to cut holes of various sizes with little effort and at high speed. To use this tool it

Fig. 2. Flanged Nut secured to Stud on Inside of Plate to be bored

is merely necessary to first drill a hole through the material in order to provide space for a stud on the end of which a flanged nut is secured. Then a few turns of a ratchet wrench results in cutting out a neat hole. An idea of the rate at which work can be done will be gathered from the fact that during a recently conducted test a hole was cut in the wall of a standard conduit cut-out box (about 0.1 inch thick) by

fourteen revolutions of the cutter, and the entire job was completed in less than a minute.

The accompanying illustrations show one of the uses of this tool, and in this connection it may be mentioned that the knives may be adjusted for cutting holes of various diameters. The knives are held in a chuck and are automatically fed to the work by means of a spring located between the chuck and nut. This device does the work of a drill press, and it is particularly useful in many cases because the tool can be taken to the work instead of requiring the work to be carried to a machine. In cutting holes in tanks and similar places where the flanged nut cannot be secured to the stud on the inside, it is merely necessary to tap the pilot hole and screw the stud into this hole. The uses mentioned are only a few of the applications which can be made of this tool. It is made by the Universal Mfg. Co., Stroh Industrial Bldg., Milwaukee, Wis.

WOOD & SAFFORD CYLINDER GRINDER

For use in regrinding the cylinders of automobile engines and small traction engines, the Wood & Safford Machine

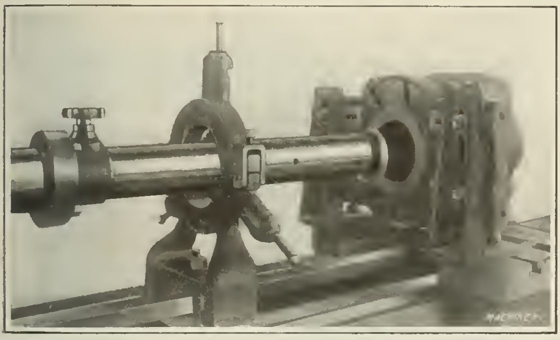


Fig. 1. "Perfection" Cylinder Grinder made by Wood & Safford Machine Works for Use on Engine Lathe

Works, Great Falls, Mont., have developed a cylinder grinding attachment known as the "Perfection" cylinder grinder, which can be used on any ordinary engine lathe having a hollow spindle and a swing of not less than 14 inches. This attachment consists of a grinding wheel carriage or spindle mounted on the lathe spindle in place of a chuck; one adjustable angle-plate; two angle-plate supports, which can be adjusted to fit any size of lathe, these supports being mounted on the front end of the carriage; one centering device for locating the cylinder on the angle-plate in a position central with the grinding bar; one countershaft; five carborundum wheels; one diamond wheel dresser; and the necessary clamps and cap-screws for fastening the cylinders to the angle-plate. The capacity of this grinding attachment is for cylinders from 3¼ to 6½ inches in diameter, and an extension may also be provided for regrinding cylinders from 1½ to 3¼ inches in diameter, such as those in motorcycle engines.

One of the most important features of this outfit is the

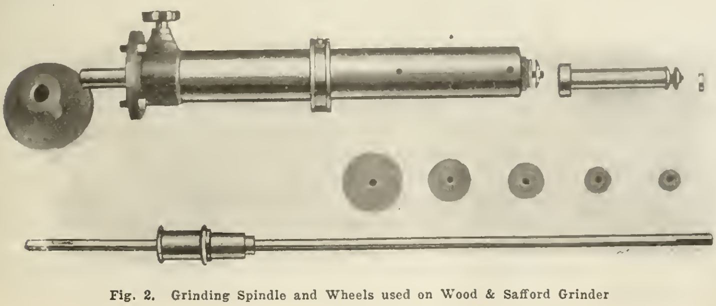


Fig. 2. Grinding Spindle and Wheels used on Wood & Safford Grinder

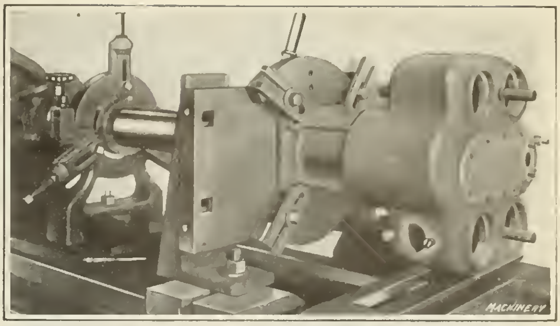


Fig. 3. Cylinder secured in Place on Angle-plate ready to be ground

micrometer attachment for enabling the operator to adjust the grinding wheel to within 0.0005 inch of the desired position. To attach the grinding spindle to a lathe for the first time it will be necessary to machine the rough flange casting to fit the lathe spindle where the faceplate or chuck is screwed on; also it will be necessary to machine the cast-iron bushing which fits into the outer end of the hollow spindle. After this has been done, it is an easy matter to set the attachment up ready for use.

The grinding spindle is made of steel tubing and holds one quart of oil. This spindle is fitted with an adjustable tapered bearing. The grinding wheel is located ⅞ inch off center, thus giving the wheel a planetary motion on a circle 1¾ inch in diameter. The angle-plate that supports the cylinder block is made of reinforced cast iron, and a hole in the center of this plate is 6⅜ inches in diameter with a 5-inch cast-iron bushing. The centering device fits in this bushing, enabling the cylinder to be located in the correct position relative to the grinding wheel before the work is clamped to the angle-plate.

GEOMETRIC THREADING MACHINE

The Geometric Tool Co., New Haven, Conn., is now making a smaller size of the threading machine of its manufacture which is well known to the machinery trade. Formerly the

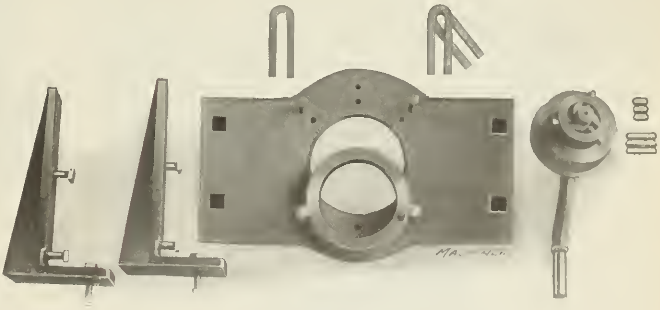


Fig. 4. Angle-plate, Clamps, etc., for holding Work on Machine ready for grinding

smallest size in which this machine was built was a nominal ¾-inch size, with a capacity for handling threading operations on pipe from ¼ to ¾ inch in diameter. The new machine is known as a ½-inch size, and may be used for threading ⅛-, ¼-, ⅜- and ½-inch pipe.

HIGH-SPEED RIVETING MACHINE

The No. 3A heavy-duty riveting machine illustrated and described herewith has recently been placed on the market by the High-Speed Hammer Co., Rochester, N. Y. It is essentially adapted for miscellaneous riveting operations in automobile factories where there are numerous jobs which come within the range of this machine, which is for handling rivets from 1/4 to 7/16 inch in

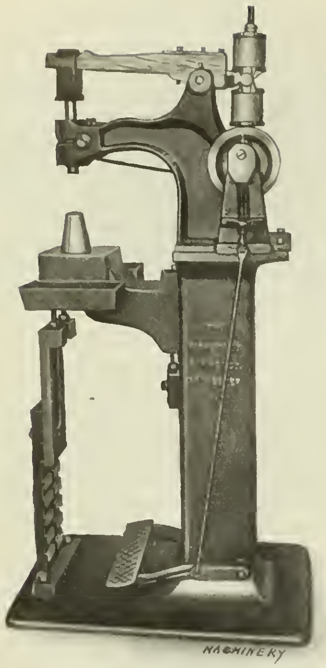


Fig. 1. High-speed No. 3A Heavy-duty Riveting Machine

diameter. The adjustable supporting column for the table is one of the important features of this machine, and the same device is now used on other machines built by the High-Speed Hammer Co. It will be seen that this support is made in two parts, adjustment for fixed distances being made by loosening one screw and then raising or lowering the upper member of the support so that it engages the next notch on the lower member. The binding screw is then tightened, after which fine adjustment is obtainable by manipulating the screws in the upper member which engage with the table.

These riveting machines are of the so-called "elastic blow" type, being provided with two heavy rubber bumpers at the rear of the machine and a third bumper placed between the hammer head and the helve. The shock of rebound is absorbed by the hickory helve. The construction of the clutch is such that the number of blows may be varied from the maximum to any lesser number by simply varying the pressure of the foot on an operating treadle. This is easily accomplished by a simple friction drive clutch which is employed in place of a positive clutch. Phosphor-bronze bushings are used in all bearings throughout the machine, and drive to the hammer is provided by a worm, worm-wheel and round belt. This machine has a gap 18 inches deep by 8 inches high, and the capacity is for handling rivets from 1/4 to 7/16 inch in diameter. It is recommended that the hammer be driven at from 1600 to 1700 revolutions per minute. The floor space occupied is 15 by 26 inches, and the net weight of the machine is 470 pounds.

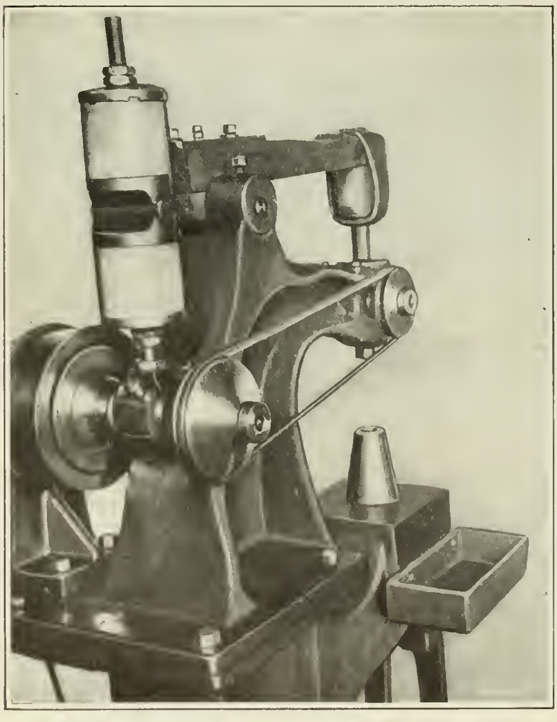
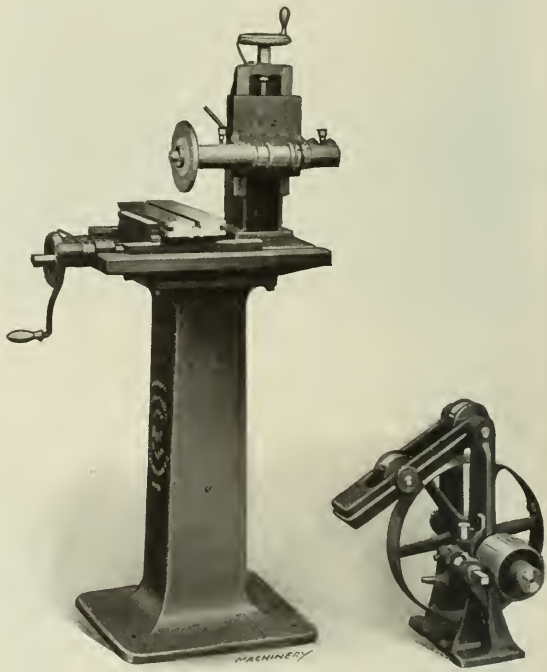


Fig. 2. Close View of Opposite Side of High-speed Riveting Machine

AMERICAN NO. 1 SURFACE GRINDER

The American Machine Tool Co., Hackettstown, N. J., is now building the No. 1 surface grinder shown in the accompanying illustration. This grinder is designed for doing accurate work on dies, punches, gages and small machine parts, being heavily constructed to insure rigidity and accuracy of the product. All sliding surfaces are provided with adjustable gibs, and the handwheels on the traverse feed and elevating screws are each provided with an indicator and graduated to 0.001 inch, thus affording means of making fine adjustments in all directions.

The table is moved endwise by a crank fitted to the square end of a shaft operating a pinion which, in turn, meshes with a rack on the bottom of the table. This gives a rapid, easy movement without tendency to bind; and the crank can be easily removed and used on the square shaft in front of the handwheel on the traverse feed if faster movement is desired. The spindle slide works on a rigid upright provided with scraped ways, and the spindle is made of crucible steel, accurately ground and fitted in scraped bearings. There are no caps to work loose and cause vibration, as both bearings are cast solid, the front bearing being tapered to fit the spindle and the rear bearing solid but split on one side to provide means of compensating for wear. The spindle is provided with take-up nuts for adjusting end play and wear.



No. 1 Surface Grinder built by American Machine Tool Co.

There is only one pulley on this grinder, which is the arbor pulley. As shown, the countershaft is in an inverted position. It is provided with a tightener which always maintains the required belt tension, and the shifter rod is always in a perpendicular position. There is no weight on the belt to cause it to shift off the pulley, and a simple twist of the rod suffices to shift the belt. The regular equipment furnished

with the grinder includes a set of wrenches and one emery wheel.

The principal dimensions of this machine are as follows: capacity for surface grinding operations on work 9 by 6 by 5 inches in size; maximum traverse of table, 9½ inches; size of front spindle bearing, 1¼ by 5 inches; size of rear spindle bearing, ⅞ by 2¾ inches; length of feed handle, 7 inches; size of emery wheel, 6 inches diameter by ⅜ inch face width; height from floor to top of table, 36½ inches; size of table, 15 by 5 inches; adjustment of table in line with spindle, 6 inches; spindle adjustment above table, 1 to 7½ inches; height from floor to top of handwheel on raising screw, 51½ inches; floor space occupied, 27 by 23 inches; and weight of machine, about 500 pounds.

SOUTHWARK SCRAP RECLAIMING PRESS

For reclaiming scrap material and repairing steel cars, the Southwark Foundry & Machine Co., Philadelphia, Pa., is now building the Southwark-Gross press illustrated and described herewith. Adoption of all-steel equipment in railroad rolling stock created a demand for a press to be used in reclaiming from the scrap heap bent and damaged parts of wrecked cars,

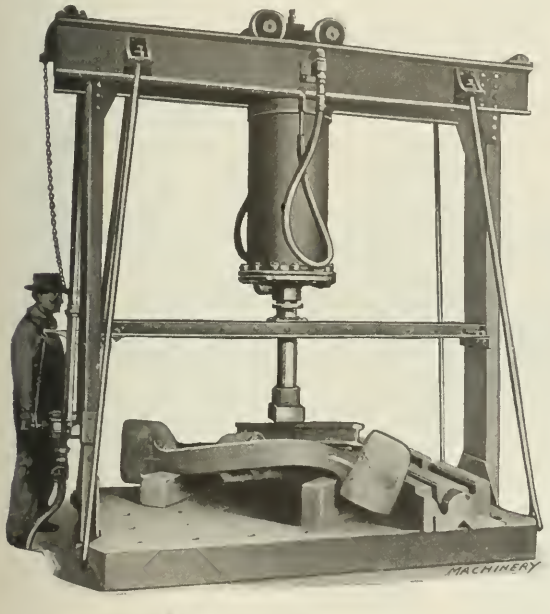


Fig. 1. Straightening a Bent Truck Frame on Southwark-Gross Press

and for various other pressing operations in railroad repair shops. Its use is not in any way confined to railroad work, however, as the press is suitable for various miscellaneous pressing operations.

The base of the Southwark-Gross press is a heavy steel casting with a flat surface which forms a foundation for the structural steel frame that consists of two steel uprights supporting a main cross frame. The top of this frame is braced by heavy tie-rods attached to the four corners of the base. Provision is made for suspending the cylinder from the cross frame by means of a four-wheeled carriage, and travel of the ram is controlled by means of a balanced type four-way valve located in a position convenient for the operator. The carriage is moved back and forth across the top frame by an endless chain traveling over sprockets. A piston-rod guide is supported between two angle-irons fastened to the vertical columns. The piston is 20 inches in diameter and has a maximum stroke of 36 inches; it is packed with leather cup packing, which can be quickly renewed when necessary. The die is fitted to the end of the piston-rod, and can be changed in the same way that dies are changed on a steam hammer.

Air is supplied to the double-acting cylinder by a flexible hose connection of sufficient length to permit free movement of the cylinder as it travels across the table. For straightening bent truck frames, center and side sills, side sheets, channels, angles, truss rods, etc., this new press will be found to effect a great saving in time and labor; it is also convenient for forming hopper sheets, bending guard rails and other work required by locomotive and car maintenance-of-way departments. In most cases work requiring bending or straightening can be handled cold, but in certain instances where extra-heavy work is being handled it is safer to heat the metal before subjecting it to a pressure of fifteen tons, which is the capacity of this press. An attempt to bend such work cold is likely to result in cracking the metal, but with modern means of welding, such as the oxy-acetylene process and similar methods, cracks of this kind are not serious, as repairs may be made very quickly, and the repair has a strength practically equal to that of the original metal. The principal dimensions are as follows: size of base platen, 5 by 8 feet; bore of pressure cylinder, 20 inches; length of stroke of piston, 36 inches; diameter of piston-rod, 4⅞ inches; size of air hose, 1¼ inch; clear height under die, 36 inches; and pressure capacity for an air pressure of 100 pounds per square inch, 15 tons.

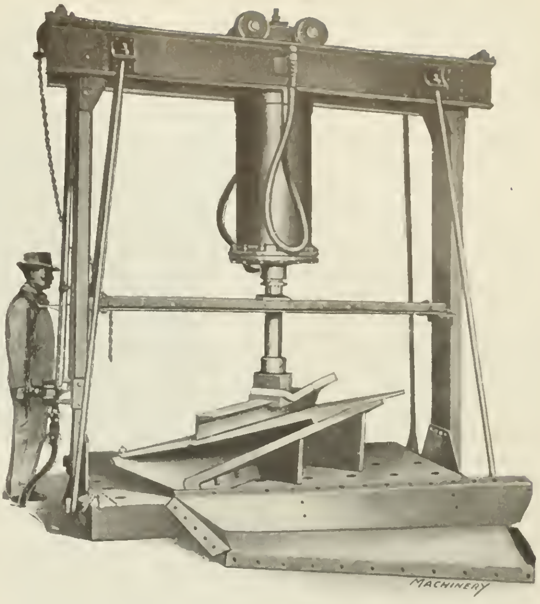
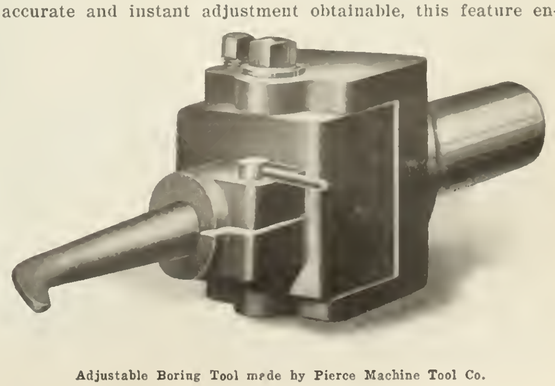


Fig. 2. Use of Southwark-Gross Press for Performance of Forming Operations

PIERCE ADJUSTABLE BORING TOOL

The accompanying illustration shows the Pierce adjustable boring tool designed for general boring operations, the work being done with a forged tool having a shank ½ inch in diameter. One of the important features of this tool is the accurate and instant adjustment obtainable, this feature en-



Adjustable Boring Tool mede by Pierce Machine Tool Co.

abling maximum production to be obtained from both the tool and machine. The absolute rigidity of the tool enables it to be used for the most accurate classes of work. The clamping arrangement is positive, and the tool is easily adjusted to the required size. In adjusting, it is merely necessary to loosen the collar screw and make the required adjustment of a set-screw the point of which seats on an incline, forcing the adjustable swivel block outward and thus moving the cutting tool to the required position. The finest adjustment can be quickly made by this means.

The cutting point is always central and on the correct line when boring, regardless of any adjustments for size that may have been made; consequently, it is unnecessary to change the cutting point to suit the adjustment of the tool. The cutting tool is quickly clamped in position by a convenient lever which insures instant and positive grip and eliminates the use of wrenches. The standard shank furnished on this tool is 1 inch in diameter, but any desired shank can be made to order. This tool is manufactured by the Pierce Machine Tool Co., 617 W. Jackson Blvd., Chicago, Ill.

SOUTHWARK UNIVERSAL FLUE WELDER

The Southwark Foundry & Machine Co., Philadelphia, Pa., is now building the universal flue welder illustrated and described herewith. In working out the design, particular attention has been paid to the provision of the essential features required to meet conditions which have arisen in flue welding since the general adoption of the locomotive superheater. A clamping head at the front and driving mechanism at the back are the two main parts of this machine. The clamping head is made from one circular shaped casting with four air cylinders mounted on the inside. Metal snap rings are provided on the pistons instead of the cup leather type; and the front ends of the piston-rods are equipped with sectional dies which clamp the outside of the flue at the line of weld.

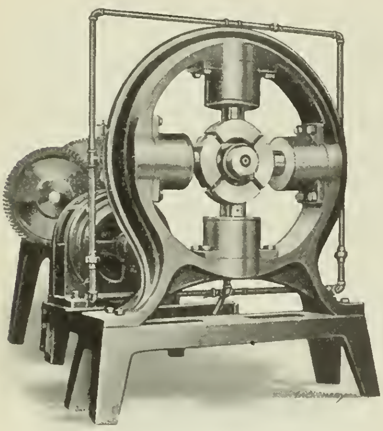


Fig. 1. Front View of Southwark Universal Flue Welder, showing Clamping Head

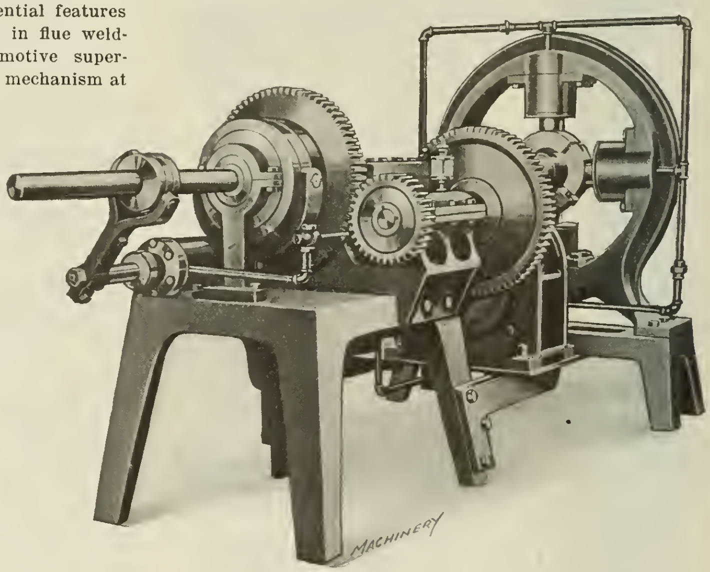


Fig. 2. Three-quarter View of Southwark Flue Welder from Opposite End, showing Driving Mechanism

Piped up to a single air line, the cylinders operate simultaneously with the opening of the valve. Running through the center of this head longitudinally is a welding mandrel which fits inside of the flue. Four rollers are assembled in the body of this mandrel, which is hollow. These rollers can be moved radially by a tapered mandrel which reaches through the middle of the spindle from the back end of the machine. This mandrel is operated by an air cylinder that is also controlled by the main foot valve. The main mandrel is driven through two gear reductions from a 1½-horsepower motor.

An adjustable platform in front of the welder head, which supports the welding furnace, permits the proper location of different lengths of "safe ends"; and a cast-iron tank or water-back protects the welding head from the excessive heat of the furnace. The size of the mandrel back of the welding rollers approximates the inside diameter of the flue. This supports the weight of the safe end while being heated and moved to the welding position, thus preventing loss due to dropping of the safe end. Standing away from the furnace, the operator uses a foot valve which controls the entire operation of the welder, the piping being so arranged that the clamping heads close in on the outside diameter of the flue before the taper mandrel expands the rolls to provide for making the weld. It is customary to rig up the front end of the machine with some type of roller table to support long flues. With this equipment a crew can easily weld 120 superheater flues in a day.

FORD-SMITH HEAVY-DUTY GRINDER

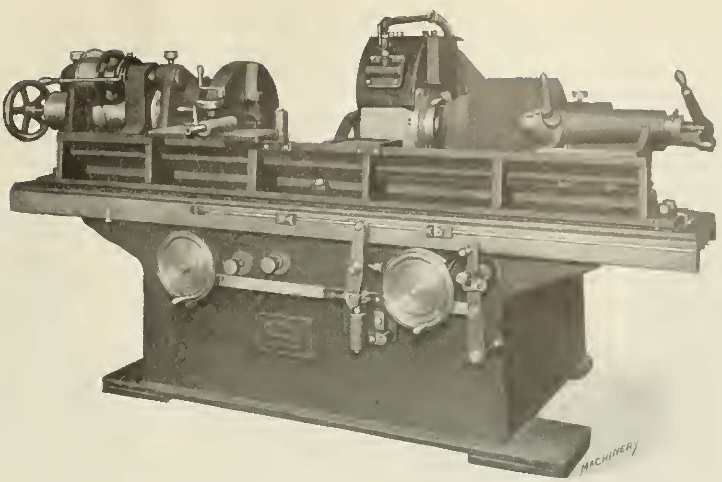
The Ford-Smith Machine Co., Ltd., corner Princess and Earl Sts., Hamilton, Ont., Canada, has recently placed on the market a combination traverse and form grinder which is adapted for both standard and special cylindrical grinding. While this machine is designed for standard cylindrical work, the headstock is so arranged that any special requirements can be easily met. This machine has recently proved very successful in grinding large punches used in the manufacture of shrapnel and high-explosive shell forgings. These punches range from 3 to 6 inches in diameter, and vary in length from 2 to 5 feet.

In grinding a shell forging punch the threaded end and parallel part of the punch pass into the hollow spindle and are gripped in the chuck with the formed end out; this end is then ground with a wide form wheel to exactly the required shape. As many as are required are thus ground. The punch is then put on centers, the formed end running in a ball bearing cup center. The form wheel (on a special wheel center) is then removed and a 22- by 2½-inch traverse wheel substituted, after which the punch is ground parallel, as in a regular traverse grinder. Worn punches can thus be kept in repair at small expense, as the necessity of annealing and rehardening is eliminated. Saving in this direction and through the production of better forgings quickly pays for the equipment. This work indicates the line of usefulness of a grinder built heavily enough to carry form wheels up to 8-inch face and equipped with a hollow spindle to allow gripping the work close up, having, in addition, the usual cylindrical traverse grinding features.

The headstock, as stated before, can be arranged to suit any requirements desired. The work is held by means of a universal chuck, together with a special interior centering arrangement inside the hollow spindle. Numerous changes of speeds and feeds are provided, all levers being situated at the

front of the machine within reach of the operator. The wheels used are 22 inches in diameter by whatever width is required for the work to be ground. A special truing device is attached to the machine table, making it an easy matter to keep the wheel in first-class shape. Water is supplied to the wheel by a pump of ample capacity at the rear of the machine, from a tank cast on the bed.

Careful attention has been paid to the design of the wheel hood, which is both convenient in use and also in changing wheels. The drive is self-contained, and the machine may be direct-connected to a motor or driven from the lineshaft, as required. This machine has a large capacity, swinging 18 inches by 5 feet between centers, with adjustment for taper grinding. It has been simply and carefully designed all through for extremely heavy duty, and all parts are of rugged construction, thus eliminating vibration. Twenty horsepower is required for form-grinding and ten to fifteen horsepower for traverse grinding. The floor space occupied is 6 by 15 feet, and the weight of the machine is 14,000 pounds.



Heavy-duty Grinder built by Ford-Smith Machine Co.

MINSTER "HI-DUTY" DRILLING MACHINE

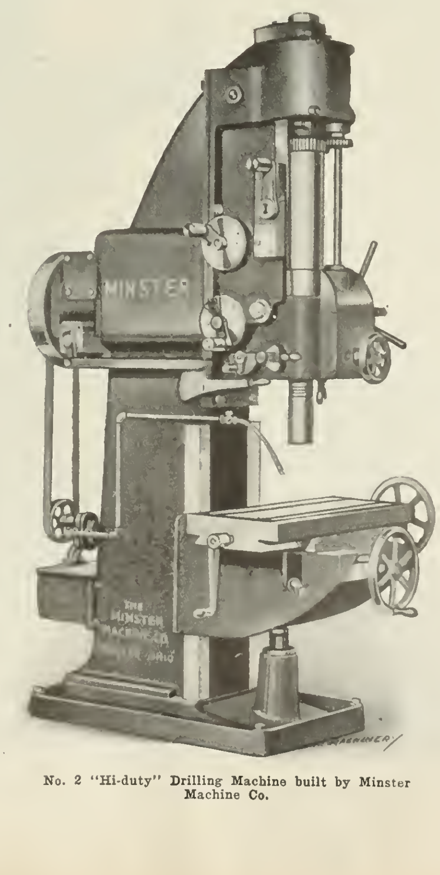
The No. 2 "Hi-duty" drilling machine which forms the subject of the following description is manufactured by the Minster Machine Co., Minster, Ohio. This machine is designed with sufficient strength and power to drive a 2½-inch high-speed drill in solid steel at a speed and feed which insures obtaining the maximum production from the drill. The machine is provided with a wide range of feeds and speeds which enables the user to operate it economically on a variety of work. Owing to the high spindle speeds which are available, the machine is suitable for driving small high-speed steel drills, and its range extends all the way from this class of service up to heavy boring operations, such as enlarging holes in steel and cast iron.

The drive is provided by a large single pulley running at constant speed and then through high-carbon steel shafting and heat-treated stub-tooth transmission gearing to the main spindle. An extremely simple gear-box is provided which gives six initial speed changes through sliding gears. Standard ball bearings are used throughout the transmission gear-box, thus giving high efficiency. The transmission gears are flooded with oil which is circulated over the gears by an improved gravity feed system of oiling.

The two cranks engaging holes in dials at the left-hand side of the head provide for obtaining any of the six changes of speed, and the crank above these dials near the front of the head engages the direct drive and back-gears. All of the high speeds are obtained through a smaller gear on the spindle sleeve, thus obviating high tooth velocity, and there are no gears having a tooth velocity of over 800 feet per minute. The lever below the speed dials operates an expanding band friction inside the gear-box which runs in oil to insure proper lubrication. Up and down movement of this lever controls the direction of rotation of the drill spindle and forms a convenient braking device as well as a tapping attachment.

Feed is imparted to the spindle by a vertical shaft seen at the front, and this shaft is arranged to be driven at various speeds by changing the gearing mounted upon a swinging quadrant at the upper end of the spindle sleeve. It is only necessary to change this gearing to suit the feed; twelve regular feeds are provided to take care of all reaming and drilling operations. The steel stub-tooth feed gearing is contained within the feed-box, which is cast integral with the head at the right-hand side of the spindle. The feed gearing is of the sliding gear type and no pull pins are used. The twelve changes of feed are transmitted to a large worm-wheel keyed to the pilot shaft, upon which is cut a coarse wide-faced pinion which engages a wide feed rack that is cross-keyed to the spindle sleeve. The small levers are used for obtaining speed changes, and a suitable index plate indicates the proper position of all levers for both feeds and speeds. An automatic knock-out for the feed gives a positive and accurate depth gage for drilling, and a safety stop prevents the spindle from feeding beyond its proper traverse. Attention is called to the means provided for delivering cutting compound to the drill.

The principal dimensions of this drilling machine are as follows: capacity for drilling holes in steel up to 2½ inches in diameter; distance from center of spindle to face of column, 14 inches; end of spindle to table, 35 inches; end of spindle to base, 50 inches; diameter of spindle sleeve, 4 inches; minimum diameter of spindle, 2¼ inches; Morse taper in spindle, No. 5; width of feed rack, 2 inches; diameter of driving gear, 11 1/3 inches; face width of driving gear, 2½ inches; size of finished surface of table, 20 by 26 inches; vertical adjustment of table, 18 inches; range of feeds, from 0.006 to 0.069 inch per revolution; range of speeds, from 30 to 550 revolutions per minute; size of driving pulley, 20 inches in diameter by 3½ inches face width; driving pulley speed, 550 revolutions per minute; and net weight of machine, 5300 pounds.



No. 2 "Hi-duty" Drilling Machine built by Minster Machine Co.

BECKER BACKING-OFF MACHINE

For use in relieving form cutters, the Becker Milling Machine Co., Hyde Park, Boston, Mass., is now building a machine which forms the subject of this article. It is adapted for backing off cutters up to 13 inches in diameter having all numbers of flutes from three to twelve, inclusive, and all even numbers of flutes from twelve to forty, inclusive. Hobs and worms can also be cut on this machine, and when giving

Becker Backing-off Machine for relieving Form Cutters

hobs a clearance the cam can be thrown out in reversing. The gearing used in cutting hobs and worms may be easily disconnected when not in use. The machine is designed to give straight or periphery, side and end relief on all classes of cutters that come within its range.

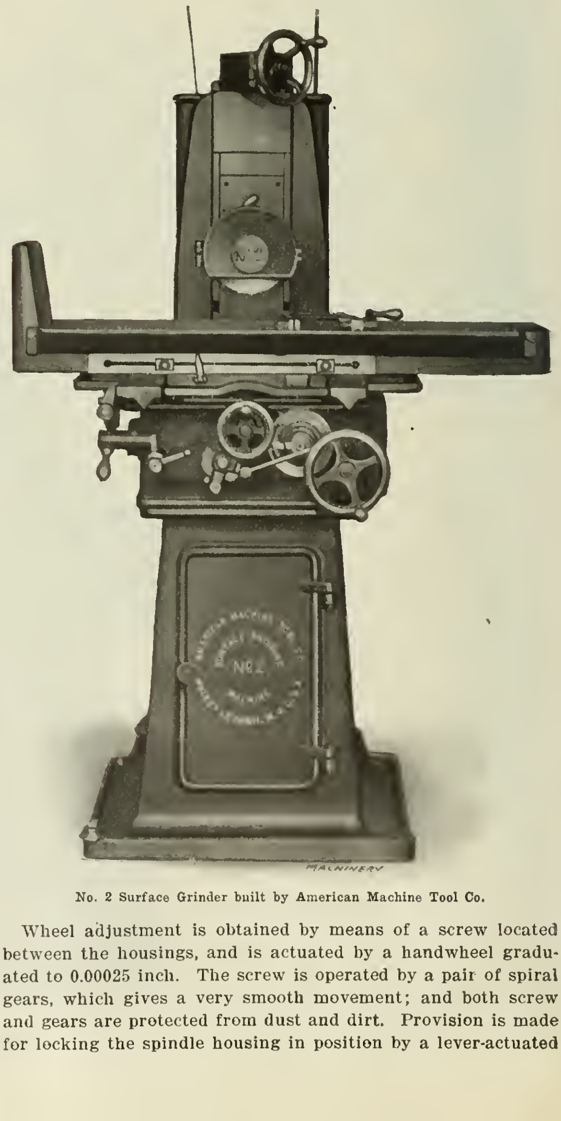
It will be seen that this machine is of the arm type, and alignment of the tailstock is maintained by two T-slots in special ways at the back of the bed. Provision is made for locking the tailstock in any desired position by four clamping bolts, and the maximum adjustment of the tailstock is through a distance of 24 inches. The spindle is made of crucible steel, and has a maximum diameter of 3¾ inches; it is driven through spur gears mounted directly on the spindle. The spindle bearings are of solid phosphor-bronze, and are provided with means of compensating for wear. The taper hole is No. 13 B. & S., and the spindle is bored to accommodate a ¾-inch draw bolt. Clutch drive insures positive rotation of the tool to be relieved. The drive is through a single pulley 14 inches in diameter by 4 inches face width, and three speed changes are provided through simple gearing.

A single-throw cam at the back of the machine provides for giving relief from 0 to ¼ inch, which is ample to meet all requirements; this cam is rigidly held by cam-shaft supports, and wear on the cam rolls may be taken up by tapered gibs to insure a positive throw. Cutters to be formed can be placed in the proper relation to the forming tool without loosening the bolt or nuts, by operating the worm meshing with a worm-wheel on the cam-shaft. A micrometer stop attached to the periphery relief slide provides for accurately resetting the tool after changing the work. Periphery and side relief are obtained by the same cam; end relief is obtained by a separate cam located at the end of the machine. The tailstock is made to take either a collar bearing or center bearing, according to the nature of the work; a collar bearing is used for taking heavy cuts on work supported by a long arbor to insure rigidity due to support provided on the arbor near the work; and a center bearing is employed in cases where a short arbor is used to carry small work.

The tool-holder block is made to hold tools from ¼ to 1 inch thick; it is set on a 30-degree slide plate and operated by a handwheel at the side to raise or lower the tool to the required position. Provision is made for feeding the tool to the work by a differential handwheel, giving accurate control. This differential is used for fine feed, and it is thrown out of engagement to obtain direct or quick adjustment. Longitudinal adjustment is secured by a handwheel operating bevel gears on the carriage screw, which gives a maximum adjustment of 12 inches. Motor drive may be employed, in which case a three-horsepower variable-speed motor is recommended with a speed range of from 500 to 1500 R.P.M. This motor is mounted on a bracket at the back of the machine. The floor space occupied by the machine is 67¾ by 47¾ inches, and the weight of the machine is approximately 6500 pounds.

AMERICAN NO. 2 SURFACE GRINDER

The No. 2 surface grinding machine illustrated and described herewith is a recent product of the American Machine Tool Co., Hackettstown, N. J. This machine has been developed to meet the requirements of tool-room work, and is especially adapted for finishing dies, punches, gages, etc. All belts are enclosed by the box form of construction, which eliminates the use of guards and gives the machine a neat appearance, in addition to protecting the operator. All slides and working surfaces are provided with covers to shield them from grit and dirt. The working parts are accessible, and the handwheels and levers for controlling the various movements are located in positions most natural and convenient for the operator.



No. 2 Surface Grinder built by American Machine Tool Co.

Wheel adjustment is obtained by means of a screw located between the housings, and is actuated by a handwheel graduated to 0.00025 inch. The screw is operated by a pair of spiral gears, which gives a very smooth movement; and both screw and gears are protected from dust and dirt. Provision is made for locking the spindle housing in position by a lever-actuated

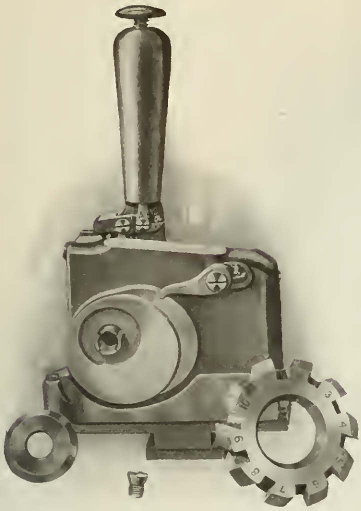


Fig. 1. Parts of Rivett-Dock Thread Cutting Tool

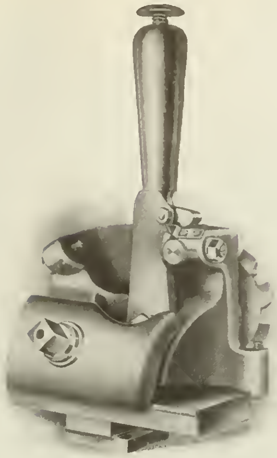


Fig. 2. Rivett-Dock Thread Cutting Tool Assembled

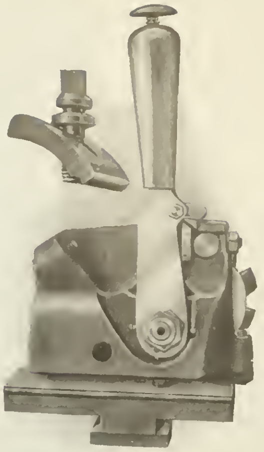


Fig. 3. View of Tool showing Adjustment for Depth of Cut

cam which is positive and rapid in operation. The spindle is hardened, ground and lapped, and runs in tapered split bronze bushings provided with adjustment for taking up lost motion in any direction. The wheel used on this machine is 7 inches in diameter by ½ inch face width. The arrangement of belting to the spindle is very simple; it works on the double-loop principle, providing a liberal amount of belt lap to the pulley.

The mechanism box is cast in one piece and bolted to the main frame in such a way that it may easily be removed for making repairs and adjustments. All mechanism for the various feeds is located in and on this box, and all running shafts in the box have phosphor-bronze bearings which are lubricated from the outside. The table is 46 inches long by 8 inches wide and provided with dust guards which do not interfere with accessibility of the trip mechanism at the front. The working surface is 18 by 6 inches, and has three ½-inch T-slots cut in it. Travel of the table is automatic and is controlled by adjustable dogs operating against a reversing lever. This lever can be turned down and the table moved beyond the reversing point without changing the dogs. Traverse motion of the saddle is automatic, feeding at each reversal of the table in either direction. An adjustable automatic stop is provided which throws out this feed at any desired point, and the traverse feed is from 0 to ⅜ inch at each reversal. By throwing out the automatic traverse feed mechanism, work requiring side grinding can be ground to 0.001 inch by the use of a graduated handwheel. The clutch actuating device in the gear-box is always thrown, regardless of speed momentum.

The countershaft has tight and loose pulleys 8 inches in diameter by 3¼ inches face width, and the driving pulley is 16 inches in diameter by 2¼ inches face width, with a speed of 450 revolutions per minute. The belt shifter provided on this countershaft completely overcomes the tendency of the belt to run on both pulleys due to the weight of the shifter handle. This handle always returns to the vertical position after shifting the belt. Using a 7-inch wheel, this machine will grind work 18 inches long by 6 inches wide by 9 inches high. The regular equipment includes one vise with jaws 4 1/8 inches long by 1 1/16 inch deep with a 2-inch opening, one wheel 7 inches in diameter by 1/2 inch face width, a countershaft, and the necessary wrenches for making all adjustments. The floor space occupied is 30 by 65 inches, and the net weight of the machine, with countershaft, is 1490 pounds.

RIVETT-DOCK THREAD CUTTING TOOL

The Rivett Lathe & Grinder Co., Brighton, Boston, Mass., has redesigned the familiar Rivett-Dock threading tool. In redesigning this tool, the objects sought were more positive indexing of the cutter, minimum amount of travel of the operating lever, and a greater latitude of adjustment of the cutting tool. The illustrations will make clear the design, construction and operation of this tool. It is so arranged that it may be clamped into the tool-block slot on any lathe carriage by first clamping the baseplate in position and then adjusting the tool base on the baseplate.

The principle of this threading tool is the same as that of the old model. The tool consists of a fixture for supporting and indexing the special threading cutter. The cutters are made standard, and a special cutter is required for each pitch of thread. This type of cutter has ten cutting points, equally spaced around the circumference and graduated in lengths by increments of one-tenth the depth of the thread. Thus by starting with the lowest point of the tool and taking the successive cuts with each of the ten points by indexing the cutter after each cut, the thread is completed in ten passes over the work. The advantages of a threading tool of this kind are that the depth of feed for each cut is arbitrarily fixed and requires no judgment on the part of the operator. There is therefore less chance of breaking tool-points, and the resulting threads are more accurate. The cutter is mounted on a short taper arbor; the hole of the cutter proper is ground to an included angle of 28 degrees, and by tightening an expanding stud, a bushing fitting this ground tapered hole binds the cutter to the arbor. The cutter-arbor is hardened and ground all over, and fitted in adjustable bushings.

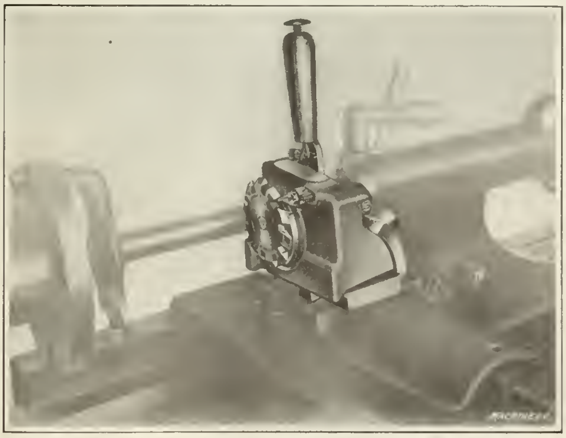


Fig. 4. Thread Cutting Tool in Operation on Lathe

The cutter is mounted eccentrically on the arbor, so that by operating the lever

which turns the cutter-arbor, the cutter is drawn down and back. In the original Rivett-Dock threading tool, withdrawing of the cutter from the work was taken care of by withdrawing the slide on which the cutter was mounted. By employing the eccentric arbor, however, a comparatively shorter movement of the operating handle is necessary for operating the tool. Another point of superiority over the old tool is that the hack of the point of the tool coming into operation comes *down* on the supporting stop instead of sliding onto it. The indexing is effected by drawing the operating lever back and pushing it forward toward the work. This allows a gravity pawl to drop in between two of the teeth of the cutter, and the tool is thus indexed on the forward stroke. At the top of the operating handle and working through it is a spring plunger that must be pressed before the handle can be operated. This plunger releases a catch that allows the handle to be drawn back for the indexing movement.

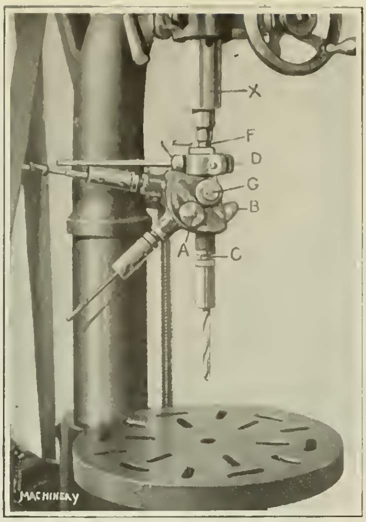


Fig. 1. Eisler Three-spindle Turret Head for Use on Drill Press

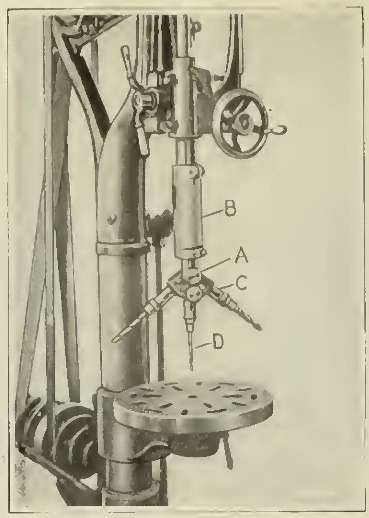


Fig. 2. Eisler Drill Press Turret Head with Sleeve Connection to Spindle

The stop against which this latch catches is adjustable by means of a threaded shank, and it is graduated so that the entire threading tool may be advanced any desired amount from 0.0005 inch up. With the old type threading tool it was necessary to hold the operating lever over while the threading cut was being taken, but with the new tool this is not necessary, as the stop and latch take care of this feature. At the back of the threading tool base is a stop screw that may be set to limit the stroke of the operating handle. This feature takes care of variations in size of different cutters. The entire threading tool housing may be tilted to any desired degree to accommodate the inclination of any pitch of thread.

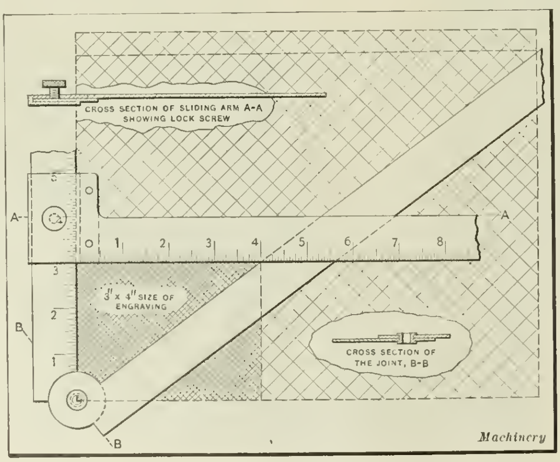
EISLER DRILL PRESS TURRET HEAD

The drill press turret head shown in the accompanying illustrations was developed by Charles Eisler, 43 Dodd St., Bloomfield, N. J., to adapt drilling machines for manufacturing work where there is a sequence of operations to be performed. When there are a large number of parts to be made, saving of time through eliminating the necessity of resetting the work is an important factor that should commend this turret head to favorable consideration. Fig. 1 shows a plain drill press turret head which requires little explanation to make its use readily understood by any mechanic. When the position must be changed, knob *A* is pulled and a plunger automatically locates the next tool in the working position by plunger *A* entering the proper hole *B*. Shank *C* can be made to suit special chucks or with a taper to fit any standard chuck. A stop-rod *D* prevents the body of the tool from rotating. The tools in this turret are driven in the usual manner by a tapered shank *F*, and the body of the head pivots on pin *G*. When spindle *X* is raised, drill spindle *C* immediately stops rotating.

Fig. 2 shows a similar form of turret head except that an automatic stop is provided. When knob *A* is pulled, tool *D* immediately stops rotating without the necessity of raising the drill press spindle. This also shows a sleeve attached to the spindle *B*, which is a desirable feature where the tool is used almost continuously; it is never necessary to stop the drill press when the position of the turret is changed. The turret shown in Fig. 2 is made to accommodate taper shank drills, and in this illustration the drift holes are shown at *C*. The position of the turret head can be changed in one second while the drill press is running. The head is so designed that the operator can change it without being required to leave his working position at the front of the machine. This head is made in several sizes, and different types are made with from two to five spindles. It will be noted that the tool in the operating position is in direct line with the drill press spindle.

MEADWELL PROPORTIONAL MEASURING AND CALCULATING SCALE

At present there are two commonly used methods for solving problems in proportion—one by arithmetic, the other mechanically with the slide-rule. The arithmetical method is sometimes too slow, and many people are unfamiliar with the use of the slide-rule. To facilitate the solving of such problems, and particularly those in which one or more of the members of the proportion contain fractions, W. E. Meadwell, Ithaca, N. Y., developed the proportional measuring and calculating scale illustrated herewith, which affords a simple and accurate method of handling work of this kind. A simple problem in proportion that often arises is to convert the dimensions of a figure of given size to some larger or smaller size, keeping the same relation between the length and width. The Meadwell proportional measuring and calculating scale permits all four dimensions of the two figures to be visualized at the same time; nothing must be remembered, nothing is left to chance, and everything is in plain sight all the time.



Meadwell Proportional Measuring and Calculating Scale for solving Problems in Proportion

This instrument consists of a horizontal sliding arm on which is mounted a lock-screw, and two similar swinging arms held together by an eyelet. The instrument can be made of wood, celluloid, composition, or light metal,

the latter being preferable, as strength is needed as well as a certain amount of flexibility. For solving all mathematical problems such as those confronting draftsmen, engineers and students, these arms are divided into 1000 spaces, but for advertising men, artists, printers and engravers, the scale division would be in inches and fractions of an inch.

The use of the proportional measuring and calculating scale can probably be best explained by carrying through the steps of an actual problem. With the scale having arms divided into 1000 divisions, suppose the following proportion is to be solved:

$$8.73:5.31::3.8:X$$

Stated in plain English, this problem reads: If the long side of a figure 8.73 by 5.31 inches in size were reduced to 3.8 inches, what would be the dimension of the short side of the small figure? To solve this problem, lay the scale on your desk and slide the horizontal arm to the 8.73 mark on the left-hand arm. Then swing the free arm to the 5.31 mark on the horizontal arm. Next slide the horizontal arm down the left arm to the 3.8 mark, without moving the right-hand or swinging arm. The horizontal arm now crosses the diagonal or right swinging arm at the 2.31 mark, which is the required value of X in this problem.

For finding the dimensions of a larger figure, where those of the smaller one are known, the dimensions of the smaller figure are first located within the triangle bounded by the three arms of the instrument. Then, without moving either of the swinging arms, slide the horizontal arm upward on the left arm to the known dimension of the large figure, and this dimension, together with the one obtained by locating the intersection point at the horizontal and swinging arms, will indicate the dimensions of the large figure. The simplicity of this device and the low cost at which it can be manufactured make it an ideal instrument for use in large engraving houses, publishing establishments, advertising agencies, etc. The use of an instrument graduated in inches and fractions would be identical with that already described.

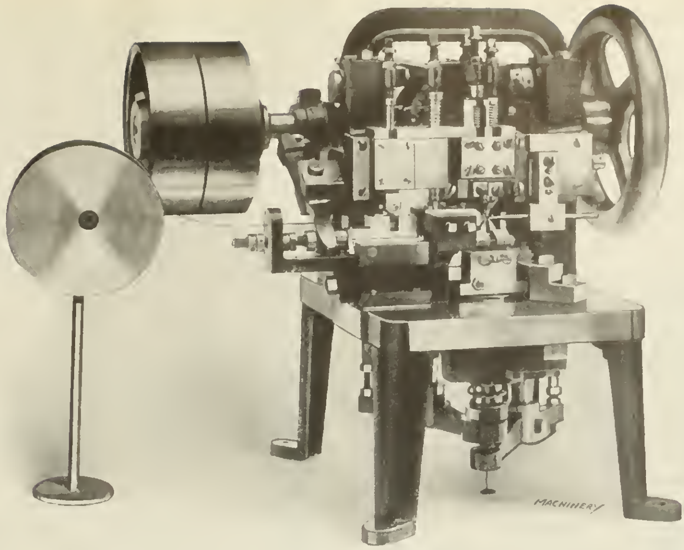


Fig. 1. Front View of Lind Automatic Chain Making Machine, showing Stock Reel and Forming Tools

LIND CHAIN MACHINE

Production of chain has been carried on from the earliest times. All of it was made by hand in the early days, and a great deal of chain is turned out in this way at the present time. Modern fashion, dress and style of living has created a demand for chains made of gold, silver and platinum which have closer and finer links than could be produced by this method. To meet this demand the mechanical engineer was called upon to solve the problem, and as a result of his work it is now possible to procure machines which will make perfect chain so reasonably that chains are now used for a great variety of purposes. These automatic chain making machines have many small and delicate parts in their mechanism, and in order to operate successfully, great care and skill must be exercised in machining, finishing and adjusting these parts.

The J. A. Lind Co., 117 Point St., Providence, R. I., is now building automatic chain making machines in four sizes. The accompanying illustrations Figs. 1 and 2 show the smallest, which is adapted for manufacturing chain from stock ranging from 0.007 inch in diameter with forty-five links per inch up to chain made from stock 0.020 inch in diameter with twenty links per inch, the rate of production being from 120 to 140 links per minute. This is a bench machine which occupies a space of about 18 by 18 inches and weighs approximately 100 pounds. Not over 1/8 horsepower is required for driving it. While having a range for handling four or five sizes, the machine requires great nicety of adjustment in order to operate satisfactorily, and so it has been found good practice to confine each machine to a special size of chain, and this is particularly desirable when a shop has a constant demand for various standard sizes of chain. Insertion of different sets of forming tools of the proper size enables the machine to turn out chain in the several sizes of links within its range. Examples of chain produced on this machine are shown in Fig. 3.

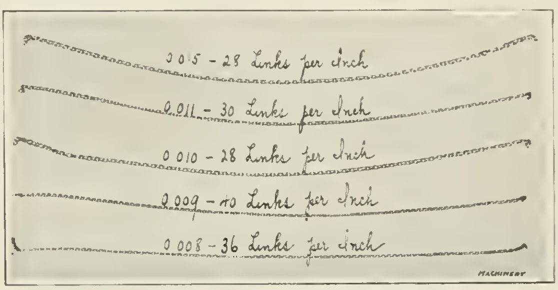


Fig. 3. Examples of Chain produced on Lind Machine

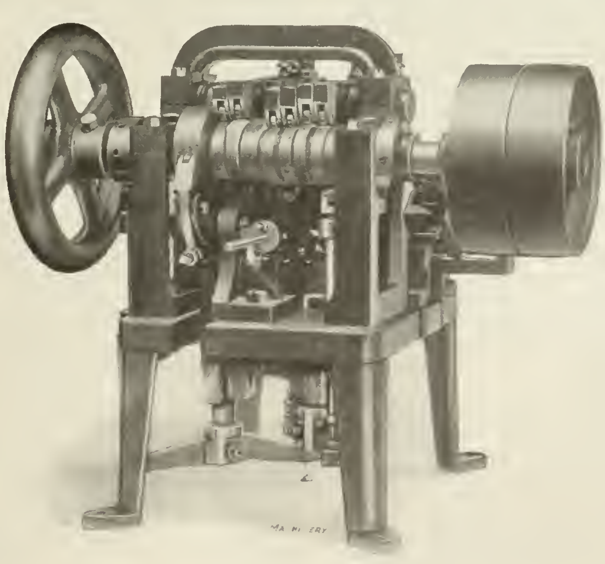
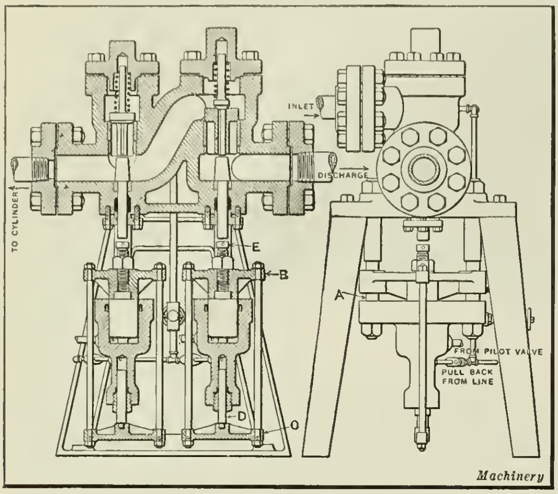


Fig. 2. Opposite Side of Lind Automatic Chain Making Machine

METALWOOD PILOT-OPERATED VALVE

A pilot-operated quick-operating valve with adjustment for speed has recently been placed on the market by the Metalwood Mfg. Co., Leib and Wight Sts., Detroit, Mich. This valve is built in all sizes and for all pressures. For use with water, the valve is constructed with hard bronze valves and seats; and for use with oil, the valves and seats are made of steel. The operating cylinders are suspended from the body by tie-rods *A*, which are provided with shoulders for ram shoe *B*,



Metalwood Pilot-operated Quick-operating Valve with Adjustment for Speed

giving positive stop for the ram. The shoe also carries a yoke to which yoke *C* is attached, which carries pull-back ram *D* under constant pressure. The opening of the valve is adjusted by screw *E*, which is locked in position by means of a jaw nut. The speed of operation of the press is varied by lengthening the screw when the ram shoe is against the column shoulders, which raises the amount of lift on the valves.

NEW MACHINERY AND TOOLS NOTES

Tapping Chuck: Braden Mfg. Co., New York City. This chuck has a reversing mechanism that withdraws the tap when the required depth of hole is reached. A conical friction holding arrangement prevents breakage of taps.

Pneumatic Portable Grinder: William B. Mershon & Co., Saginaw, Mich. While designed for internal work, this grinder is also adapted for center and other classes of grinding. It has a speed of 20,000 revolutions per minute and requires an air pressure of from 50 to 100 pounds.

Toolpost Turret: Universal Machine Works, 311 W. 59th St., New York City. Six stations are provided in this turret for turning tools and six stations for boring tools. The turning tools are carried in swiveling holders, and a special eccentric tool-holder is provided for the cutting-off tool.

Toggle Drawing Press: Toledo Machine & Tool Co., Toledo, Ohio. Toggle drawing and deep stamping presses built in a number of sizes for a wide range of work from small tinware to automobile bodies. The weights range from 6700 to 650,000 pounds. The press can be started or stopped at any part of the stroke with slight effort.

Multiple-spindle Drilling Heads: Nelson-Blank Mfg. Co., Detroit, Mich. The two-spindle head is designed especially for drilling two ¾-inch holes, 3.82 inches apart, in 9-inch shell plugs, and the heads having three or more spindles are adapted for drilling holes to a predetermined depth, the spindles being provided with vertical adjustment.

Calculator for Drawing Dies: O. H. Jensen, Buffalo, N. Y. A circular slide-rule for determining the maximum reduction in drawing sheet steel with double-action and combination dies, allowing for different thicknesses of stock and diameters of blanks. It is based on the results of exhaustive experiments that were charted and reduced to a slide-rule basis.

Continuous Reading Gage: Industrial Products Co., Chicago, Ill. A gage designed to indicate variations to 0.0001 inch in work being ground. It consists of an Ames gage and mechanism for transmitting to it the horizontal movement of a diamond-pointed rod. The reduction is such that a movement of the diamond through 0.001 inch causes the hand on the dial to move from 0 to 10.

Portable Toolpost Grinder with Extension Spindle: Wisconsin Electric Co., 1402 Dumore Bldg., Racine, Wis. This grinder has an extension spindle for deep internal grinding, lapping out deep drawing dies, etc. The spindle has a reach of 10 inches and is designed to increase the range of the smaller high-speed attachment regularly furnished. Power is transmitted to the spindle through a flexible coupling that eliminates vibration.

Arbor Press: G. T. Eames, Kalamazoo, Mich. Arbor press with swinging tables that permit instant adjustment to suit various sizes and shapes of work. An auxiliary pressure-applying handle moves the ram 5/8 inch per stroke, so that the mandrel is brought into position for the application of greater force by the compound handle, which moves the ram 1/16 inch per stroke. The maximum pressure that can be applied is 30 tons.

Machine for Graduating Fuses: American Ammunition Co., Bordentown, N. J. In this machine, the fuse is held in a draw-in collet, operated by an air chuck; a plunger brought up behind the fuse body prevents its being forced out of the chuck by the pressure of the graduating roll. The machine is driven by a regular punch press releasing gear. The graduating roll is forced into contact with the fuse body by weights working on a bellcrank.

Bench and Column Grinder: Lamb Knitting Machine Co., Chicopee Falls, Mass. The hollow grinder head, which forms a reservoir for the lubricating oil, is secured to the column by three cap-screws, but it may be furnished separately as a bench machine. The wheels are 6 inches in diameter and have a 1-inch face. The steel spindle is 1⅛ inch in diameter between the self-aligning ball bearings, ⅞ inch in the bearings, and ¾ inch where it supports the wheels.

Portable Hoist: Ingersoll-Rand Co., 11 Broadway, New York City. This hoist differs from existing types principally in size. The drum is 7 inches in diameter, 17 inches long, and holds 300 feet of ⅞-inch Manilla rope. The hoist is 21½ inches long, 31¼ inches wide, and 23 inches high, and the maximum capacity is 600 pounds. It may be operated by steam or compressed air, and is designed primarily for underground work, though it is also suitable, of course, for use in industrial plants.

Spring Nut Lock: Industrial Development Co., Chicago, Ill. A spring nut lock consisting of two hexagonal plates joined at one side. The holes in the plates fit the bolts on which the locks are to be used. Normally, these holes are out of alignment, so that their forced alignment, when the plates are on the bolt, causes the spring connection to exert a strong pulling force on one plate and a pushing force on the other, which gives a tight grip on the bolt thread, and locks the nut securely in place.

Washer Stamping Press: Southwark Foundry & Machine Co., Philadelphia, Pa. A machine which turns out a complete washer at each stroke of the ram, from either scrap or new sheet or plate material. The machine may also be used for different classes of stamping, punching, shearing, etc. If desired, it may be equipped with roller feed for automatically handling washer stock in bands or bars. The plunger has broad wearing surfaces and is fitted with taper gibs to take up wear.

Heavy-duty Manufacturing Lathe: Himoff Machine Co., 128 Mott St., New York City. This lathe is intended for turning projectiles and forgings where the finished diameter does not exceed 9 inches. The bed, which is 8 feet long, is reinforced with box-type cross-ribs, which resist twisting stresses. The headstock spindle is forged from steel containing between 0.50 and 0.60 per cent carbon; a 2¼-inch hole extends entirely through it. The tailstock spindle is 3½ inches in diameter and has a 6-inch travel.

Electric Hoist: Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. An electric hoist especially adapted to the requirements of machine tool service. This hoist is built in several sizes for connection with direct- or alternating-current circuits. To provide against overloading, the hoist has been designed with an unusually high factor of safety; and a combination mechanical and electrical brake is furnished, which automatically regulates the braking effect to meet the requirements of the load handled on the hoist.

Riveting Machine: Hanna Engineering Works, 1059 Elston Ave., Chicago, Ill. This machine is designed to operate in places where the space is limited, and is especially suitable for automobile assembling. The toggles, levers and guide links are arranged to give a large opening of the toggle-joint movement, with a gradual increase of pressure. The relatively large distance through which the rated maximum pressure may be exerted makes little adjustment necessary to compensate for variations in the rivet or plate after the machine is set.

Metal-cutting Band Saw: Quality Saw & Tool Works, Springfield, Mass. In this machine a band saw replaces the

short-blade hacksaw generally used, thus giving a continuous stroke. Adjustable guide rollers support the saw both sidewise and against the thrust of the cut. The saw is cooled by contact with the guide wheels, but a lubricant may be used to wash away the chips. As the outer saw wheel is adjustable, saws varying nine inches in length may be used, so that those that are broken before they are worn out may be utilized.

Horizontal Hydraulic Pump: Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio. A four-plunger pump that may be equipped with sixteen different sizes of plungers, ranging, by quarter inches, from 1¾ inch to 5 inches in diameter. The water capacity is from 24 to 326 gallons per minute, and the pressures are from 700 to 9500 pounds per square inch. For the highest pressures, the water cylinders are made of forged steel; for pressures between 1500 and 2900 pounds per square inch, cast steel is used; and for the lowest pressures, semi-steel.

Rotary Pump for Lubricating Machine Tools: Goulds Mfg. Co., Seneca Falls, N. Y. Rotary pumps designed so that they may be used with practically any type of machine tool. These pumps are made reversible for use with screw and automatic machines, in which the direction of rotation is reversed, and non-reversible for machine tools that operate in one direction only. Practically any of the ordinary methods of drive can be employed, while the amount of oil and cutting compound handled is easily controlled by the relief valve and pipes built in the cover.

Shell Threading Lathe: Gisholt Machine Co., 1117 E. Washington Ave., Madison, Wis. A special machine for use in taking the finish-boring and facing cuts, and also for milling threads in the base or nose of shells. It can be adapted for cutting right- or left-hand threads, either internal or external; and the thread may be U. S. standard or metric. This machine enables the boring, facing and threading operations to be performed without transferring the shells from one machine to another, thus saving the time ordinarily required for resetting, and also insuring the production of an accurate thread.

High-speed Ball-bearing Bench Saw: H. G. Crane, Brookline, Mass. A portable, well constructed machine for sawing soft metals, fiber, wood, etc., at a speed of from 1000 to 6000 revolutions per minute. The ball bearings are mounted in dust-proof housings, but can be easily lubricated. The table top may be quickly raised or lowered to any position for slotting and grooving. The motor is hung on a dust chute that is hinged at its upper end; this provides an easy way of keeping the belt in the proper tension. Motors are supplied for 110- and 220-volt alternating and direct current, and of 1/4, 1/3 and 1/2 horsepower.

Back-geared Lathe: Hollingworth Machine Tool Co., Covington, Ky. A machine known as the style H engine lathe which is furnished with three large V-ways and one flat way. The machine is ordinarily equipped with a four-step cone and single back-gears, but double back-gears may be furnished to special order. The machine swings 19 inches over the ways and 12 inches over the carriage; maximum distance between centers for a 6-foot bed is 30 inches; dimensions of spindle bearings are, front, 2¾ by 5 inches, and rear, 2⅜ by 4 inches. The taper attachment for this machine has a capacity for turning tapers up to 19 degrees, or 4 inches per foot.

Internal Grinding Machine: Reno-Kaetker Electric Co., Cincinnati, Ohio. This vertical grinding machine will grind automobile cylinders from 3¼ to 5½ inches in diameter and up to 10¼ inches in length; it can be used also for other classes of internal grinding. The machine has a vertical bar carrying the grinding wheel spindle which is made radially adjustable in order to vary the diameter ground by the wheel. The bar is provided with a circular rack in which a pinion driven by an auxiliary motor engages and provides the up and down feed motion. The emery dust may be drawn out by an exhaust fan, through the exhaust port of the cylinder, or blown out by an attachment furnished with the grinder.

Guard to Prevent Motor Reversal: General Electric Co., Schenectady, N. Y. A device developed for the purpose of guarding against accidental alternating-current motor reversal—especially in cases where motors are installed in connection with elevators, hoists, conveyors, machine tools, etc. This consists of a reverse phase relay which operates on the same principle as a squirrel cage induction motor and is made in both circuit opening and circuit closing types. The operating coils of the relay correspond to the stator of an induction motor, while a hollow aluminum cylinder connected to the contacts corresponds to the rotor. The cylinder does not rotate, but moves either up or down when one of the phases of the line is reversed, this movement causing a toggle to make or break the contact.

Shell-boring Turret Lathes: Reliance Machine Co., Toronto, Ont., Canada. A turret lathe of massive construction, designed for boring 4-inch to 8-inch high-explosive shells. The front headstock bearing is 8½ inches in diameter and 12 inches long, and is fitted with self-oiling rings, as is also the rear spindle. The spindle is made in one piece, with a 15-inch heavy flange to which the chuck is bolted, and is large enough to take the shell inside the bearing. The main driving gear is 4½ inches across the face, and the back-gearing has a ratio of 9 to 1. The thrust of the tool is taken by a special self-adjusting thrust bearing capable of a continuous working load of 8400 pounds. The length of the carriage and the application of power to a steel rack, 3 inches wide and 4 diametral pitch, in the center of the carriage, are relied upon to prevent twisting.

Noiseless Gear: Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. Gears made of heavy duck bonded together with bakelite by heating while under heavy pressure. They are said to be as strong as cast iron and unaffected by atmospheric changes. The tensile strength of this material, parallel to the laminations, is 10,000 pounds per square inch; the compressive strength, perpendicular to the laminations, is 30,000 pounds per square inch; and parallel to the laminations, 17,000 pounds per square inch. The material weighs 0.05 pound per cubic inch, has a specific gravity of 1.4 and has a water absorption, by weight, of 0.25 to 2 per cent, depending on the relative amount of edge surface exposed. These gears may be machined in any direction and drilled and tapped readily. The teeth are cut with the same tools as are employed for cutting steel, but the cutting speed is 25 per cent greater and the feed is increased 50 per cent. In most cases, neither housings nor bushings are required; though, where the diameter of the gear is several times the width of the face, end plates may be advisable.

* * *

ROTARY ENGINES

Thousands of misguided inventors have spent their time and money developing inventions of rotary steam engines, but so far as we know there is not a successful rotary steam engine on the market today. In view of all the thought and energy that has been expended on the problem, this seems strange, until one has given the matter careful analysis. The rotary engine apparently has one advantage over the reciprocating engine—the absence of reciprocating parts, which in any machinery are disturbing elements. They eat up energy when run at high speed and cause serious vibration and rapid deterioration. It seems, then, that a prime mover in which these disturbing elements are absent would be superior to one having reciprocating and oscillating parts. While this is true, the fact is that the rotary engine has a number of disadvantages far more serious than this.

It is a matter of extreme difficulty to make a steam-tight joint between moving parts of any except circular shape. A bored cylinder fitted with a piston containing expanding rings may be made practically steam-tight, but it may be safely asserted that in practically no design of rotary steam engine has it been found possible to fit the moving parts so closely that they would be steam-tight without causing tremendous frictional resistance. The advantage of the rotary steam engine of the ideal type is absence of reciprocating parts. Against that single advantage may be placed the following disadvantages, which we have arranged in the logical order leading up to the greatest one—wastefulness:

1. Difficulty of making moving parts steam-tight.
2. Excessive internal friction and resistance.
3. Steam leakage.
4. Excessive steam consumption.

Excessive steam consumption is due to the inherent defects of design. It is quite feasible to provide for cut-off in the stroke of a rotary piston, the same as in a reciprocating piston, and the same economy would result were it not for leakage and friction.

In view of the inherent defects of the rotary steam engine, it seems little less than madness to attempt to develop a rotary gas engine. In the rotary gas engine the difficulties of securing gas tightness are greatly increased. The inventor has to cope also with high temperature and great differences in temperature at the beginning and end of the working stroke.

* * *

A rolling mill recently installed by the Lukens Iron & Steel Co., Coatesville, Pa., is capable of producing finished plates 192 inches wide. These plates are the largest that it is possible to transport with the present loading railway gage. The rolls are 204 inches long by 34 inches in diameter. The largest mill in Continental Europe is said to be that at Witkowitz, in Hungary, which has 178-inch rolls; and the largest in Great Britain are the 168-inch rolls at Dalzell's steel works.

EFFECT OF THE WAR ON METAL PRICES

PRICES AT BEGINNING OF WAR AND NOW AND EFFECT ON FOREIGN TRADE

WHILE the prices of iron and steel have risen rapidly during the past few months, at the beginning of this year few were greater than had been obtained some time in the past twenty years. Yet these prices have not decreased the demand for American goods in other lands, though they have caused a revival in all lines pertaining to the iron and steel industry all over the world. Mines, mills and factories have been more efficiently worked in order that the greatest production may be obtained. As a result of improvements made in the mining methods, the mines of Caen, Normandy, which back in 1900 produced only 142,000 metric tons, are now producing 1,000,000 metric tons annually; and the estimated production of the Katanga copper mines in Belgian Congo will be nearly double that of last year and about two and one-half times that of the year before. New deposits are being worked and new sources of supply are being sought. This fact is shown most forcibly in the case of 80 per cent ferro-manganese. Before the outbreak of the war this metal was supplied almost entirely through British channels at from $35 to $40 a ton. At the beginning of 1915 the price was advanced to $68, but by January, 1916, it could not be obtained for less than $125. In April, May, June and August of this year, it sold for $175 a ton, and it was reported that some small lots had been sold for $185 a ton. But these prices and the conditions demanded by the British agents caused many manufacturers to work known American deposits and also to buy foreign ore, which is smelted in American furnaces. Much of this ore comes from Brazil, where American corporations have secured control of large ore deposits.

Germany, since the outbreak of the war, has obtained its ferro-manganese by mining the deposits at Ilseder-hütte, near Peine, east of Hanover. As this lay beneath the village of Ilsede, it could not be mined; but when the nation was cut off from its accustomed sources of supply the village was removed and these deposits developed. Recent reports from Dutch sources, however, say that the supply of manganese is small, so that, together with a lack of skilled workmen in the mills, German iron is deteriorating in quality.

Pig Iron, Billets, Plates and Beams

The accompanying table gives the average prices of iron and steel, in various forms, copper, tin and lead for the past eleven months, together with prices for December, 1915, and the highest prices, in most cases, for twenty years. In November, when Bessemer pig iron sold for $30.95 a ton, it surpassed its previous high record price, which was made in January, 1900. During the years that have passed since that price was obtained, the price of this iron has fluctuated greatly, but has been above $20 only during part of 1902 and 1903 and the last quarter of 1906 and most of 1907. The outbreak of the war found this metal selling for $14.90, and its price did not begin its present upward trend until the fall of 1915. Basic pig iron reached its pre-war record price in May, 1907, when it sold for $22.90 in Pittsburg. In both January and December, 1914, it sold for $12.50 a ton, and did not begin its rapid increase in price until August, 1915, when its price jumped from $12.75 to $14.06. Still, the exports of pig iron this year were greater than ever. During the eight months ending August 31, 1916, over 238,300 tons were sent abroad, compared with 127,700 tons in 1915 and 83,700 the year before. The value of this year's exports was $5,946,000.

Bessemer steel billets established a record price last March when they sold for $40.60 and, as shown in the table, they have been making a new record each month since; $60 a ton was quoted in November. Since March they have been on a parity with open-hearth billets. The previous record price for Bessemer billets was made in September, 1899, when they sold for $38.87; the price fell to $16.50 during the next year. It again passed the $20 mark the following February, and was sold for less than that only during the four months before June, 1914. In December, 1914, Bessemer steel billets brought only $19 a ton in Pittsburg, but the following fall the price was raised so rapidly that the year closed with these billets selling for $30.60 a ton. During the first eight months of this year, the value of our exports of billets, ingots and blooms of steel was $49,335,790, against $7,773,290 in the same period last year and $694,050 in 1914. This increased value of exports is due both to the increase in the amount of goods shipped, 895,000 tons in 1916 against 353,000 tons in 1915, and the great increase in price. Nearly three-fourths of these exports, or 632,700 tons, valued at $36,365,600, were sent to France, while 116,416 tons were sent to Great Britain and 63,970 tons to Canada. During the same period our imports of billets, etc., amounted to 8200 tons, as compared with 1700 tons in 1914 and 1100 tons in 1915.

Because of the great increase in the price of billets, in April the fifteen-year-old price of Bessemer steel rails was abandoned and $33 a ton was demanded for all rails delivered after May 1, 1917. The price of open-hearth rails was raised, at the same time, to $35. In November, because of the continued increase in the price of billets, these prices were again raised to $38 and $40 a ton.

The revival of ship-building is shown in the prices of plates. These reached their lowest price March, 1898, when they sold for 0.97 cent a pound. Their high record price was made in September of the following year, when it reached 2.85 cents. Since then the average price has been about 1.6 cent, though in January, 1914, they brought only 1.2 cent in Pittsburg, and in December only 1.05 cent. A year later, however, they sold for 2.04 cents a pound, and this year they have steadily in-

COMPARATIVE PRICES OF IRON, STEEL, COPPER, TIN AND LEAD

	1915 Dec.	1916 Jan.	Feb.	March	April	May	June	July	August	Sep.	Oct.	Nov.	Former Record Price
Ferro-manganese, dollars per ton	100	125	140	150	175	175	175	172.50	175	164	162	164	65
Bessemer pig iron, dollars per ton	19.85	21.32	21.45	21.55	21.95	21.95	21.95	21.95	21.95	22.20	24.32	28.45	24.90
Basic pig iron, dollars per ton	18.55	19.20	18.77	19.20	19.20	18.95	18.95	18.95	18.95	19.075	20.82	24.95	22.90
No. 2 Foundry pig iron, dollars per ton	18.55	19.95	19.51	19.45	19.45	19.325	19.45	19.45	19.45	19.50	21.075	26.40	26.85
Lake Superior charcoal iron, dollars per ton	19.15	19.25	19.50	19.75	19.75	19.75	19.75	19.75	19.75	19.75	20.35	25.75	....
Malleable Bessemer iron, dollars per ton	18.10	19.00	19.00	19.20	19.50	19.20	19.50	19.50	19.50	19.15	19.50	25.00	....
Bessemer billets, dollars per ton	30.80	33.75	34.00	40.60	45.00	44.25	41.20	40.00	43.60	45.00	45.75	55.00	38.87
Open-hearth billets, dollars per ton	30.20	34.75	35.00	40.60	45.00	44.25	41.20	40.00	43.60	45.00	45.75	55.00	....
Bessemer steel rails, dollars per ton	28.00	28.00	28.00	28.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	38.00	32.29
Beams, cents per pound	1.74	1.865	2.03	2.40	2.50	2.50	2.50	2.50	2.50	2.60	2.70	2.80	2.25
Tank plates, cents per pound	1.74	1.875	2.13	2.50	2.67	2.75	2.75	2.86	2.90	2.95	3.00	3.25	2.85
Sheets, black, No. 28, cents per pound	2.54	2.58	2.60	2.75	2.91	2.92	2.92	2.90	2.75	2.88	3.22	3.75	3.77
Wire nails, dollars per keg of 100 pounds	2.22	2.12	2.22	2.38	2.40	2.50	2.50	2.50	2.59	2.60	2.62	2.85	3.20
Heavy melting steel scrap, dollars per ton	17.40	17.50	17.37	17.95	18.12	17.12	16.25	16.25	16.00	16.12	17.87	19.25	22.00
Copper, cents per pound	20.24	24.00	26.68	27.12	28.75	28.85	27.81	20.87	26.90	28.00	28.55	29.50	24.62
Tin, cents per pound	38.53	42.09	41.80	50.15	50.37	49.25	41.81	38.15	38.48	38.56	41.17	42.25	50.34
Lead, cents per pound	5.33	5.85	6.19	7.06	7.62	7.46	6.81	6.43	6.23	6.87	7.00	7.00	6.31

Machinery

creased in value until 3.25 cents was reached in November. Beams have had a like experience, but have usually lagged a little behind. They did not reach their highest price until December, 1899, when they sold for 2.25 cents a pound. While they sold for 1.2 cent a pound at the beginning of 1914, at the close they could be obtained for 1.07 cent. A year later they were worth 1.74 cent a pound, and last November could not be obtained for less than 2.8 cents. Both plates and beams have been in great demand at home and abroad, large orders having been placed for delivery this coming year. During the first eight months of this year our exports of sheets and plates amounted to 730,983,000 pounds; 120,000,000 pounds more than in the same period of 1915 and nearly twice as much as in 1914. The value of these shipments increased from a little over $12,000,000 in 1915 to over $20,000,000 this year. Each year Canada was the best market, taking, this year, over 341,000,000 pounds; Japan was the second, having purchased over 114,000,000 pounds.

Nails and Scrap

So far, the record price of wire nails has not been surpassed; this is $3.20 for a keg of 100 pounds, which was obtained during the first three months of 1900. Wire nails were selling for $1.52 when the war began, but were not affected by the upward trend of prices until December of the following year, when they sold for $2.04 a keg. Last November they had reached $2.85 a keg. This rise in price is partly explained by the exportation of 222,524,850 pounds during the first eight months of this year, against 127,706,950 pounds in the same period last year and 43,341,100 pounds in 1914. The total value of the nails, spikes, tacks, etc., that were exported in the first eight months of this year was over $8,660,790, against a little over $3,566,000 for the same period last year.

While the exports of scrap and old iron and steel increased four-fold in the first eight months of this year over the exports of the same period for the last two years, the price of heavy melting scrap did not reach $22 a gross ton, which was paid for it in November, 1899, until the middle of November, when $25 was offered for it. In fact, until September, 1915, the prices of scrap were especially low. In November, 1914, the price of heavy melting scrap reached its lowest point in many years; it was then sold for $9.25 a ton. The 41,430 tons of scrap imported during the first eight months of this year had a value of $525,980, or about $12.80 a ton, while the 121,833 tons of scrap sold abroad had a value of $2,040,471, or $16.87 a ton.

Copper, Lead and Tin

Considerable attention has been drawn to copper by the recent inquiry for prices for 200,000,000 pounds by France, although that country is sharing with Great Britain and the other allied governments in the 448,000,000 pounds purchased during the summer months. Besides, American producers sold 400,000,000 pounds to the Allies in the first half of this year. As the domestic consumption of copper in October was 150,000,000 pounds, experts say that 2,000,000,000 pounds will not meet the demands next year, even with Germany out of the market. During November, it was said that several carloads had been sold for 32.25 cents a pound, though the regular price was 29.5 cents. In January, 1907, copper sold for 24.41 cents a pound. Except for a few months before and after that time, it did not sell for over 20 cents a pound until last December. During 1914 it steadily decreased in value until 11.73 cents was reached in October, which was the lowest price in twelve years.

In the first eight months of this year there were imported 422,820 gross tons of copper ore, matte, concentrates, etc., which gave 122,353,595 pounds of the metal. Of this, 26,655,300 pounds came from Canada, 21,285,500 pounds from Mexico, 29,349,275 pounds from Cuba, and 32,957,900 pounds from Chile. In the form of bars, pigs, plates, clippings, etc., there were imported 204,095,000 pounds. The value of all the imports during the first eight months of this year was $65,656,500. There were exported in various forms in this period, which was before any part of the large order for the allied governments was filled, 522,131,230 pounds, a decrease of 100,000,000 pounds over the same period in 1914, but an increase of 66 per cent in value.

Lead, too, has reached prices heretofore unknown, selling for 8 cents a pound during the third week of March. Selling for 4.11 cents in January, 1914, it gradually fell to 3.52 cents in October, which is the lowest it has been in twenty years. Beginning, then, its upward climb, it passed in March its previous high mark of 6.31 cents, reached in February, 1907. The imports during the first eight months of this year were but a little more than one-half that brought into the country during the same period of 1915. This was due to the conditions existing in Mexico, as the imports from that country were reduced over one-half. There were exported 126,334,370 pounds of bars, pigs, etc., an increase of only 6,340,000 pounds, but the value was over 60 per cent greater.

Tin reached its highest value in April, when it sold for 50.37 cents a pound; its previous high price was 50.34 cents, obtained in January, 1913. During the past three years, though, its price has fluctuated greatly. In one case it lost 18 cents in two months. In the first week of January, it was selling for 44 cents a pound, but its average price for the month was only 42.09 cents. It then quickly jumped to its highest point, and in September had dropped down to 38.56 cents again. In November, 42.25 cents was the selling price. There were imported into the country in the first eight months of the year 104,462,790 pounds of bars, pigs, plates, etc., and 14,794,500 pounds of ore and scrap. The amount exported was small. During this year a smelter has been opened at Perth Amboy, which obtains tin from Bolivian ores. D. E. J.

* * *

WOMEN AND GIRLS IN MACHINE SHOPS

As is well known, women and girls have been employed in the machine shops of Europe to a large extent since the outbreak of the war, on account of the need of the men at the front. The *Travelers' Standard* states that this change in industrial conditions has made it necessary to revise certain of the rules and regulations prevailing in such shops for the guidance of the employes. Following is a list of special rules that have been adopted by the Iron Trades Employers' Insurance Association, Ltd., of Scotland, for use in machine shops in which women are employed:

NOTICE

Employment of Women and Girls

1. No female worker shall be allowed to be in machine shops unless her hair is tightly done up, well secured, and confined by a tight-fitting cap of close net or of some other suitable and efficient material.

2. Further, she must wear a close-fitting overall completely covering the dress—the said overall to fasten at side or back and to include sleeves buttoned or otherwise secured at their ends.

3. Any machinist found trying a gage while her machine is running will be liable to instant dismissal.

4. Belts must be changed by a male supervisor, or a man specially appointed for that purpose, and not by the ordinary operative.

5. Machines must not be cleaned under any circumstances whatever while running.

6. No guards shall be removed from any machine without authority from the supervisor, and such guards are to be replaced and the machine inspected and passed by the supervisor before a re-start is made.

* * *

NATIONAL-ACME MFG. CO.'S INCREASE OF CAPITAL STOCK

An eastern banking firm has agreed to purchase the stock of the National-Acme Mfg. Co. of Cleveland, Ohio. The syndicate will pay $150 cash and five shares of stock, par value $50, in a company of similar name to be organized, for each of the present shares of the company. The National-Acme Mfg. Co., which builds multiple-spindle and single-spindle screw machines and manufactures machine screws, etc., has plants in Windsor, Vt., Cleveland and Montreal. It has just redeemed the issue of $1,500,000 preferred stock, and has outstanding $5,000,000 common stock. It is expected that the new company will be capitalized at $25,000,000.

LAYING OUT CHORDS OF CIRCLES

BY GUS LUCK[1]

In the shop where the writer is employed, it is frequently necessary to lay out bolt holes on circles of a number of different radii and for a great variety of spacing between the centers of adjacent bolts. The old, inefficient cut-and-try method of obtaining the required spacing for a circle of given radius, and for a given distance between the centers of adjacent bolts, was a source of constant annoyance and loss of time, which was only partially relieved by tables drawn up to give the exact chord required for the cases most frequently encountered. To avoid trouble of this kind, I developed a laying-out device which has given very satisfactory results. Reference to Figs. 1 and 2 will show that it consists of three graduated bars which are pivoted together. The two side bars are laid off in thirty-seconds of an inch for circles of various radii, while the third bar is graduated for different numbers of divisions into which it is required to divide a circle. In use, the runners *A* on the side bars are first set for the required radius of circle; then the sliding clamp *B* on the base is run along to the graduation which represents the required number of divisions in the circle, after which the clamp is tightened. The trammel points are set on the center-punch marks on the runners on the side arms, which gives the required spacing, and the circle is divided up in the usual way.

This spacing device is somewhat similar to a spider's web, from which I got the idea which led to its development. The two side arms which are graduated for different radii are pivoted together by a special hinge of the form shown in Fig. 3. To lay out the chord bar, the runners on the side arms are set at their maximum position of 10 inches. The points of the trammels are set exactly 10 inches apart, and the side arms are then spread sufficiently so that these points will enter the center-punch marks on the runners. When this setting has been obtained, the clamp on the chord bar is tightened to secure the instrument in place. It will be evident that under these conditions the included angle between the side bars is 60 degrees, and that the tram bar is set to divide the circumference of a circle of 10-inch radius into six equal spaces. Consequently, a line is scribed against runner *B* on the chord bar and this is marked 6.

For obtaining other numbers of divisions, the method of procedure is as follows: The circle of 10-inch radius is laid out and points on the tram bar are set to divide this circle into the required number of spaces; then the tram points are set in the center-punch marks on the runners on the side arms, after which the clamp of the chord bar is tightened and a line is drawn for that number of spaces.

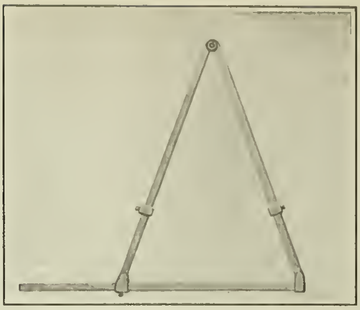


Fig. 2. Another View of Chord Setting Device

The required distance between the tram points for any number of divisions may be calculated as follows: Let N = number of spaces required and α = one-half the included angle for this number of spaces.

$$\alpha = 180 \div N$$

$$\text{Required chord} = \sin \alpha \times 2R$$

In order to explain the method, we will carry through the calculation for determining the chord for seven spaces. In this case, $N = 7$, $R = 10$ inches, and $\alpha = \frac{180}{7} =$ 25 degrees, 43 minutes.

Sin 25 degrees, 43 minutes = 0.43392.

Required chord = 0.43392 × 20 = 8.6784 inches.

It would be obviously impossible to set the trammel points accurately to four decimal places, but this calculation enables the approximate setting to be obtained more rapidly than by a cut-and-try method, and then the final adjustment may be made until exactly the required spacing is obtained.

When this instrument is used by patternmakers, the trammel points are set by a shrink rule to the required radius. Then one point is placed on the hinge center and the runners on the side bars are set to the other point. The chord that will give the required spacing is then obtained in the manner previously described.

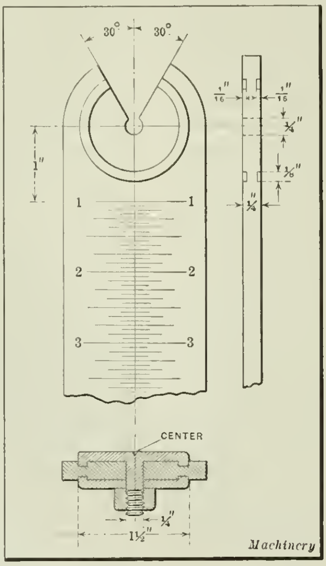


Fig. 3. Plan and Cross-section of Radius Arm Hinge

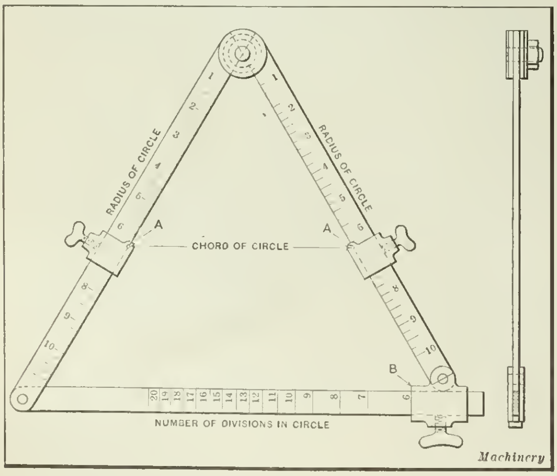


Fig. 1. Device for obtaining Chords of a Circle for Various Numbers of Spaces

[1] Address: 1140 National Ave., Milwaukee, Wis.

* * *

GREAT BRITAIN FAVORS DECIMAL SYSTEMS?

The Department of Commerce has been officially advised that the British government is considering the adoption of a uniform decimal system of weights, measures and currency, instead of the cumbersome systems now in use. At a recent meeting of the British Imperial Council of Commerce, which was attended by representatives from practically all the commercial organizations of the empire, it was decided to investigate trade conditions that would be affected by the change and also to create sentiment in favor of the change in Australia, Canada and all the British provinces. Those advocating the change claim that not only should the system of measurements be uniform throughout the empire, but that the old systems would be a handicap to the efforts to hold and increase British commerce at the close of the war, while the decimal systems would be a great advantage at that time.

* * *

The navy department will open bids December 6 for four battle cruisers, which are intended to be the most powerful of all armed cruisers. They will be 850 feet long and have a displacement of 35,000 tons. The speed required will be between 32 and 35 knots and the propelling engines will develop about 180,000 horsepower. The vessels will carry ten 14-inch guns, and will cost $20,500,000 each.

NOTES ON THE INSPECTION OF BRONZE AND BRASS[1]

Brass and bronze castings are subject to various defects that are difficult to discover by surface inspection, or even by hydrostatic testing, when such a test is practicable. The most common defect results from the inclusion of oxide in the metal of the casting. When the molten metal contains an admixture of oxides, owing to insufficient protection from the air, the entire casting is bad. The best way to discover this defect is to make tensile tests on specimens cut from a coupon cast from the same melt, as the admixture of oxide is indicated by the greatly reduced elongation and the low ultimate strength. If a tensile test is impracticable, the presence of oxide will be indicated, when a machined piece is bent, by a number of small cracks which open on the outside of the bend; if the oxidation is extreme, the surface of the fracture will also have an abnormal color.

Oxidation of metal in the crucible is a very common defect, especially in the mixtures containing a high percentage of copper; that is, the bronzes. It is the writer's belief that in foundries where tensile or hydrostatic tests are not made, the metal is in many cases allowed to become seriously oxidized in the crucible, because this defect does not show on the surface of the casting. To specify bronze castings merely by the mixture is therefore useless; the proportion of one or two of the ingredients may be decreased by oxidation. A bronze casting may be made of the correct mixture, and may show no surface indications of defects, and still be a honeycomb of metal filled with oxides.

The presence of included dross is more difficult to discover if a hydrostatic test cannot be made, and this test does not always reveal such defects. The best insurance against this defect is correct molding—a thing which, strange to say, is very unusual. This fault, however, cannot be charged entirely to the foundryman; the designer is often equally to blame. The various parts of the casting should be so arranged that they are connected by a rising channel of increasing cross-section and with a minimum of offsets to one of the risers, which should be of much greater diameter than the thickest part of the casting. Chills may be used to some extent as a substitute for this arrangement, but only when a channel of increasing dimensions is impracticable, and then only to a limited extent.

Whenever practicable, castings should be poured from the bottom. While some castings cannot be poured from the bottom, it is a question whether those poured from the top are ever entirely free from dross. In determining the position of the casting in the mold, extensive flat upper surfaces should be avoided, as dross may accumulate by being caught under the flat surfaces of the mold or core. When a flange forms the upper surface of the casting, it should be expected to contain some dross, and an adequate amount of finish should be allowed so that this dross will be entirely removed in machining.

Another source of trouble is insufficient risers. A casting may be made in accordance with the drawings and specifications, and yet contain deposits of dross which may cause it to fail under ordinary working conditions; still these defects may be such that they would not be discovered by the most careful inspection or by a hydrostatic test. In specifying brass or bronze castings the total cross-section of the risers should be given in per cent of the greatest horizontal cross-section of the casting.

Minor leaks in hydraulic casting may be stopped by peening, but the fact that the casting leaks at a certain point generally indicates that the metal is defective at this point. The belief that certain brass and bronze mixtures are normally porous and permit water to pass through them under high pressure is erroneous, at least up to a pressure of 1000 pounds per square inch. If water comes through the walls of a casting, even in minute quantities, under smaller pressures, the metal is not clean or the casting is porous from some other condition.

If the defect is small and other circumstances permit, a hole may be drilled and a plug of the same metal as the casting may be screwed in. If plugging is not practicable or permissible, defective spots should be cut out by chipping or drilling so that all the defective metal is removed. The cavity may then be filled by melting metal into it from a rod by means of a gas flame, or by pouring metal into it from a crucible. When a defective spot in a casting is welded, the cooling of the metal in the weld will be accompanied by contraction which will put a tensile stress in the metal of the weld as well as in the old metal which surrounds it. If the casting is of small lateral dimension, the ends are not constrained, and the break extends all the way across it, the stress set up in the old metal by the shrinkage of the weld is compressive, and there is therefore no danger of cracking. In all other cases, shrinkage stress must be prevented by keeping the casting heated to a very high temperature while the weld is being made and until it has solidified.

Another way to prevent cracking is to anneal the casting immediately after the weld has been made. There is no reason to believe that the metal surrounding the weld is injured by the shrinkage stress until corrosion occurs on its surface. Therefore, if the elastic limit of the metal surrounding the weld is lowered by heating the entire casting to a sufficiently high temperature, additional flow will occur, and the cooling stress will thus be gradually reduced to a minimum according to the length of time the annealing is continued. The annealing temperature should be maintained for several hours, so as to give the metal time to flow. Repairs of this kind should, of course, be made before any machining has been done, because the dimension of the casting may be appreciably affected by the shrinkage in the weld as well as by annealing. Castings which are subject to hydrostatic test should be given a preliminary test before any machining is done. A pressure of 100 pounds, or even less, will generally be sufficient to reveal defects.

In machining brass and bronze castings, trouble frequently arises from the fact that the patternmaker did not make proper allowance for minimum shrinkage. When a brass or bronze casting is constrained, shrinkage in the constrained direction is generally much less than normal shrinkage. Core or other inside dimensions, which are tied up with outside machining dimensions, should therefore not be laid out on the pattern with a shrinkage rule, but with a normal rule. The designer can aid in preventing errors of this kind by marking over-all machining dimensions of castings "Must be exact," when it is really necessary that they should be exact.

When a rod, bar, tube, or shape of brass is pulled through a die, the permanent reduction is proportionately greater at and near the surface than in the interior. The stress thus set up in the surface of drawn brass frequently exceeds the initial elastic limit, and cracking may therefore be expected when corrosion takes place. This is the reason that this defect is called "season cracking." Drawn material should therefore be immediately treated in some way to relieve the stress. This may be done by stretching the metal near the surface mechanically or by temporarily reducing its elastic limit by heating, and thus allowing it to be stretched by the compressive stress in the interior metal. It can also be done by annealing. Merica and Woodward, in a paper read before the American Institute of Metals in 1915, stated that if sufficient time is allowed for annealing, so that the metal is given ample opportunity to flow, the temperature need not be as high as it would have to be in order to eliminate initial stress by a quick annealing. The presence of initial stress in wrought brass may be detected most quickly by cutting a longitudinal slit in the end of the piece. If the initial stress is of sufficient magnitude to be objectionable, the halves of the piece will curve out to a measurable degree.

Extruded brass rods are sometimes subject to a hidden defect, namely, piping. Such rods are generally cut to length by sawing, but if the pipe is small, it will be hidden by the rubbing of the saw. The presence of this defect may be discovered by nicking the end of the rod and breaking it off.

Because brass must not be kept under stress greater than its initial elastic limit and equal to its acquired elastic limit for any considerable length of time, brass and bronze should be regarded as generally unsuitable for bolts and studs. It

[1] Abstract of a paper by Ernst Jonson read at the annual meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio.

Cutting Sprockets

like cutting gears is a particular job—the spacing must be right and the blank rigidly supported if the cutter is to form the teeth accurately—you must watch out for these points to get sprockets that work properly. And then good work must go hand in hand with fast production—your machines must give you both of these to keep up with the present pace of manufacturing and prove a profitable investment.

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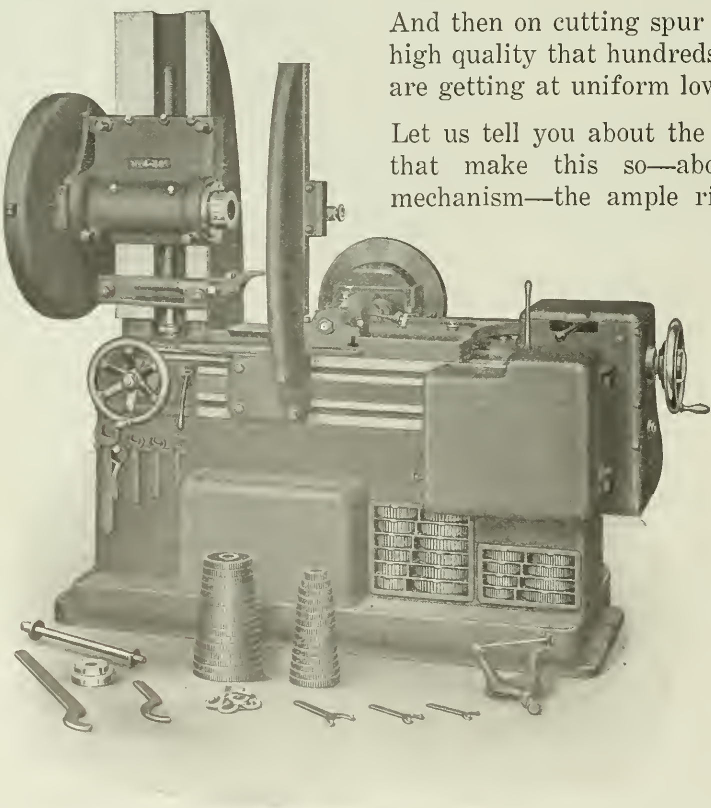
Automatic Gear Cutting Machines

are especially well fitted to handle the cutting of sprockets with a degree of speed and accuracy that will meet the production demands of every sprocket maker.



And then on cutting spur gears you can get the same high quality that hundreds of users of these machines are getting at uniform low costs.

Let us tell you about the features of these machines that make this so—about the positive indexing mechanism—the ample rigidity allowing rapid cutting — the convenient arrangement and control.

Our descriptive circulars give this—we want you to read them.

This is our No. 4 Automatic Gear Cutting Machine, a size well suited for ordinary sprocket requirements as well as for spur gears to 48-inches in diameter with 10-inch face.

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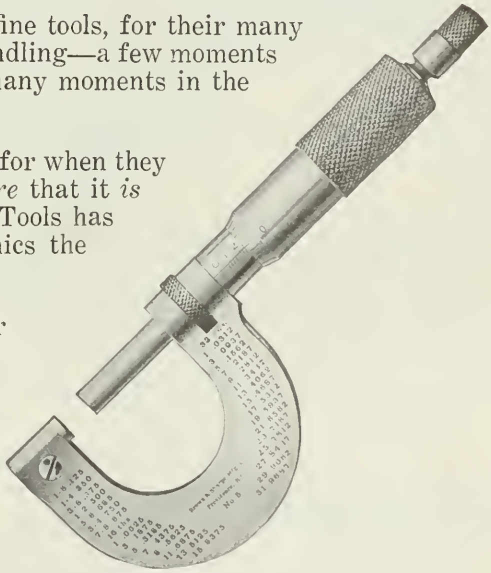

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is practically impossible to fit and tighten a bolt in such a manner that one is sure not to stress it above the initial elastic limit, at least on one side. All bolts used in flanged connections are stressed more on one side than on the other, because of the deflection of the flanges; and even under the most favorable conditions, when the connected parts are so stiff that the deflection is insignificant, brass bolts may easily be drawn up so tight that the entire cross-section at the root of the thread is stressed above the initial elastic limit. Another source of defects in brass work lies in heat-treatment by workmen unfamiliar with the properties of brass. Men accustomed to do such work on iron and steel are very likely to ruin the brass by overheating. The best insurance against trouble is to allow no brass forging to be done by men who are not experienced in this kind of work. Specifications should provide that no hot working of brass is done by those not regularly engaged in such work, and hot working should be avoided as much as possible. Brass, being very ductile, may be formed into any shape by cold working, accompanied by annealing. Large rivets must be driven hot, but flanging and other kinds of bending should be done cold. This work should be done by experienced men and in shops equipped with the necessary appliances; for instance, the flanging of circular heads should be done by pressing between dies, and in several stages, each being followed by annealing. One should not attempt to do such work on brass by hammering over a form, as is done with copper.

* * *

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

of MACHINERY, published monthly on the 1st at New York, N. Y., for October 1, 1916.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the state and county aforesaid, personally appeared Matthew J. O'Neill, who, having been duly sworn according to law, deposes and says that he is the General Manager of MACHINERY and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, The Industrial Press	140-148 Lafayette St., New York
Editor, Fred E. Rogers	" " " " "
Managing Editor, None	
Business Managers } Alexander Luchars, President	" " " " "
Business Managers } Matthew J. O'Neill, Gen'l Manager	" " " " "

2. That the owners of 1 per cent or more of the total amount of stock are:

The Industrial Press	140-148 Lafayette St., New York
Alexander Luchars	" " " " "
Matthew J. O'Neill	" " " " "
Fred E. Rogers	" " " " "
Louis Pelletier	" " " " "
Erik Oberg	" " " " "

3. That there are no bondholders, mortgagees or other security holders.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

MATTHEW J. O'NEILL, General Manager.

Sworn to and subscribed before me this 15th day of September, 1916.

THOMAS R. WILLIAMS,

(SEAL) Notary Public, New York County, No. 254.
(My commission expires March 30, 1918.)

OBITUARIES

W. K. Millholland, president of the W. K. Millholland Machine Co., Indianapolis, Ind., died October 9, aged sixty years. Mr. Millholland had acquired a varied experience as a mechanic, salesman and manufacturer. In 1909 he organized the W. K. Millholland Machine Co., which has grown from a small beginning to a concern employing over one hundred men. He is survived by a widow and seven sons, four of whom are employed in the company.

Frederick W. Hoefer, president of the Hoefer Mfg. Co., Freeport, Ill., whose death September 28 was noted in the November number, was one of the leading manufacturers of Freeport, having been established there in business for twenty-eight years. Mr. Hoefer was an inventor of wire forming machines, spring coiling machines and other machines having original characteristics. He secured patents on spring coiling machines which were on distinct principles and which gave him control of the spring coiling machinery during the life of the patents. Some years ago the Hoefer Mfg. Co. disposed of the wire forming and spring coiling machinery, and the business was afterward devoted to the manufacture of drilling machines. His widow, two daughters and a son, Chester A. Hoefer, secretary of the company, survive him.

Edward T. Hendee, secretary of Joseph T. Ryerson & Son, Chicago, Ill., died suddenly at Minneapolis, Minn., November 12, aged thirty-six years. Mr. Hendee graduated from New York University in 1900 with the degree of B.S., and afterward received the degrees of M.E. and M.S. He also received the degree of Sc.D. at Columbia University in 1901; and from 1901 to 1902 he was assistant professor of mechanical engineering at New York University. In 1902 Mr. Hendee became associated with Joseph T. Ryerson & Son of Chicago as advertising manager, in which capacity he displayed much initiative and force. He built up and became manager of the machinery department; in 1911 he was made assistant to the president, and in 1913 assumed charge of the railway supply department of the company. He was elected secretary in 1913, and continued to fill the position up to the time of his death. Under Mr. Hendee's able leadership, both the domestic and foreign machinery business and the railway supply business for the company were very widely extended. He gave loyal and indefatigable service to his company and inspired with enthusiasm everyone with whom he came in contact. The three qualities of loyalty, energy and enthusiasm were prominent factors in his remarkable success. Mr. Hendee was married in 1907 to Miss Bessie E. Comstock. His widow and two sons survive him.

Edward T. Hendee

PERSONALS

H. T. Benham has been made manager of the advertising department of E. C. Atkins & Co., Indianapolis, Ind., succeeding T. A. Carroll, resigned.

Donald Baker, who recently went with the Williams Mfg. Co., Ltd., Montreal, Canada, has been promoted to the position of assistant superintendent.

Louis Ruthenburg has been appointed general manager of the Dayton Engineering Laboratories Co., Dayton, Ohio, succeeding W. P. Anderson, resigned.

L. S. Devos, formerly purchasing agent for R. Martens & Co., 24 State St., New York City, has joined the selling force of the Selson Engineering Co., New York City.

J. O. Smith, vice-president of the American Emery Wheel Works, Providence, R. I., has resigned. Mr. Smith has made no announcement of his plans for the future.

Roy B. Dow, formerly secretary of the Cochrane-Bly Co., Rochester, N. Y., manufacturer of cold sawing machines, is now connected with the Erdle Perforating Co., Rochester, N. Y.

Lieut.-Col. A. H. W. J. Boom has announced the removal of the offices of the purchasing delegation, Government of the Netherlands, War Department, from the Hotel McAlpin to 50 E. 42nd St., New York City.

Carl E. Akeley of the American Museum of Natural History, New York City, has been awarded the John Scott medal and premium for the invention of the cement gun, a device for applying cement mortar by the use of compressed air.

Norman L. Warford, formerly with the powdered coal department of the Anaconda Copper Mining Co., Anaconda, Mont., has joined the Powdered Coal Engineering & Equipment Co. of Chicago, in the capacity of engineer in charge of construction.

A. H. Young, supervisor of labor and safety, Illinois Steel Co., South Chicago Works, has been appointed director of the American Museum of Safety, New York City, succeeding to the position made vacant by the recent removal of Dr. William H. Tolman.

Frederick Fisher has joined the R. E. Ellis Engineering Co., Inc., of Chicago, as vice-president and treasurer. Mr. Fisher was formerly associated with the Bucyrus Co. and has ac-

quired valuable experience in general shop practice as a chemical engineer.

John V. N. Dorr, president of the Dorr Cyanide Machinery Co., New York City, has been awarded the John Scott medal and premium by the Franklin Institute of Philadelphia for the invention of the Dorr classifier, the Dorr thickener and the Dorr agitator.

The John Fritz medal, awarded in January, 1916, to Dr. Elihu Thomson for his inventions and achievements in electrical engineering, will be presented to Dr. Thomson in Boston, Friday evening, December 8, 1916, in the Central Lecture Hall of the Massachusetts Institute of Technology.

R. W. Valls, formerly chief engineer and designer for the Shaw Electric Crane Co., Muskegon, Mich., has resigned his position, and has been made chief designer and manager for the crane department of the Champion Iron Co., Kenton, Ohio, which will place a line of electric traveling cranes on the market.

R. G. Clyne, for the past seven years mechanical engineer with the Western Cartridge Co., East Alton, Ill., has resigned, and will go into business for himself in St. Louis, Mo., designing and building special machinery. He has devoted over twenty-six years to the design of machinery used in the manufacture of cartridges.

George O. Smalley has been promoted to the position of first vice-president and general manager of the Bound Brook Oilless Bearing Co., Bound Brook, N. J., succeeding the late Leigh S. Bache. Mr. Smalley has been connected with the company for the past ten years, the last four years of which he was assistant general manager and assistant treasurer.

H. A. Runge of the Internations Commercial Corporation, 44 Whitehall St., New York City, has been elected vice-president in charge of machinery and heavy hardware. Mr. Runge was for a number of years connected with the export department of Manning, Maxwell & Moore, Inc. For the past fifteen years he has devoted his time to foreign trade, specializing on machinery, machine tools, railroad materials and sugar plantation machinery and supplies.

COMING EVENTS

December 5-8.—Annual meeting of the American Society of Mechanical Engineers in New York City. Engineering Societies' Bldg., 29 W. 39th St., headquarters. Calvin W. Rice, secretary.

January 6-13.—National Automobile Show in Grand Central Palace, New York City.

SOCIETIES, SCHOOLS AND COLLEGES

International Correspondence Schools, Scranton, Pa. "Manual of Information for Students," which is given to each student when he enrolls, its object being to inform the students on the correspondence system of education, instruction papers, correspondence, method of procedure, postal matters, how to study, and how to make the training received useful in obtaining a position.

NEW BOOKS AND PAMPHLETS

Some Graphical Solutions of Electric Railway Problems. By A. M. Buck. 36 pages, 6 by 9 inches. Illustrated. Published by the University of Illinois, Urbana, Ill., as Bulletin No. 90 of the Engineering Experiment Station. Price, 20 cents.

Anatomy of a Steel Hopper Bottom Coal Car. By George L. Fowler. Chart, 25 by 18 inches. Published by Norman W. Henley Publishing Co., New York City. Price, 25 cents.

This chart shows a diagram of a steel hopper bottom coal car and gives a reference list of all the parts which are indicated by numbers in the diagram. This list is arranged alphabetically and contains the names of 150 parts.

Plain and Ornamental Forging. By Ernst Schwarzkopf. 267 pages, 5 by 7½ inches. 228 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $1.50 net.

This work treats of the general properties of iron; forge and blacksmith tools; various practical exercises, including upsetting, offsetting, shouldering, drawing, forming, bending, welding and forging. It deals with the properties of steel, annealing, hardening and tempering, toolmaking, art forging, etc. It is designed primarily to assist the beginner to comprehend both the theory and practice of forge work through self-instruction, and contains much elementary and simple matter in the opening chapters.

Canadian Trade Index. 560 pages, 6¾ by 10 inches. Published by the Canadian Manufacturers' Association, Inc., Toronto, Canada. Price, $5.

The work is in three parts, the first part being an alphabetical list of Canadian manufacturers, giving also their branch offices, factories, export representatives, etc. The second part is the index proper, consisting of an alphabetical list of articles manufactured in Canada with the names and addresses of the makers. The third part, in French, gives the names of articles made in Canada with reference to the sections in which the names of the makers may be found. The work obviously is indispensable to those wishing a segregated list of Canadian products and manufacturers.

Automobile Welding with the Oxy-acetylene Flame. By M. Keith Dunham. 167 pages, 4 by 6 inches. 65 illustrations. Published by Norman W. Henley Publishing Co., New York City. Price, $1.

This little treatise on oxy-acetylene welding was written by a practical man who has had much experience in the use and design of oxy-acetylene apparatus. It should be useful to all classes of repair men, including machinists, blacksmiths, garage and service station men, millwrights, etc. The contents by chapter heads are as follows: Apparatus Knowledge; Shop Equipment and Initial Procedure; Cast Iron; Aluminum; Steel; Malleable Iron, Copper, Brass, Bronze; Carbon Burning and Other Uses of Oxygen and Acetylene; and How to Figure Cost of Welding. The book is of a size that is convenient to carry in the pocket or to keep in the tool chest of the repair man.

Liquid Measuring Pumps. By F. J. Schlink. 27 pages, 6 by 9 inches. Illustrated. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards No. 81.

This report pertains to the accuracy of liquid measuring pumps commonly used in dispensing gasoline for use in motor cars. There are several types of measuring systems in use, the most common being the piston type, which is the same in principle as the ordinary plunger pump, equipped with stops to define the volume discharged. The principal causes of short delivery are leaks in valves or piping, formation of vapor due to excessive suction lift, or the introduction of air under the piston. Of numerous measuring systems of various types chosen at random and tested by the Bureau of Standards' inspector in a number of different cities, 70 to 80 per cent had excessive errors. Figures based on the best estimates obtainable show that in Illinois the losses to users due to short measure in gasoline are not less than $530,000 annually.

Applied Electricity for Practical Men. By Arthur J. Rowland. 375 pages, 5 by 7¼ inches. 325 illustrations. Published by McGraw-Hill Book Co., Inc., New York City. Price, $2.

The book has been in process of making during twenty years' experience of the author, who is professor of electrical engineering at the Drexel Institute in Philadelphia. It was written from the standpoint of one who puts up and operates electric circuits and apparatus, and it does not treat of problems of apparatus design. Theory is avoided except as it has direct bearing upon practical matter, the aim being to make the work of greater value to practical men who wish to obtain a working knowledge of the electrical science without burdening their minds with theory of little or no use in their daily work. The book treats of fundamental principles, electromotive force and Ohm's law, magnets and magnetic flux, direct-current dynamo (electromotive force), drum armatures and multipolar machines, electric heating, electric power, direct-current systems of distribution, direct-current motors, principles of alternating current, alternating-current transformers, polyphase-current principles, alternators, alternating-current motors, other alternating-current machinery, storage batteries, electric lights, and wiring.

Melting Aluminum Chips. By H. W. Gillett and G. M. James. 88 pages, 6 by 9 inches. Published by the Bureau of Mines, Department of the Interior, Washington, D. C., as Bulletin No. 108.

This bulletin gives an account of experiments made to compare the recovery of metallic aluminum in melting down chips such as are obtained in the automobile factories in machining aluminum castings. As aluminum has sold at three times its normal price for the past year, and as a recovery of but 60 per cent of the metal in the chips is common, and a 90 per cent recovery is commercially possible, the preventable loss is of considerable magnitude. The bulletin discusses the causes of the high loss in the usual method of melting chips, and shows that the difficulty of getting the tiny globules of molten metal resulting from the fusion of the very fine chips to coalesce, when covered with a skin of oxide and dirt, is apparently the main cause for low recoveries. Two methods of melting can be successfully used to promote coalescence. In one method the chips are kept just above the fusion point and the globules made to coalesce by hand puddling, which breaks through the skin and makes the globules unite. In this method, melting is best done in an iron pot heated by oil. The other is by the use of a flux which dissolves the skin of dirt and oxide, producing clean globules which can unite. The flux suggested is 85 per cent common salt, 15 per cent fluorspar, used in large amount (20 to 30 per cent of the weight of the chips) and mixed with the chips before charging. Much higher temperatures are required by this method than by the puddling method.

Lubricating Engineers' Handbook. By John R. Battle. 333 pages, 6 by 9 inches. 114 illustrations. Published by J. B. Lippincott Co., Philadelphia, Pa. Price, $4 net.

This comprehensive reference book of data, tables and general information for the use of lubricating engineers and others concerned in the use of lubricants is a valuable contribution to engineering literature. The author declares that of all the supplies used in the operation of power plants and mills, lubricants and their practical application are the least understood, and when it is considered that not a spindle can turn without overheating and wear, the importance of lubricants may be more fully appreciated. The book treats of friction, theory of lubrication, briefly of the history of petroleum, the characteristics of petroleum and other lubricants and greases, of lubricating oil and grease tests, and includes oil data and many miscellaneous notes. Data are given on the average cost of power per horsepower year, and the lubrication of power transmission apparatus, including shafting, is taken up; also on lubricants for cutting tools and oils for quenching tools for hardening. Chapters are devoted to the lubrication of steam engines and steam turbines; oil cups, grease cups and filters; oil houses and oil-house methods; and the general forms of bearings and materials used for lining bearings. Air compressors and automobiles present special problems for the lubricating engineer, as well as coal mining machinery and Diesel engines. These are taken up in separate discussions. The work, as a whole, is thorough and comprehensive. It is profusely illustrated, and contains much valuable data useful to all classes concerned with the use of machinery and lubricants.

A Treatise on Milling and Milling Machines. 409 pages, 6 by 9 inches. 267 illustrations. Published by the Cincinnati Milling Machine Co., Cincinnati, Ohio. Price, $1.50.

This comprehensive work on milling and milling machine practice should be welcome to manufacturers and mechanics generally. Milling as a means of machining metal parts has developed broadly during the past ten years, and is generally conceded to be one of the principal methods of machining parts manufactured in quantities. The contents of the book by chapter heads follow: The Construction and Use of Milling Machines; Erection, Care and Adjustment of Milling Machines; Tool-room Millers—The Dividing Head, etc.; Setting Up the Machine; An Analysis of the Process of Milling; Milling Machine Feeds; Speeds of Milling Cutters; Stream Lubrication—Cutter and Work Cooling System; Milling Cutters—Notes on the Design and Efficiency of Modern Cutters; Cutter Sharpening; Power Required to do Milling; Various Methods of Milling; Milling Jigs and Fixtures; The Sizing and Cutting of Spur Gears; Shop Trigonometry—Bevel Gears and Their Calculation—Instructions for Cutting; Spiral Gear Cutting—Calculations, Formulas, Tables, etc.; Worm-gearing—Calculations and Methods of Cutting; Continued Fractions and Their Application to Shop Problems—Angular Indexing; Change-gears for Cutting Spirals; Cams—Tables for Setting the Milling Machine for Milling Spiral Cams; Tables of Natural Trigonometric Functions. The book is profusely illustrated with halftone and line illustrations, and well printed on good quality paper. Mathematical tables and data on gear cutting are included, making it a most valuable reference book for the mechanic concerned with milling practice in any way.

NEW CATALOGUES AND CIRCULARS

Modern Tool Co., 2nd and State Sts., Erie, Pa. Bulletin 34 on "Modern" adjustable collapsing taps.

Chicago Pneumatic Tool Co., Chicago, Ill. Bulletin 34-X, describing and illustrating "Giant" gas engines.

Kelly Reamer Co., Cleveland, Ohio. Catalogue G, treating of Kelly reamers with adjustable high-speed blades.

General Electric Co., Schenectady, N. Y. Bulletins 46101-A, 46103-A and 46104-A, descriptive of General Electric Type P, Type M, and Type G demand meters, respectively.

Rodney Hunt Machine Co., Orange, Mass. Catalogue 30 of Hunt water controlling apparatus, comprising flumes, penstocks, standpipes, relief valves, hoists and stands, trash racks, etc.

Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. Circular containing outline of shop courses in blueprint reading, shop drawing, shop mathematics, shop mechanics and practical electricity.

Wahlstrom Tool Co., 5520 Second Ave., Brooklyn, N. Y. Catalogue of Wahlstrom automatic drill chucks with positive drive. These chucks are made in two styles for straight and taper shank tools, respectively.

Wood & Safford Machine Works, 109-111 S. 6th St., Great Falls, Mont. Circular of the "Perfection" cylinder grinder which may be used on engine lathes for grinding the bore of automobile cylinders and similar work.

Southwark Foundry & Machine Co., Philadelphia, Pa. Circulars descriptive of Southwark universal flue welder, washer press, gross press for reclaiming scrap material and repairing steel cars, and hydraulic extrusion presses.

National X-Ray Reflector Co., 235 W. Jackson Blvd., Chicago, Ill., is issuing a series of detail plates illustrating installations of indirect lighting systems in banks, theaters, moving picture houses and other public buildings.

Coats Machine Tool Co., Inc., 30 Church St., New York City. Catalogue descriptive of the Coats duplex hacksaw machine which is equipped with two blades, thus doubling the production. This machine takes 270 cutting strokes per minute in mild steel.

Link-Belt Co., Chicago, Ill., has issued two new booklets describing the Link-Belt coal and ashes handling machinery which was recently installed for the Victor Talking Machine Co. at Camden, N. J., and for the W. H. Grundy Co. at Bristol, Pa., respectively.

Chicago Pneumatic Tool Co., Fisher Bldg., Chicago, Ill. Bulletin 130, treating of the lubrication of pneumatic tools. The pamphlet outlines the advantages of "Airoilene" grease and oil for this purpose, and illustrates Chicago automatic oilers and "Little Giant" grease machines.

Link-Belt Co., 39th St. and Stewart Ave., Chicago, Ill. Bulletin 282, entitled "Link-Belt Silent Chain Transmitting Power in the Dye-making Industry," illustrating Link-Belt silent chain drive installed in the plant of the Schoellkopf Aniline & Chemical Works, Inc., Buffalo, N. Y.

Moore & White Co., 2707-2737 N. 15th St., Philadelphia, Pa. Catalogue devoted to Moore & White high-speed friction clutches, containing a general description and giving dimensions and specifications of the various sizes. The catalogue also contains price lists of cast-iron pulleys made by this company.

Tate-Jones & Co., Inc., Pittsburg, Pa. Circular 149-A, treating of large and medium sized forging furnaces for heating billets for large hammer and press work and for medium sized forging work. Circular 150, illustrating small forging furnaces for forging machines, drop-hammers, forging presses, etc.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 3130 of Class ER-1 power-driven, single-stage, straight-line air compressors, which are built in sizes with from 6- to 12-inch stroke and piston displacement capacities of 52 to 955 cubic feet per minute. These compressors are equipped with the Ingersoll-Rogler type of air valve.

Gisholt Machine Co., 1209 E. Washington Ave., Madison, Wis. Circular advertising Gisholt solid-adjustable reamers, which combine the advantages of both the solid and the adjustable types. This circular gives tables of prices and dimensions for shell reamers, hand reamers and taper shank chucking reamers with high-speed steel blades.

Vanadium-Alloys Steel Co., Pittsburg, Pa. New pamphlet on "Vasco" vanadium, which is an alloy steel for tools and all purposes where toughness and durability are particularly required. The pamphlet treats of alloy steels in general and their uses, and describes the various types of "Vasco" vanadium steel. A complete list of carbon steel extras is also included.

Winfield Electric Welding Machine Co., Warren, Ohio, is bringing out a booklet describing the various electric welding processes. The book shows installations of Winfield electric welding machines in different parts of the United States, and gives information and data in connection with spot- and butt-welding that will be of interest to manufacturers in general.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 8311, treating of "Little David" pneumatic riveting hammers of the inside trigger pattern. These hammers are made in six sizes, the dimensions and specifications of which are tabulated in the catalogue. The important feature of this tool is the rivet set retainer designed to meet the regulations and requirements of the safety laws of the various states.

Watson-Stillman Co., 192 Fulton St., New York City. Catalogue 94, describing the Watson-Stillman line of hydraulic valves and fittings. Dimensions and prices are given for hydraulic pipes, hydraulic nipples, flexible metallic pipe and tubing, bushings and plugs, unions, couplings, swivels, fittings, safety valves, check valves, stop valves, operating valves, by-pass valves, regulating valves and special valves. Tables of equivalent internal sectional areas of pipes are included.

Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa. Catalogue 51, treating of cold saw cutting-off machines. The latest designs and sizes of Newton cold saw cutting-off machines are described, as well as saw blade sharpening machines, milling machines, slotting machines, rotary planing machines, keyseat milling and cottering machines, cylinder boring machines, rail drilling machines and locomotive rod boring machines. The catalogue also illustrates cold saw cutting-off machines in use in various plants.

Bellevue Industrial Furnace Co., Detroit, Mich. Catalogue 3 of Bellevue furnaces for heat-treating steel. The catalogue lists and illustrates stock sizes of Bellevue furnaces and accessories designed to supply standard equipment for all methods of metal heat-treating. These furnaces are adapted for oil or gas, according to the class of work for which they are intended. Furnaces for heating, casehardening, annealing and tempering in various styles and sizes are shown, as well as enameling ovens, kilns for testing and experimental work, fire-brick, burners, blowers, thermometers, air pressure gages and pyrometers.

Van Dorn & Dutton Co., Cleveland, Ohio, is issuing a booklet entitled "Facts About Gears" that contains suggestions as to the selection of materials for certain qualities, heat-treatment and specifications. There are also included tabulated data on gearing terms, drawings and specification formulas for every type of gearing. The contents treat of: different types of gears; facts about gears; gearing terms; how to order gears of all kinds; spur gear specifications; bevel and miter gear specifications; worms and worm-gears; sprocket specifications; Lewis' rule for strength of gear teeth; diametral pitch formulas and table; circular pitch formulas and table; decimal equivalents of parts of an inch and of fractions of millimeters; metric pitch-module; standard keyways; comparative sizes of gear teeth; weights of round steel; weights of metals; and circumferences and areas of circles. The book should be of considerable value to all gear users and may be obtained free upon request.

Star Corundum Wheel Co., Detroit, Mich. Catalogue of Star grinding wheels which are made by three distinct processes, namely, vitrified, silicate and elastic. The catalogue gives the uses of these three classes of wheels, outlines general safety requirements and gives grinding wheel speeds. Price lists are given for wheels for various standard types of grinding machines, as well as for special machines. The book also gives information on testing and inspection, selection of grades for different work, and tables of decimal equivalents, weights of wheels, etc. The Star Corundum Wheel Co. is issuing with its catalogue of grinding wheels a pamphlet containing a safety code for the use and care of abrasive wheels, which is based on the report of a special committee appointed by the National Machine Tool Builders' Association to consider safety in connection with abrasive wheels and grinding machines and a tentative report of a special committee appointed by the state of Pennsylvania to draft laws pertaining to grinding and polishing.

TRADE NOTES

Grayson Tool & Mfg. Co. has moved from Indianapolis, Ind., to Charleston, W. Va.

American Machine & Foundry Co. has moved from 346 Carroll St. to 5520 Second Ave., Brooklyn, N. Y.

Blomquist-Eck Machine & Mfg. Co., 203 St. Clair Ave., N.E., Cleveland, Ohio, has changed its name to Blomquist-Eck Machine Co.

Wausau Abrasives Co., Chicago, Ill., has established headquarters at 118 S. Clinton St., where a complete stock of goods manufactured by the company will be kept.

Bullard Machine Tool Co., Bridgeport, Conn., has insured its men and women employes, aggregating about one thousand, for various sums amounting to a total of about $500,000.

Adams-Bagnall Electric Co., Cleveland, Ohio, is installing a porcelain enameling plant to improve the quality and service of its line of porcelain enameled reflectors for industrial lighting.

C. W. Burton Griffiths & Co. of London, importers of American machine tools, who formerly had an office at 2732 Grand Central Terminal Bldg., New York City, have moved to 110 W. 40th St.

Leland-Gifford Co., Worcester, Mass., manufacturer of drilling machines, has opened an office in Room 418, Singer Bldg., 149 Broadway, New York City, in charge of Walter F. Henly, formerly with the Fairbanks Co.

Doehler Die-Casting Co., Court and Ninth Sts., Brooklyn, N. Y., has let the contract to the Turner Construction Co. for a steel and concrete addition to its Brooklyn factory, 50 by 100 feet, seven stories high, costing approximately $150,000.

Ready Tool Co., Bridgeport, Conn., has moved into its new plant at the corner of Iranistan and Railroad Aves., and is installing new machinery and equipping the plant with an electric welding machine for welding high-speed steel and stellite.

Biggs-Watterson Co., Cleveland, Ohio, has removed its office from the Hippodrome Bldg. to Rooms 721-722 of the Guardian Bldg., Cleveland. The company has also opened offices at 412 Traction Bldg., Cincinnati, Ohio; 2613 Dime Bank Bldg., Detroit, Mich.; and in Toledo, Ohio.

Patterson, Gottfried & Hunter, Inc., New York City, dealer in machinery, metals, hardware, tools and supplies, having stores at 147-151 Lafayette St. and 211-215 Center St., has opened a new store at 170 Fulton St., between Church St. and Broadway, for the convenience of downtown customers.

Charles Churchill & Co., Ltd., London, England, have issued a warning that an impostor is travelling in the United States and attempting to borrow money on the strength of his alleged relationship to one of the directors of the company. He tells the usual story about having lost his money and having become stranded.

Champion Iron Co., Kenton, Ohio, will place upon the market a full line of electric traveling cranes, and the Biggs-Watterson Co., 721-722 Guardian Bldg., Cleveland, Ohio, will act as exclusive selling agent. The Champion Iron Co. has secured the services of R. W. Valls, formerly designer and chief engineer of the Shaw Electric Crane Co., Muskegon, Mich., as chief designer and manager of the crane department.

Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio, has received an order from the Goodyear Tire & Rubber Co., Akron, Ohio, for seventy hydraulic hot plate presses, which will be used for vulcanizing purposes in the Goodyear rubber plant in Akron. They will be operated by hydraulic pump and accumulator systems already installed. The presses are all of one design and have a pressure capacity of 115 tons each.

S. K. F. Ball Bearing Co., Hartford, Conn., has been awarded the contract for the self-aligning ball bearing hangers and pillow blocks specified for use throughout the new plant of the Courtenay Mfg. Co. of Newry, S. C. The order is said to be the largest ever placed in the United States for ball bearing hangers and pillow blocks to be installed in one mill. The sizes range from bearings for 6-inch shafts down to 1 11/16-inch shafts.

Becker Milling Machine Co., Hyde Park, Mass., states that the report of the sale of the company to the Manufacturers Co. of Boston is misleading. The deal was the sale by Eugene N. Foss, president, of his stock in the company to Robert F. Herrick; the price alleged to have been paid is $2,000,000. The Becker Milling Machine Co. will continue the same as usual, and additions will be made to the plant at an early date. There will be no change in the organization or the policy of the company.

Modern Tool Co., 2nd and State Sts., Erie, Pa., manufacturer of grinding machines and threading tools, has appointed Leo C. Steinle direct representative in France, with offices at Paris and Lyons. Mr. Steinle is actively connected with the Steinle Turret Machine Co. of Madison, Wis., whose interests he is also caring for abroad. R. H. Wood has been made manager of the company's district office, 32 N. Clinton St., Chicago, Ill. Mr. Wood was for a number of years connected with the Buffalo office of the Warner & Swasey Co.

N. & W. Tool Co., 284 Asylum St., Hartford, Conn., was organized by A. T. Nielsen and A. E. Wilson early in this year to specialize in punch and die work. The demand for general tool work became so great, however, that the concern has branched out. It is equipped to do almost everything required in the general line of tools, jigs, fixtures and die work. Mr. Nielsen acquired his experience with the Moller, Jorkumsen Co. at Horsens, Denmark, and Mr. Wilson was formerly with the Pratt & Whitney Co.

R. E. Ellis Engineering Co., Inc., 549 Washington Blvd., Chicago, Ill., has secured the representation of the Hannifin Mfg. Co., maker of air-operated chucks and equipment; Murchey Machine & Tool Co., maker of automatic die-heads and collapsing taps; Kelly Reamer Co., maker of reamers and boring-bars; Tate-Jones & Co., Inc., maker of oil and gas burning furnaces; Bury Compressor Co., maker of air compressors; Hoefer Mfg. Co., maker of auxiliary multiple-spindle drill heads; Standard Electric Tool Co., maker of portable electric drills and grinders; Acme Die-Casting Corporation, maker of die-castings in aluminum and standard alloys.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa., announces that a group of bankers has acquired a controlling interest in the company. These bankers also own a substantial interest in the S. K. F. Ball Bearing Co. of Hartford, Conn., but the two companies will be operated independently of each other. The former policy of the Hess-Bright Mfg. Co. will be continued except that its manufacturing facilities will be increased somewhat to meet the constantly growing demand for its product. F. E. Bright retires from active participation in the company's affairs, but remains chairman of the board. Aside from this change, the organization remains as before.

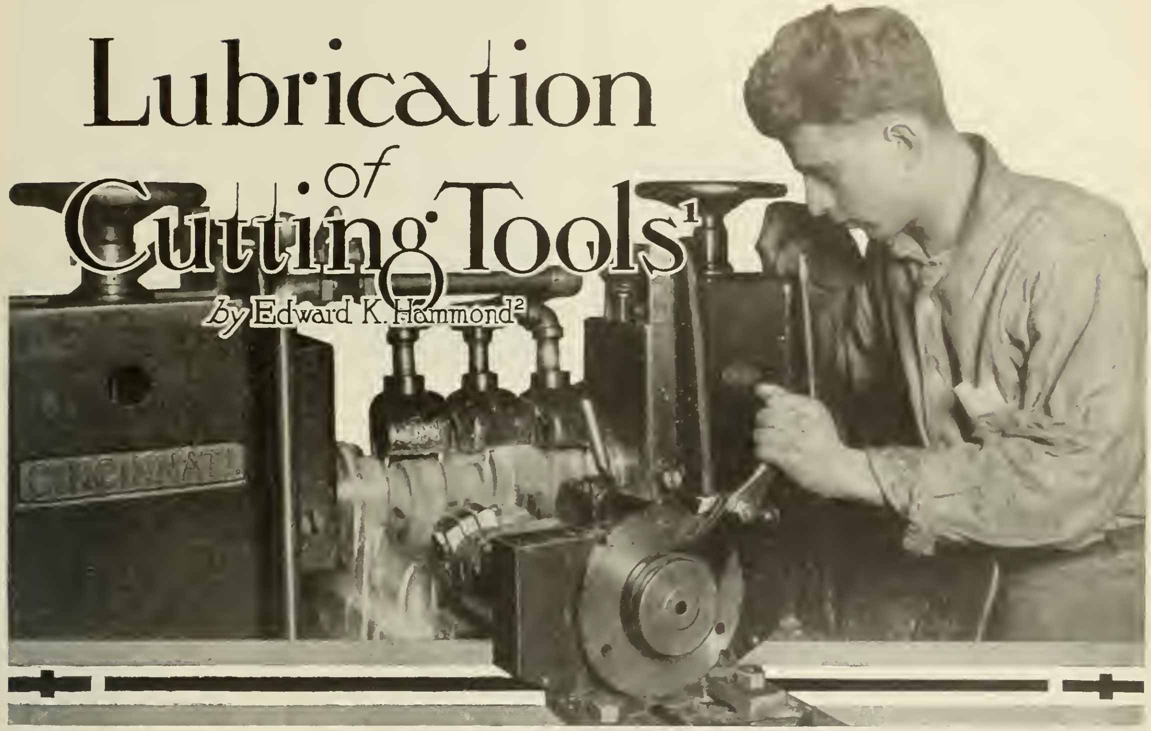
American Committee, Lyons Sample Fair, Lyons, France, has issued a booklet giving rates and other essential data relating to the Lyons Sample Fair, which will be held at Lyons, France, March 1 to 15, 1917. The aim and object of the various committees is to bring together at the next annual Lyons Fair a large and representative gathering of manufacturers and wholesale buyers from countries all over the world, with the exception of the enemies of France; this will be an opportunity for placing American goods before buyers from Europe, South America and the Orient. Those who are interested can obtain further information from the National Headquarters, 1790 Broadway, New York City.

Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio, has found it necessary to make immediate plant and equipment extensions owing to the demand for its hydraulic presses, pumps, valves, accumulators and intensifiers. An addition 60 by 100 feet will be made to the machine shop to relieve the crowded condition, and considerable new equipment will be required for the addition, including a twenty-ton electric traveling crane, large motor-driven horizontal boring mill, and heavy-duty motor-driven planer. A 20-foot extension will be added to the power house building, and some new power plant equipment will be installed. The main stock-room will be extended and another story added, and a new structural shop about 50 by 60 feet will be erected. The plans also provide for an extension of the present erecting shop building measuring 47 by 130 feet. Brick and concrete construction with steel superstructure will be employed throughout.

George Schow, Ovre Slotsgate 7, Christiania, Norway, has consolidated his Russian and Scandinavian interests with A/S Netco, Northern Engineering & Trading Co. The capital has been increased to 1,500,000 crowns in order to take care of the growing business. The company's headquarters will be, as before, at Christiania; the president of the company is Halfdan Steen-Hansen, and F. Morch-Reiersen, Jr., is the managing director of the Norwegian office. The company has opened branch offices in Petrograd, Russia, in charge of Fedor Andrejevitsch Bystrom; in Moscow and Samara, Russia, in charge of Kort Kopke; and also in Stockholm, Sweden, with Captain Erik Cronvall as the managing director. Branch offices will be opened in Copenhagen, Denmark, in the near future. The New York office is in charge of Ingvar Tokstad, president of the Normanna Co., Inc., who is also the secretary of the Norwegian-American Chamber of Commerce. Mr. Schow is general manager of agencies for all the countries referred to, and their work will be under his personal supervision.

Lubrication of Cutting Tools[1]

by Edward K. Hammond[2]



The characteristics and uses of oils and compounds for cooling and lubricating metal cutting tools will be discussed in a series of articles, of which this is the first. These articles will deal with the theory of lubricating and cooling, methods of distributing, means for applying to the tool and work, methods of collecting after use, recovering oil from chips, methods of filtering and sterilizing, practice in conducting shop and laboratory tests, detailed information concerning oils and compounds used for various machining operations on different metals, specifications for the purchase of oils and compounds, and many other phases of this highly important but heretofore neglected subject.

IN making inquiry concerning current practice in the lubrication of metal cutting tools, it is surprising to find that in many factories where the most modern methods of manufacturing are employed, little exact information is available concerning the theory of tool lubrication. This is doubtless due to the fact that there are so many variable factors that it is hard to separate them and obtain data which would place the subject of tool lubrication on a scientific basis. It must not be inferred from this statement that practice in tool lubrication is generally of a character that produces inefficient results, although this is doubtless true in many cases; but a great number of manufacturers have been content simply to experiment with different oil mixtures and cutting compounds until they have found those which meet the requirements of different classes of work, and then continue their use without having definite assurance that the results secured are the best obtainable, as regards either cost or efficiency.

Functions of Oils and Cutting Compounds

Oil or cutting compound is delivered to a tool in order to increase production, to give longer life to the cutting tool, and in some cases to secure a better finish on the work. The functions of an oil or cutting compound may be presented under five heads: (1) To cool the work and cutter. (2) To wash away chips. (3) To lubricate the bearing formed between the chip and lip of the cutting tool. (4) To enable the cutting tool to produce a good finish. (5) To protect the finished product from rust and corrosion. Each of these functions is quite broad and prevents trouble from a large number of causes.

1. Cooling Tool and Work

The cooling action is the most important function. During the performance of any machining operation generation of heat is due to friction between the tool and work, and to distortion of the chips. This results in raising the temperature of both the cutting tool and the work; and if provision is not made for the removal of this heat, the temperature may become so excessive that the cutting edge of the tool breaks down. This means that there will be a great deal of time lost in stopping machines to change tools and in redressing and regrinding the worn-out tools. Another important consideration is the possibility of having the temperature of the work raised so that it expands considerably during the machining operation, and while the tools may continue to produce parts of the required size when measured at this high temperature, the work will contract on cooling so that it will be under size. It is evident, then, that manufacturers should pay careful attention to the selection of suitable cutting oils and compounds for use in cooling their cutting tools. (The term "lubricant" is commonly applied to a fluid used on metal cutting tools, but as the cooling action of this fluid is by far its most important function, the term "coolant" is more strictly accurate.)

2. Washing Away Chips

In deep-hole drilling, milling and certain other machining operations, ability of the oil or cutting compound to wash away chips is a matter of great importance. For drilling deep holes the tool is ground in such a way that the chips are broken up into short pieces and the fluid is delivered in sufficient volume and under a high enough pressure so that the chips are washed out of the hole. Similarly, in milling and certain other operations there would be a tendency for chips to accumulate around the cutter and retard its action unless the cutting compound provided for washing them away. Unless high pressure is needed to facilitate washing away the chips, the fluid should be delivered at low pressure, as the

[1] For other articles published in MACHINERY dealing with the cooling and lubricating of metal cutting tools, see also "Lubricating Systems for Cutting Tools," January and February, 1914; "Graphite Cutting Compound," June, 1910; and "On the Art of Cutting Metals," published serially from January to August, 1907, inclusive.

[2] Associate Editor of MACHINERY.

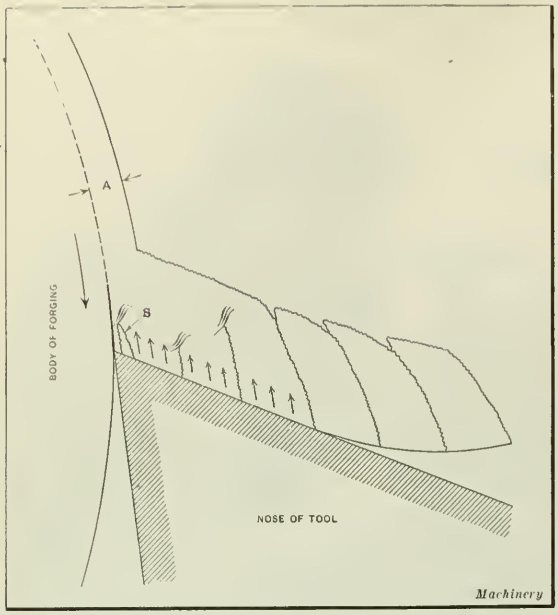


Fig. 1. Conditions under which Chip is removed, showing Possibility of Lubricating Action

results obtained in cooling and lubricating will then be more efficient.

3. Lubrication

The lubricating action is of little importance in machining such materials as cast iron, aluminum, high-carbon steel and some grades of brass, because the chips produced either break up into very small pieces or the material is removed in the form of a powder. As a result, there is little rubbing contact between the chip and tool lip, and so there is not much possibility for improving the operating conditions by the introduction of a lubricant. In such cases, the cooling action is the point of greatest importance. As compared with this condition, lubrication is highly important when machining such materials as low-carbon steel, etc., where long chips are produced that curl back over the lip of the tool. In such cases a bearing is produced in which the frictional resistance is severe, and unless the oil or cutting compound is an efficient lubricant as well as coolant, this friction will result in rapidly wearing out the tool.

The ultimate cause of a tool wearing out is due to dullness produced by rubbing or pressure of the chip upon the lip surface of the tool. The chief element causing this dullness—especially when the tool is running at high speed—is softening of the tool due to heat produced by friction of the chip upon the lip surface. In addition to friction between the chip and lip of the tool, heat developed in cutting is also due to distortion of the chip after it is parted from the work. When machining large pieces, most of the heat is conducted away by the work, but sufficient heat will often be absorbed by the tool to result in its rapid destruction unless a suitable lubricant is applied to reduce friction between the chip and lip of the tool, and to absorb heat developed in cutting. It is generally conceded that there is metallic contact between the cutting edge of a tool and the work, and as friction decreases with increased speed it will be evident that both this frictional resistance and friction between the chip and lip of the tool is reduced by increasing the speed. Hence, if drills and other tools tend to break, it is well to try an increase of speed rather than a reduction of speed, provided that heat developed by the cut is not already excessive. Such a practice results in reducing the load on the tool, and will often be the means of overcoming trouble from broken tools. In many cases the opposite practice is followed, *i. e.*, the speed is reduced, which results in increasing the friction and consequent load on the tool, so that breakage of tools becomes more frequent.

Considerable diversity of opinion exists concerning the possibility of oil affording a lubricating action for the bearing between the lip of a tool and the chip. It is fairly certain that absolute metal-to-metal contact exists between the work and the cutting edge of the tool; but as oils are less efficient cooling mediums than cutting compounds dissolved in water, on account of their lower specific heats, it is assumed that the superiority of oil where long curly chips are produced is due to their lubricating action between chip and tool lip. Granting the accuracy of this premise, it will be of interest to consider briefly the conditions which exist in removing a chip from the work. No better information on this subject is available than that presented by F. W. Taylor in his paper entitled "On the Art of Cutting Metals."

Removal of the chip by a metal cutting tool is due to pressure applied by the lip of the tool and is essentially a shearing action. The conditions are shown in Fig. 1, in which *A* represents the depth of cut or thickness of the layer of metal being cut away. The shearing action causes the metal to part, producing an open space at *B*, and the great pressure applied by the tool lip (indicated by arrows) causes the chip to be distorted in such a way that its thickness becomes approximately twice that indicated at *A*. The portion of the chip running over the lip of the tool acts as a lever which assists in tearing off subsequent sections of the chip. It will be evident that the pressure exerted by the tool is extremely high, in some cases amounting to as much as 100,000 pounds per square inch. Many believe that this high pressure would make it utterly impossible for an oil film to be maintained, as a pressure of approximately 1000 pounds per square inch is regarded as the maximum for journal bearings, etc., in which lubricating oil is used of about the same viscosity as that of oils used on cutting tools.

Probably the true explanation is found in the fact that the tool is kept flooded with oil which is not repelled by heat of the tool, as would be the case with water, and that the chip is continually sliding back over the tool lip. As a result, oil penetrates into space *B* that is produced in tearing the chip

Fig. 2. Use of Brush for applying Oil to Thread Cutting Tool

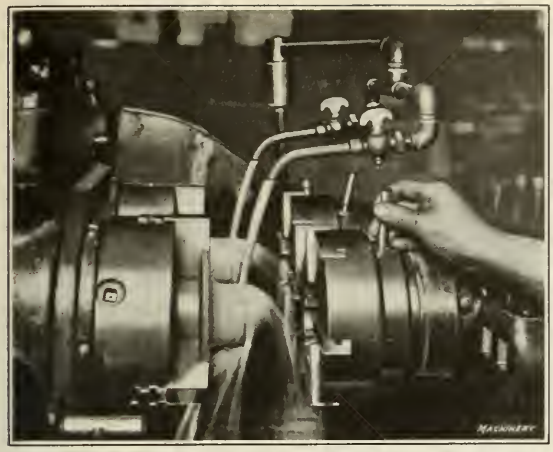


Fig. 3. Method of delivering Lubricant to Threading Dies

from the work and is drawn back into the bearing. Were it not for the continuous supply of oil covering the chip and the constant tendency of the chip to draw oil back with it—an action which is facilitated by the rough surface of the chip—the excessive pressure would doubtless result in destroying the oil film; but under existing conditions it is probable that at least a partial lubrication of this bearing between chip and tool lip is effected. It will be evident from Fig. 1 that the severe pressure and rubbing action on the tool takes place on the lip at a point some distance back from the cutting edge; after tearing off the chip there is a slight amount of metal to the left of space *B* which is cut away by the edge of the tool, and here it seems certain that no lubricating action is obtained, although the oil exerts a beneficial effect by absorbing heat.

4. Securing a Good Finish

There are certain classes of work where an equally good finish will be obtained whether the metal is cut dry or a lubricant is applied to the tool, but when obtaining a good finish for the work is dependent upon the use of an oil or cutting compound, only a small film is actually required at the cutting tool. In most cases, however, the fluid is also depended upon to enable a higher speed, feed and depth of cut to be employed than could be used if the work were machined dry. As a result, it is usually necessary to deliver a far greater volume of fluid to the tool and work than would actually be required so far as considerations of finish are concerned. This is due to several causes, among which may be mentioned necessity of cooling the tools and work, avoiding overheating the oil or cutting compound, and insuring the delivery of a sufficient volume so that there will not be occasional periods of dry cutting.

5. Protection from Rust and Corrosion

As regards protection of the finished product from rust and corrosion, it is well known that good cutting oils will prevent rusting of parts made from iron or steel, but cutting oils containing lard oil with too high a percentage of free fatty acid will cause verdigris to form on brass parts. This is a matter of importance and should receive consideration in drawing up specifications for cutting oils. Mixtures containing vegetable oils do not have this injurious action, but they are likely to give trouble through gumming the bearings of automatic machines; this is particularly marked in oil mixtures containing highly blown rape or cottonseed oil. Cutting compounds made by dissolving soluble oils in water may give trouble by causing iron and steel products to rust, provided the solution is too weak or contains free acid; and poor cutting compounds may also give trouble through gumming.

Historical

In 1883 Fred W. Taylor demonstrated that a heavy stream of water poured directly upon the chip at the point where it is removed from the steel forging would permit of employing a higher cutting speed, thus increasing the rate of production from 30 to 40 per cent. In 1884 a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part, each machine being set in a wrought-iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting) that was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well, whence it was pumped to an overhead tank from which a system of supply pipes led to each machine. Up to that time, so far as the writer knows, the use of water for cooling tools was confined to small cans or tanks from which only a minute stream was allowed to trickle upon the tool and work, more for the purpose of obtaining a "water finish" on the work than with the object of cooling the tool. In spite of the fact that the shops of the Midvale Steel Works (until recently) have been open to the public since 1884, no other shop in this country was similarly fitted up until that of the Bethlehem Steel Co. in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Works.

The use of water or a water solution of soda for the cooling of cutting tools demonstrated that great increases in the rate of production were possible through their application. In many cases, however, the use of either pure water or soda water proved unsatisfactory, and experiments disclosed the fact that delivery of certain grades of oil to the work and tool was the means of securing far better results. It was found that lard oil was one of the most satisfactory mediums for this purpose, and there are still many manufacturers who regard this as the best lubricant for the majority of cutting tools.

The use of lard oil is limited by two important considerations, namely, its high cost and its tendency to gum, causing machine members to stick and pipes to clog. With the view of overcoming these difficulties and of providing a compound which would combine the functions of lubricant and coolant, and would be obtainable at a lower price than pure lard oil, the chemist turned his attention to the possibility of combining mixtures of cheaper oils and water. The first successful cutting compounds of this kind were introduced in about 1900.

Tool Lubricants and Coolants

A great variety of oils and cutting compounds are used for lubricating and cooling metal cutting tools; these may be roughly subdivided into two general classes. The first consists of either pure lard oil, sperm oil, etc.; a mixture of lard oil with certain mineral and vegetable oils; and pure mineral oil or pure vegetable oil. Pure lard oil, a mixture of lard and mineral oil, and pure mineral oil are the most commonly used

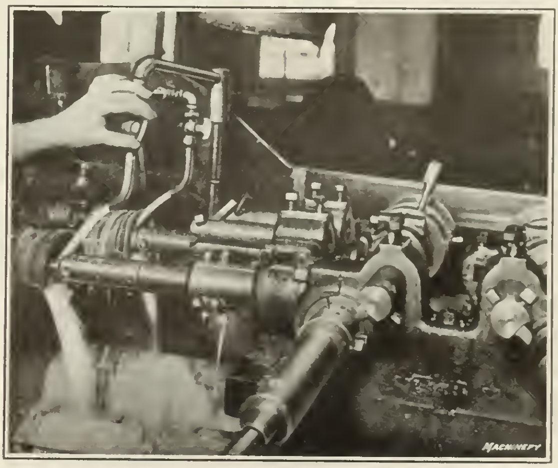


Fig. 4. Same Delivery Tubes as in Fig. 3, adjusted to deflect Flow of Lubricant into Work

Fig. 5. Delivery of Cutting Compound to Two Cutters on Lincoln Milling Machine where Cutters are close together

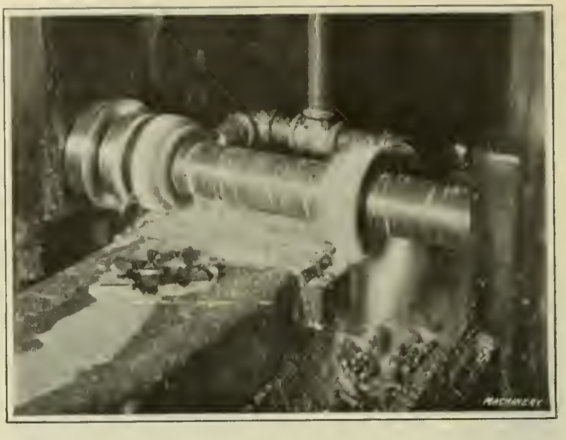


Fig. 6. Another Example of Milling Cutter Lubrication, where Cutters are spaced Some Distance apart

members of this class. The second class consists of the so-called cutting compounds which are water emulsions of soap, oil and other ingredients to prevent the water from causing rust or corrosion and to afford some lubricating action. Originally a saturated water solution of soda was used for this purpose, but this had little more than a cooling effect, and it has now been largely replaced by the so-called soluble oil compounds, which offer a certain degree of lubricating action in addition to their cooling effect. Most of these so-called solutions are really emulsions in which oil is suspended in the water, and to secure this effect the cutting compounds are made up somewhat as follows: Caustic soda or caustic potash is added to an animal oil in order to form soap, which is soluble in water. This soap is then mixed with mineral oil in the desired proportions and the mixture is added to the required volume of water. Made up in this way, the mineral oil is held in suspension in the water in the form of an emulsion, but if an attempt were made to mix mineral oil and water without the addition of soluble soap, the mineral oil would rise to the top, due to its lower specific gravity, and it would be impossible to obtain a uniform mixture. Uniformity of the emulsion is a point of the greatest importance in these cutting compounds, as separation of the oil and water may result in delivering pure water to the tools, thus causing damage by washing oil out of the machine bearings, and by rusting the machine and work.

For all classes of work except that in which the amount of heat generated by the cut is high, thus making the cooling action of the lubricant very important, there is probably no better medium for lubricating and cooling metal cutting tools than pure lard oil. This should be of high quality, however, as poor grades of lard oil contain considerable amounts of free fatty acid, which tends to produce verdigris on brass parts, cause corrosion of other metals, and damage the bearings of machine tools. An excessive amount of free fatty acid will also result in gumming. One well-known manufacturer purchases lard oil under specifications calling for not more than 15 per cent of free fatty acid. The use of lard oil, as previously stated, is limited by its high cost, which is about seventy cents a gallon under normal market conditions, and it was to find a less costly material which led to the introduction of mixtures of lard oil with petroleum oil, and later to the application of pure mineral oil and other inexpensive oils on certain classes of work where such substitutes would give satisfactory results.

Soluble oil compounds dissolved in water represent a step farther in the direction of price reduction, as these solutions can be produced at a low cost—ranging from about 1½ to 16 cents per gallon, according to the degree of dilution—and many firms have gone into the manufacture of these compounds. Their low cost makes cutting compounds especially valuable for use in such industries as bolt and nut manufacture where competition is keen and where the cost of production must be cut down as low as possible. Also for milling, drilling and many other machining operations the soluble compounds give entirely satisfactory results, and their low cost is a strong point in their favor. Attention is called to the fact that to give satisfactory results these compounds must be carefully made from high-grade materials. Otherwise they are likely to give trouble by rusting the work, washing oil out of machine bearings, and gumming slides and other moving parts.

Each manufacturer has his own special formulas for use in making these compounds, but the following is a typical mixture: Caustic soda, 0.65 per cent; alcohol and water, 5.80 per cent; resin acid, 1.64 per cent; fatty acids, 11.76 per cent; mineral oil of 22.5 Baumé specific gravity, 80.15 per cent. This mixture is dissolved in water, the degree of dilution being dependent on the nature of the machining operation and the kind of metal being machined.

Fig. 7. Nut Taps flooded with Cutting Compound to insure Thorough Cooling

Fig. 8. Multiple Lubricant Pipes with Delivery Tubes arranged to direct Fluid into Tools

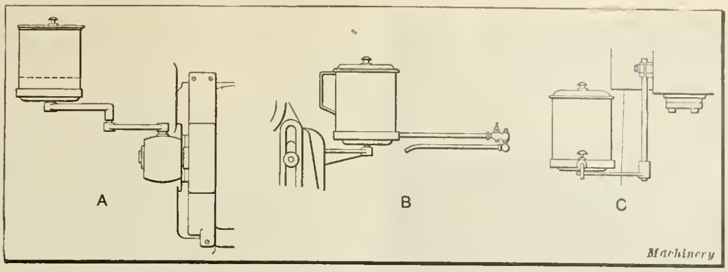


Fig. 9. Three Methods of supporting Drip Cans which afford Adjustment of Position for Delivery Pipe

Purchase of Cutting Oils and Compounds

There are many machine shops using oils and compounds on metal cutting tools that do not have adequate facilities for testing to determine the purity of cutting compounds and their suitability for handling the work for which they are intended. The best course for proprietors of such shops to follow is to deal with manufacturers of oils and cutting compounds of known reputation. Many different mixtures of oils and numerous cutting compounds appear identical, so that there is always a temptation for a buyer to favor the one that he can secure at the most advantageous price. But the experience of machine shop managers confirms the soundness of making a practice of purchasing a high-grade oil or compound produced in a factory with facilities for testing raw materials and mixing them in such a way as to insure their meeting the purchaser's requirements. Also, such factories have an established reputation that is a particularly valuable business asset in the sale of oils and cutting compounds, and one that they will not be likely to risk losing for the sake of making unfair profits. Complaints are frequently made of unsatisfactory results obtained from mixed oils and cutting compounds sold ready for use. If these were carefully investigated, it would often be found that the trouble was due to one of two causes: either the customer was buying an oil or compound unsuited for his work, or he was making his purchase from an unreliable firm that was selling him an inferior substitute instead of that for which he was paying.

Factors Influencing Selection of Oils and Cutting Compounds

It has been stated that so many variable conditions enter into the cooling and lubricating of cutting tools that it is difficult to secure exact information concerning the action of an oil or compound on the tools. Certain general facts have been established, however, and these form the basis which governs the selection of a suitable lubricant to use in different cases. One of these is the condition under which the machine is operated. A low speed and shallow cut means that little lubricating action is necessary, while a low speed and heavy cut—especially in cases where the material is tough—means that the fluid must possess great lubricating power, and so the use of oil is advisable. Operating at high speed and taking a shallow cut calls for a fluid possessing superior cooling properties, and for this work cutting emulsions are used, due to their high capacity for absorbing heat; if even a low viscosity cutting oil were employed, the friction and heat developed would cause excessive heating of the tools and finished work with troubles from this cause to which reference has already been made. Operating under high speed and heavy cut calls for a fluid with both cooling and lubricating properties. For this purpose a heavily compounded cutting emulsion should be used, because the water solution most effectively dissipates the heat, and by heavily compounding the solution a fairly effective lubricating action is obtained.

The effect of the kind of chips produced in cutting different classes of metals upon the requirements of an oil or cutting compound has been briefly referred to, and in addition it may be mentioned that the selection will be governed to some extent by the hardness of the metal. The selection will also be affected by the character of the machine, as well as the conditions of speed and the depth of cut under which it is operated.

Methods of Applying Lubricant to Tools

There are a variety of methods of delivering lubricant to cutting tools, and each has its particular field of application. These methods run all the way from the use of a squirt can or brush, with which lubricant is applied to the tool, up to a central distributing station equipped with pumps for delivering oil through pipe lines to all the machines in the factory, a system of piping for returning the lubricant, and filters and sterilizers for purifying the returned oil. The squirt can and brush are still used in certain cases for lubricating small taps, end mills, threading tools, etc., and for this purpose give fairly satisfactory results. The next step in the development of methods of supplying lubricant consists of a small drip can, mounted on the machine, from which oil or cutting compound is allowed to trickle by gravity to the tool and work. These cans are usually provided with a wire gauze strainer to remove chips and suspended impurities from the lubricant. After flowing over the work, the lubricant is caught in a second can, suspended under the machine, and from time to time its contents are poured back into the drip can ready for subsequent use. Various methods are used for suspending drip cans on machines in order to provide adjustment for delivering the fluid to the required position, and Fig. 9 shows three typical examples. At *A* it will be seen that the can is mounted on a jointed bracket, which can be swung on its pivots in order to bring the can and delivery pipe into the desired position. The can shown at *B* is carried by a fixed bracket, but the delivery pipe is jointed to afford adjustment. At *C* the can is suspended on a bracket held by a vertical rod in a split clamp, providing both vertical and horizontal adjustment of position. Methods of this kind for supplying lubricant are still used in factories where the tools work under such conditions that the coolant or lubricant does not need to be delivered in a large volume. Their only claim to favor is that they are inexpensive.

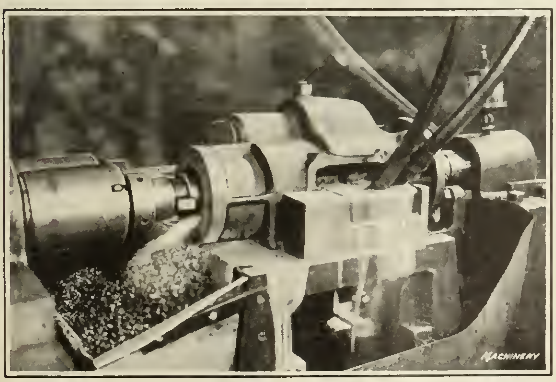


Fig. 10. Flexible Tubes for delivering Lubricant to Work

Fig. 11. Lubrication of a Facing Tool

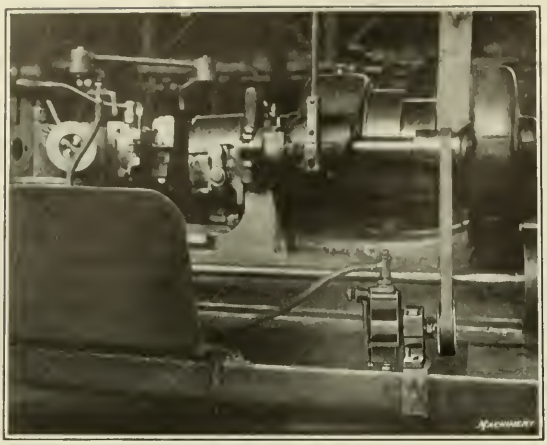


Fig. 12. Geared Pump in Use, showing Method of mounting, driving and delivering Lubricant to Work

Provision of Individual Pumps on Machines

When a considerable volume of oil or cutting compound is required for the work, the drip can is unsatisfactory, due to the necessity of frequently emptying the can; and this led to the development of individual pumps for use on machine tools. Four typical classes of pumps are used for this purpose, and these are (named in the order in which they are most generally applied) the geared, wing, plunger and centrifugal types. Each of these will be described in detail under individual headings. In all cases, too much emphasis cannot be laid upon the necessity of having the pump and delivery pipe of ample capacity to supply a copious flow of lubricant to the tools and work. The average size of delivery pipes on machine tools runs from 1/4 to 3/4 inch, but the latter should be made the minimum and means provided to regulate the volume of lubricant delivered by the pump according to the requirements of the work. Many cases of failure to secure satisfactory results are due to the inability of the pipe to deliver the required volume of lubricant at low pressure, rather than to the unsuitability of the lubricant. A large delivery pipe provides for the delivery of a copious flow of lubricant at low pressure, which is the ideal condition, as regards both the cooling and lubricating

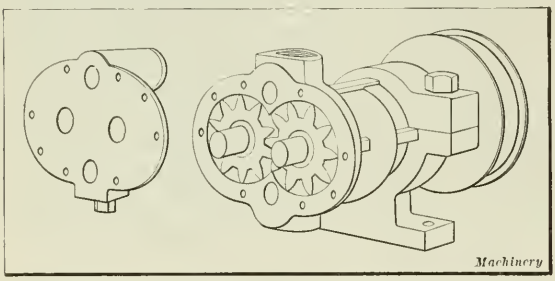


Fig. 13. Geared Pump made by Goulds Mfg. Co., showing Arrangement of Gears

action of the fluid. In addition to the importance of keeping down the temperature of lubricants so that they may exert the desired cooling action, low temperature is of great importance from the standpoint of pump efficiency. If the temperature is allowed to rise to such a degree that vapor is given off from the lubricant, it is likely to interrupt the pump suction. In order to be sure of efficient operation of pumps it is also necessary to keep the inlet to the suction pipe well below the surface of the reservoir. This is also a matter of importance due to the fact that drawing air into the pipe may cause oxidation of the oil which produces a sludge that will tend to clog the pipes and give trouble in other ways.

The Geared Pump

The commonest form of lubricant pump used on machine tools equipped with a tank and pump, consists of the rotary geared pump which is so well known that it requires little description. The pumps can be made to deliver lubricant when running in either direction, thus adapting them for use on machines where reversal is required to back off threading dies, etc.

Several methods are used for driving geared pumps, the most common of which is by a belt from the countershaft or a pulley on the machine, or by direct-connected gearing. The claims made for the geared type of pump are that it affords a positive pressure without fluctuation in the rate of delivery. In pumps of this type made by C. F. Roper & Co., Hopedale, Mass., and by other firms, provision is made against loss of prime so that any liquid from water up to the heavier oils may be easily pumped without the necessity of priming the pump. The compact form of these pumps is a point in their favor.

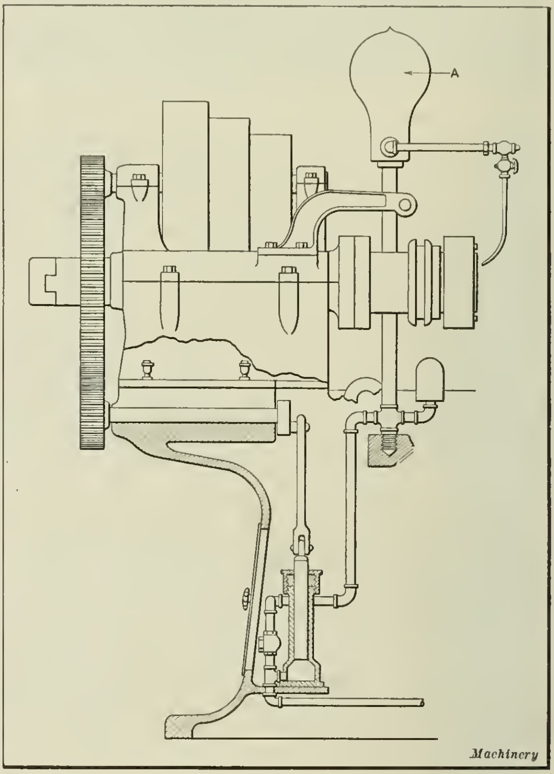


Fig. 14. Use of Plunger Pump on Bolt Threader made by National Machinery Co.

One of the geared pumps is illustrated in use in Fig. 12; and Fig. 13 shows the mechanism of this pump. Reference to the latter illustration shows that the lubricant drawn through the suction pipe is carried around in the spaces between the gear teeth and the pump chamber. This lubricant is forced out through the discharge pipe to the tools on the machine. To obtain the best results, the pump should be placed as near as possible to the level of the lubricant in the tank. This type of pump is capable of working with a suction lift of from three to four feet without priming, and will develop considerable pressure when this is necessary for washing away chips. A by-pass is provided in the pump to enable the operator to

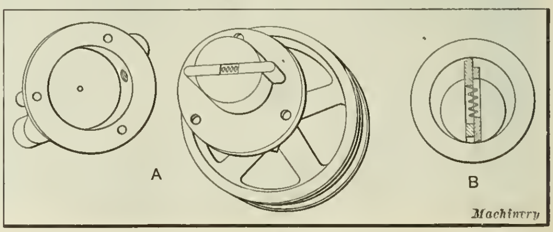


Fig. 15. Two Styles of Wing Pumps; at B is shown Means of obtaining Pressure Relief

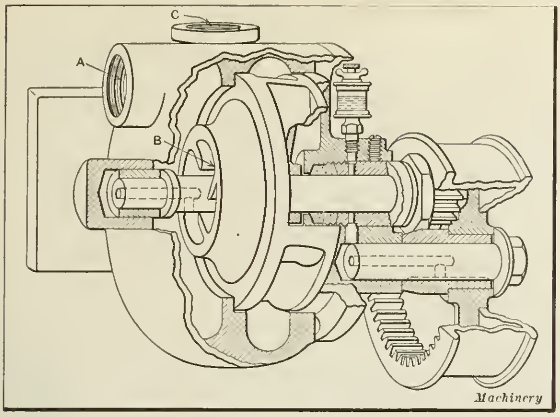


Fig. 16. "Fulflo" Centrifugal Pump made by Cincinnati Lubricant Pump Co.

regulate the volume of fluid delivered. To give an idea of the capacity of these pumps it may be mentioned that the Goulds Mfg. Co., Seneca Falls, N. Y., builds geared pumps in two sizes which are known as Nos. 1 and 2. Operating at speeds of from 200 to 500 revolutions per minute, the No. 1 pump has a capacity for one and one-half to four gallons per minute, working through suction and discharge pipes ½ inch in size; under the same conditions of speed the No. 2 pump has a capacity for delivering from four to ten gallons per minute when working through ¾-inch suction and discharge pipes.

Wing Type of Pump

Fig. 15 shows two examples of the wing type of pump which is used extensively on machine tools. This pump consists of a revolving stem which is set eccentric to the bore of the pump

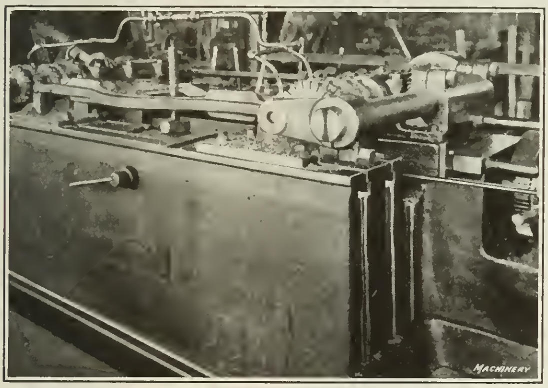


Fig. 17. Arrangement of Pipes to deliver Cutting Compound to Two Gangs of Milling Cutters

chamber, thus leaving a space at one side which contains the fluid being pumped. This type of pump delivers a large volume of oil when running at about 100 revolutions per minute, and on account of this low speed it requires very little attention. It will be seen that the revolving stem is slotted to receive a pair of flat plates or wings which are forced apart by springs. As the stem rotates, the ends of these wings remain in contact with the inside of the pump chamber, thus drawing fluid in and discharging it in one direction or the other according to the direction in which the stem rotates; this makes the wing type of pump suitable for delivering lubricant to tools on automatic screw machines, etc., where reversal of direction of rotation is often necessary. Pumps of this type will develop sufficient suction to lift fluid a slight distance, but it is better practice to have the pump submerged in order to avoid the necessity of priming. In the type of pump shown at *B* in Fig. 15, it will be noted that the wings are tapered at the ends so that when a full discharge is not required, pressure of the liquid will force the wings back, thus making a relief or overflow valve unnecessary. The simplicity of all parts of wing pumps enables them to run for a long time without getting out of order. The same methods are employed in driving these pumps as in driving geared pumps.

Reciprocating or Plunger Type of Pump

Fig. 14 illustrates the use of a plunger pump for circulating oil or cutting compound on a bolt cutting machine made by the National Machinery Co. of Tiffin, Ohio. Pumps of this kind are used in various sizes and with different numbers of cylinders according to the volume of cutting compound to be delivered. In the case illustrated the pump has an adjustable stroke to provide for varying the volume of lubricant delivered

Fig. 18. Delivery of Cutting Lubricant on Lathe with Two Turning Tools

to the tools, and a safety overflow valve relieves back pressure in case the valve on the spout is closed while the machine is in motion. To avoid "pulsations" which would otherwise result from the use of plunger pumps, it is good practice to insert an air bell *A* in the delivery line which forms a cushion that takes up inequalities in pressure. In the case of multiple plunger pumps the cranks are equally spaced around the crank circle so that the variations of pressure in the cylinders tend to compensate for each other. This condition is shown diagrammatically in connection with the description of plunger pumps for central distributing stations.

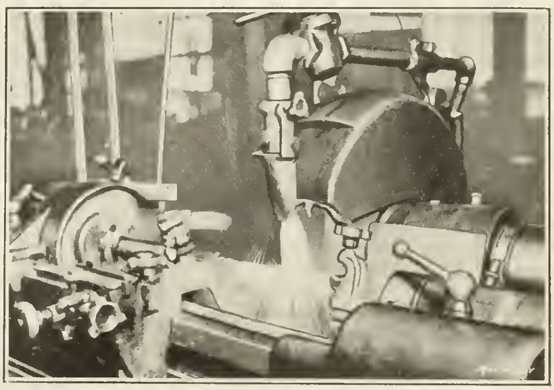


Fig. 19. Adjustable Deflector for delivering Coolant to Grinding Wheel and Work

In the plant of the Crucible Steel Co. of America at Harrison, N. J., triplex plunger pumps, 4 by 6 inches in size, with capacities for displacing forty gallons of oil per minute, are used for the lubrication of tools on shell boring lathes. One pump is used for two machines, the pump and lubricant supply being contained in a pit in the concrete into which the lubricant is returned after being strained.

Centrifugal Type of Pump

As the name implies, the operation of centrifugal pumps is based on the action of centrifugal force. They are provided with an impeller which consists of a wheel having passages into which fluid is drawn from the suction pipe, carried around inside the pump case and expelled into the discharge pipe through the action of centrifugal force. An important point in their favor is that these pumps are capable of delivering a large volume of fluid at low pressure.

The Cincinnati Lubricant Pump Co., Cincinnati, Ohio, makes a small centrifugal pump, shown in Fig. 16, for delivering oil or cutting compound to tools where an individual distributing system is used on each machine. The important features of this pump are that at no point is the channel through which lubricant passes smaller than the ¾-inch suction and delivery pipes, and hence there is practically no chance for the pump to become clogged. Small chips and grit carried by the fluid will not damage this pump, and there are no parts that are likely to get out of order. Also, the design is such that the pump cannot lose its prime, as both inlet and outlet are above the pump level and there is always enough fluid in the pump to start it. Lubricant is drawn in through suction pipe *A* and finds its way into the impeller through spaces *B* around the bearing; then the impeller expels the fluid into the delivery pipe *C*. To regulate the flow it is merely necessary to open or close a stop-cock at the outlet; with this exception there is no valve in the pump or piping. The operator does not need to leave his work to regulate the flow of coolant. The following gives the capacity in gallons per minute for different pump pulley speeds when operating under a suction lift of 12 inches and a head lift of 4 feet, which is about the maximum requirement for machine tool installations: 300 R.P.M., five gallons; 350 R.P.M., ten gallons; 400 R.P.M., fifteen gallons; 450 R.P.M., eighteen gallons. To obtain a greater volume for these suction and head lifts or the same volume for increased lifts, it is simply necessary to increase the pump pulley speed.

When the design does not prevent loss of prime, it is good practice to have the pump submerged in the reservoir to avoid the necessity of priming. On grinding machines where this practice is followed, running bearings should be protected from gritty water. On milling machines built by the Cincinnati Milling Machine Co., where flooded lubrication is required, centrifugal pumps are used that are capable of delivering eleven gallons of cutting compound when running at 1150 revolutions per minute. This washes away the chips.

Delivery of Lubricant to Tools on Moving Carriages

Provision of piping to deliver lubricant from the pump to the cutting tool is most easily taken care of in those cases where no adjustment is required to take care of feed movements, etc. It frequently happens, however, that the tool carriage has to be traversed through a considerable distance, which necessitates special means for delivering the lubricant to the work. One of the simplest methods of handling this problem is to use a flexible metal tube to connect the moving carriage and the supply pipe on the machine, and this gives very satisfactory results, except that when the tube is very long and in an exposed position, it is likely to get in the operator's way.

In many cases use may be made of telescopic tubes which furnish the necessary compensation for the movement of the tool carriage. Two such arrangements are shown at *A* and *B* in Fig. 20. A partial view of the back of a turret lathe is illustrated at *A*, on which there is a fixed bracket *a* provided with a stuffing-box through which pipe *b* slides as the saddle moves on the bed of the machine. Pipe *b*, which delivers oil to the cutting tools, projects back into pipe *c* which is of somewhat larger diameter, and oil is delivered into this pipe through tube *d* which makes connection with the pump. At *B* is illustrated the method of compensation provided on the oil delivery system for the reciprocating carriage of a gear-cutting machine. In this case use is also made of two telescopic tubes connected by a stuffing-box *e*, of which an enlarged view is shown. Oil is delivered from the pump through the pipe *f* and thence through small pipe *g* to flexible tube *h* on the carriage.

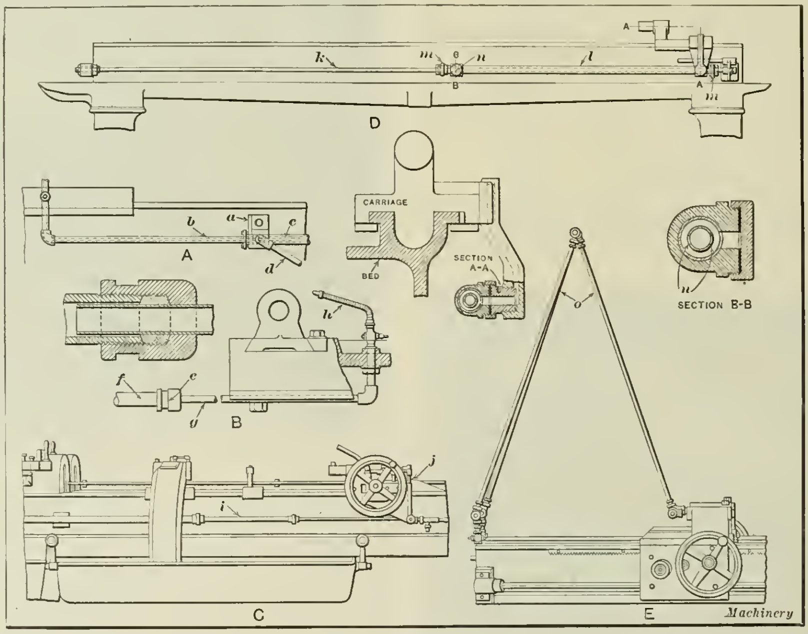


Fig. 20. Methods of delivering Lubricant to Tools where Compensation is required for Movement of Machine Members

In the case of the rifle barrel drilling machine illustrated at *C*, considerable compensation is required because the feed motion of the carriage is through a distance somewhat greater than thirty inches. This compensation is furnished by telescopic tubes *i* from which connection is made by pipe *j* to the hollow barrel drill, through which oil is delivered to the cutting point. In order to be effective in washing chips out of the hole, oil must be delivered to the barrel drills at a pressure of about 800 pounds per square inch. In some cases this pressure causes trouble by throwing the carriage back with great violence when the half-nuts on the lead-screw are released to return the carriage while there is still pressure in tube *i*. The machines are equipped with a spring at the end of the machine bed to absorb shock when the carriage is accidentally thrown back in this way, but in many cases the effect of the spring is insufficient to give the desired result.

To overcome this difficulty a rather ingenious method was developed, as shown at *D*. Instead of using telescopic tubes oil is delivered through a small tube *k* connected with the oil supply at the left-hand end of the machine; this tube runs the entire length of the bed and is capped at the right-hand end. Sliding over tube *k* is a larger tube *l* with a stuffing-box

m at each end and a connection at each end to provide for passing oil to the tube supported in the machine carriage. Oil escapes through a hole *n* in inner tube *k* into outer tube *l* and thence to the carriage; and it will be evident that the pressure inside the larger tube is balanced in all directions so that there is no danger of the carriage being thrown back through pressure remaining in the tube when the half-nuts are released from the lead-screw. As shown at *D*, the left-hand carriage connection is capped and the carriage is connected to the right-hand end of tube *l* to adapt the machine for drilling long barrels; for drilling short work with short drills the carriage would be connected to the left-hand end of tube *l*.

A substitute for the telescopic tube arrangement shown at *C* is illustrated at *E*, which will be seen to consist of two jointed tubes *o* leading to the carriages of a duplex rifle barrel drilling machine. As the carriages are fed forward the middle joints of these hinged tubes drop toward the bed of the machine, thus providing the necessary movement of the carriage without interfering with the oil supply.

Nozzles and Distributing Devices

The efficiency of the results obtained in cooling and lubricating cutting tools is largely governed by the form and size of nozzle through which the lubricant is delivered, the direction and position in which it is applied, the pressure at which it is delivered, and the volume of lubricant applied to the tool and work. If one or more of these factors is defective, it may be the cause of unsatisfactory results. The size of the lubricant delivery nozzle is important because this governs the volume delivered at a given pressure, and the form of nozzle is responsible to a large extent for the manner in which the lubricant is distributed over the tool and work. In all cases the aim should be to deliver the lubricant in such a way that it will keep a constant supply at all points on which the tools are working, and this volume should be ample to provide for cooling the tools and work and prevent the lubricant from becoming too warm.

Proper Direction in Which to Deliver Fluid

In early experiments conducted by F. W. Taylor in the use of a stream of water for cooling cutting tools, the first plan adopted was to deliver a stream of water up between the clearance flank of the tool and the work so that the water would almost reach the cutting edge of the tool at the point where the greatest cooling action is required. Mr. Taylor was so confident of the soundness of this theory that he did not at first deem it worth while to experiment with throwing streams of water in any other way, but some months later he tried the plan of throwing a stream of water upon the chip directly at the point where it is removed from the work, and found that a material increase in cutting speed could be employed under these conditions. In applying water in this way for cooling tools used in the performance of manufacturing operations, Mr. Taylor found that when a sufficiently heavy stream of water was thrown upon the work to give the desired cooling action, it had a tendency to splash more than when thrown upon the forging just above the chip, and to avoid discomfort mechanics would change the position of the delivery pipes unless care was taken to prevent this practice. Mr. Taylor was the first to find that the most satisfactory results were obtained by delivering a large volume of water at low pressure to exactly the required position, because water delivered in this way will cover a large area and will not tend to rebound from the work, thus exerting its maximum effect as a coolant.

The direction in which the fluid is applied should always be selected with the view of obtaining a location where it will remain on the work long enough to have the maximum effect, that is to say, where there will not be a great tendency to throw the lubricant; and this is particularly desirable in the case of high-speed machinery such as grinding machines, because the fluid may actually be thrown clear of the work, onto the operator and the floor surrounding the machine. In this connection the pressure at which the fluid is applied is also very important; if the pressure is too high there will be a tendency for the fluid to rebound upon striking the work, so that it will not have the maximum effect in cooling and lubricating. If, on the other hand, the pressure is low, the fluid is enabled to remain on the work, thus absorbing heat and lubricating the bearing between the chip and lip of the tool. The best practice in tool lubrication calls for the delivery of a large volume of fluid at low pressure, and as oils and cutting compounds are now being purified so that they can be used continuously, this use of a large volume of even high-priced oil involves only a moderate increase in investment in oil upon which the overhead charge is not likely to be excessive.

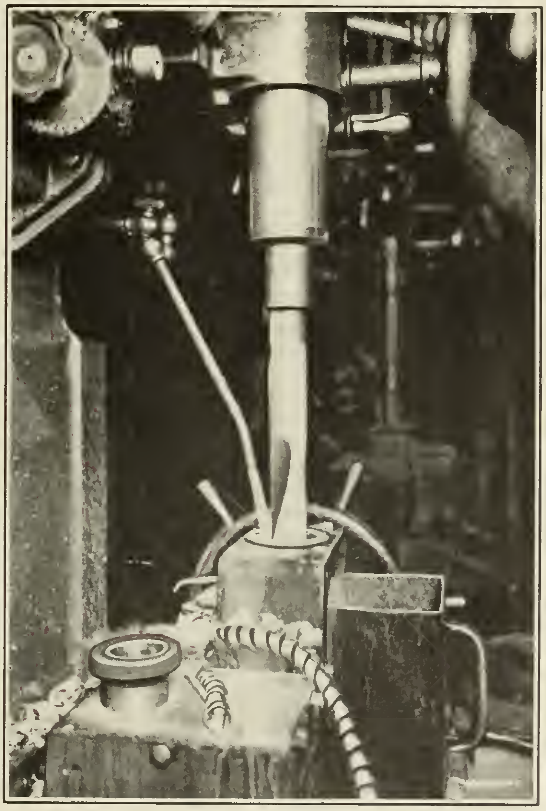


Fig. 21. Delivery of Coolant to a Large Twist Drill

Forms of Nozzles and Distributing Devices

In delivering lubricant to the tools it is obviously important to apply it at exactly the points where cooling and lubrication are required, and for this purpose many different forms of delivery tubes and nozzles are employed. Typical examples of such devices are illustrated in Figs. 22 and 23. For single-point cutting tools, narrow milling cutters, drills, etc., a pipe with a single outlet is all that is necessary, but two or more outlets are required for gangs of cutters and multiple tools unless a wide spout is used. The simplest arrangement available is a plain pipe with an open end. In most cases, however, it is necessary to provide adjustment for locating the nozzle in the desired position relative to the work. At *A* it will be seen that the pipe is hinged to provide for swinging the nozzle into place over the work. Another good example of this kind is illustrated at *B*, which consists of a small faucet supported by a rod clamped in such a way that both vertical and horizontal adjustment are obtained. Connection between the faucet and supply pipe is made by a flexible tube. A similar example is shown at *C* in which the faucet is supported by a clamp carried by a rod screwed into a tapped hole in a machine boss or similar member. The delivery pipe shown at *D* is provided with what might properly be called universal adjustment, as the first section of pipe has a ball and socket joint which enables it to be swung in practically any direction, while the second section of pipe slides in and out to give the desired length. An arrangement for delivering lubricant to a bolt threading die is shown at *E*, where it will be seen that the vertical nozzle may be swung around the

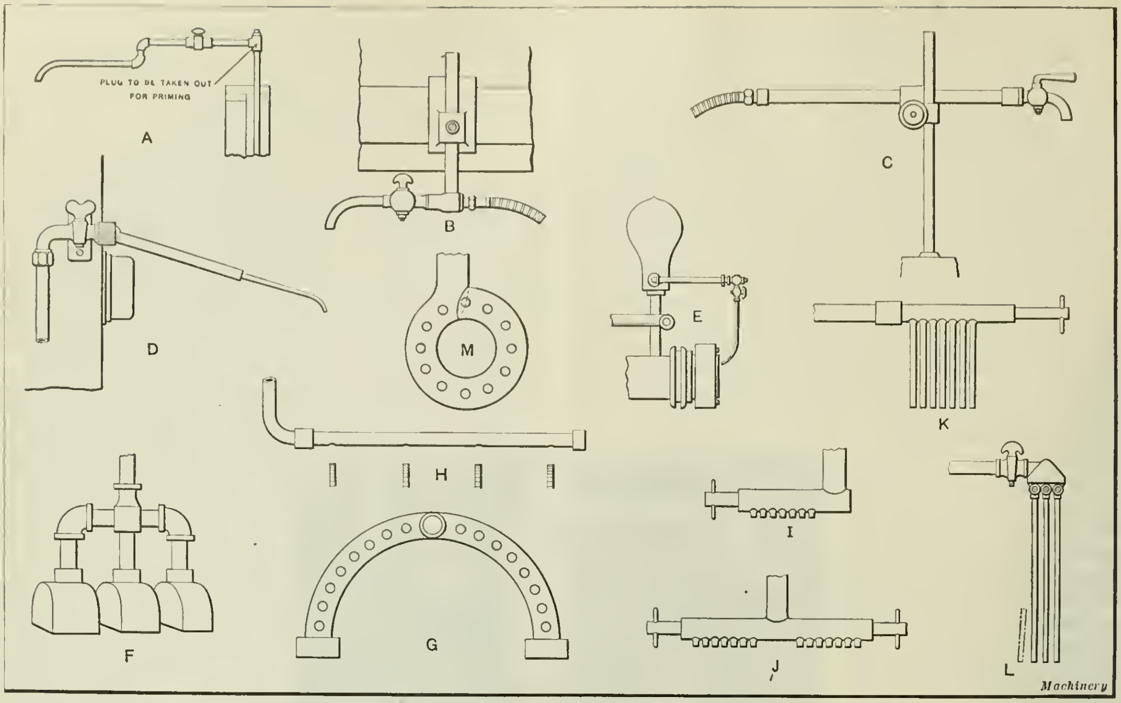


Fig. 22. Miscellaneous Examples of Nozzles and Delivery Tubes for supplying Lubricant to Tools

horizontal delivery pipe to obtain the desired radial position, and this nozzle is bent to direct the flow of lubricant into the die. The supply is delivered by a plunger pump and the air bell provides for absorbing the effect of pulsations and obtaining a uniform pressure.

In the performance of heavy milling operations, flooded lubrication of the cutters is highly important. In milling, the chips are usually short, and so friction between the cutter teeth and chips is not likely to be very great. In such cases the fluid acts as a coolant rather than a lubricant; and to keep the fluid on the work use is made of shields at the end of the delivery pipe which drop down over the cutters in such a way that any fluid which is thrown up is caught by these shields and drops back onto the tool and work. An example of this form of delivery pipe and shield is shown at *F*. In another section of this article reference will be made to the use of compressed air for cooling work and tools. In order to distribute the air over the cutter so that it may exert the maximum cooling action, the delivery pipe is constructed as shown at *G*. At each side of the cutter there is a pipe bent to the same curvature as the cutter. A series of holes is drilled in the pipe corresponding to the spacing of the cutter teeth so that air flows onto the tool and prevents the steel from becoming overheated. Another device for delivering fluid to milling cutters is shown at *H*, which consists of a horizontal pipe with holes drilled in it to correspond to locations of a gang of four milling cutters. Such an arrangement proves satisfactory provided the pipe and holes are of ample size to deliver the required volume of fluid.

For delivering lubricant to multiple turning tools such as those used on the Fitchburg "Lo-swing" lathe, and similar cases where it is required to obtain considerable distribution of the fluid, delivery tubes of the form shown at *I*, *J* and *K* may be advantageously employed. It will be seen that these consist of horizontal pipes to which delivery nozzles are connected, and the spacing and length of these nozzles may be varied according to the requirements. In handling different classes of work, there will be different numbers of tools in use, and in order to adapt these delivery pipes to the requirements of various cases, sliding plugs are provided in one or both ends, which may be moved to shut off the supply of lubricant to those nozzles which are not required. A somewhat similar arrangement is shown at *L* except that in this case the delivery tubes are pivoted in order that the adjustment of each tube may be regulated according to the position in which it is required to apply the lubricant. At *M* is shown a good method of delivering lubricant to drills, end-mills and similar tools that are doing heavy work. The ring pipe surrounds the tool and delivers the fluid in a practically continuous circle, through holes which are inclined inward toward the tool. A device is shown at *N* which was developed for use in delivering fluid to hacksaw blades and other similar tools. It will be seen that this consists of a pipe with a cap at one end and a valve at the other which provides for turning on or off the entire supply of fluid. Holes drilled along the pipe allow the lubricant to escape onto a sheet-metal plate *a* over which it flows to the saw and work. This device was especially developed for delivering lubricant to hacksaw blades and is placed in such a position that plate *a* comes up against the side of the blade, thus distributing the lubricant uniformly.

At *O* is shown a method of delivering oil or cutting compound to several tools. This will be seen to consist of an inner tube connected to the supply pipe with an outer tube which is a sliding fit over it. The bearing between the inner and outer tubes is a close fit in order to be leak-proof. Drilled in both tubes is a series of unequally spaced holes located in such a way that when the outer tube is slid along, different numbers of holes in the inner and outer tubes will come into coincidence in order to allow for the escape of oil or cutting compound at these points. For instance, in the position shown there are three openings, but if the outer tube were moved to the right through a distance equal to one space between holes, it would result in providing four openings. Pipes of this kind may be made with different spacing of holes for delivering lubricant to different combinations of tools.

The delivery pipe shown at *P* is adapted for supplying cutting compound to multiple tools, and is a substitute for the one shown at *O*. In the present case it will be seen that a single capped pipe is used in which a series of holes has been drilled and tapped. Screws are furnished to plug up these holes and the necessary number of screws can be removed in those positions where it is required to deliver cutting compound to the tools. Still another method of securing the same result is shown at *Q*; in this case holes are also drilled in the pipe, but spring clips made of sheet steel surround the pipe, and by twisting the clips around so that the opening

between the ends of the clip exposes the necessary number of holes the cutting compound can be delivered to a number of tools.

At *R* is shown a somewhat similar idea for the lubrication of gangs of tools and for use in cases where it is desired to deliver lubricant over a considerable area. A delivery tube of this form would be used for supplying fluid to multiple turning tools and similar cases. It will be seen that each outlet is provided with a small cock which can be turned on and off according to the positions at which it is desired to deliver fluid. At *S* and *T* are shown two methods of delivering lubricant to tools on screw machines and turret lathes. The method shown at *S* will be seen to consist of a double supply pipe, one branch leading to the center of the turret for carrying lubricant direct to the points of oil-tube tools, and the other delivering lubricant to other kinds of tools held in the turret. A somewhat similar arrangement is shown at *T*, where it will be seen that the first branch of the pipe delivers oil into a funnel which communicates with the center of the turret to supply oil-tube tools, while a branch pipe carries lubricant to forming tools, etc.

In handling automatic screw machine work where there are a number of tools working at the same time, the problem of delivering oil is somewhat more difficult, as it is required to supply the proper amount of oil to all tools and still prevent delivering it at intermediate points where no tools are in operation. The latter consideration makes it impractical to use a pipe with a long orifice which extends across the full length of the piece on which the tools are working. A typical example is shown at *U*, and this also illustrates a satisfactory device. Suppose we have a piece of work of the form shown on which the small diameter is being turned down by a box-tool, while a forming tool is at work on the left-hand end of the piece. It is required to deliver oil to both the box-tool and forming tool, but if oil is also delivered on the intermediate diameter on which no work is being done it will result in a reduction of the supply of oil available at those points where lubricant is required. A simple and efficient method of overcoming the difficulty is to have a horizontal pipe with holes drilled in it through which oil can flow onto the forming tool and box-tool, but with no holes drilled in the intermediate space where the bar is not being machined. This idea is capable of extension to cover a great variety of cases.

In delivering lubricant to a milling cutter of considerable width or to a hob it is necessary to distribute the fluid over the entire width of the tool, and in cases of this kind use may be made of the forms of nozzles shown at *V* and *W*, both of which provide for distributing the fluid over a considerable area. It will be seen that nozzle *V* is of the so-called "closed" type and this is used in a vertical position; nozzle *W* is open at one side and is usually employed where the delivery pipe comes to the cutter in a horizontal or slightly inclined position. Where desired, both of these types of nozzles may be supported on a clamp and the end of the regular delivery pipe dropped into them in order to avoid changing the standard form of pipe, which is required on the machine for handling many classes of work.

Probably there is no device for delivering lubricant to cutting tools which is capable of more general application than the well known flexible metallic tube that may be connected to the delivery pipe on the machine and bent to deliver lubricant to the tools and work in exactly the desired position and direction. Tubes of this kind are made in different standard lengths so that they may be coupled onto the machines, and they make a very convenient method for applying lubricant to drills, lathe tools, etc., where the fluid is not required to be distributed over a wide area; such tubes also may be used to advantage for connecting the machine supply pipe with different forms of nozzles, examples of this kind being shown at *B* and *C*, Fig 22.

At *X* is shown a method of lubricating twist drills used for drilling thin metal plates *b* on a drill press not provided with means for circulating the lubricant. When this job was first turned over to the machine operator he was instructed to lubricate the drill from time to time with oil from a squirt can, but this method proved slow and tedious, and the operator devised the substitute shown in this illustration. It will be seen to consist of a shallow pan *c* filled with oil and a support *d* over this pan which holds work *b* ready for drilling. Support *d* has a hole drilled in it, and after passing through the work the tip of the drill dips into the oil before its travel is stopped. In this way the drill is provided with a supply of lubricant each time it completes cutting one hole and none of the operator's time is taken up in applying oil with a brush or squirt can.

Methods of Delivering Coolants to Grinding Wheels

Various forms of nozzles and distributors are used for delivering coolants to grinding wheels and work that is being ground. A number of devices for this purpose are illustrated in Fig. 24. At *A* is shown one of the simplest methods of delivering coolant to a grinding wheel; it will be seen that this consists of a pipe *a* arranged to throw the fluid tangentially against the wheel at the point where it is in contact with the work. A shut-off cock *b* provides for stopping the flow of coolant when so desired. This device is used on the

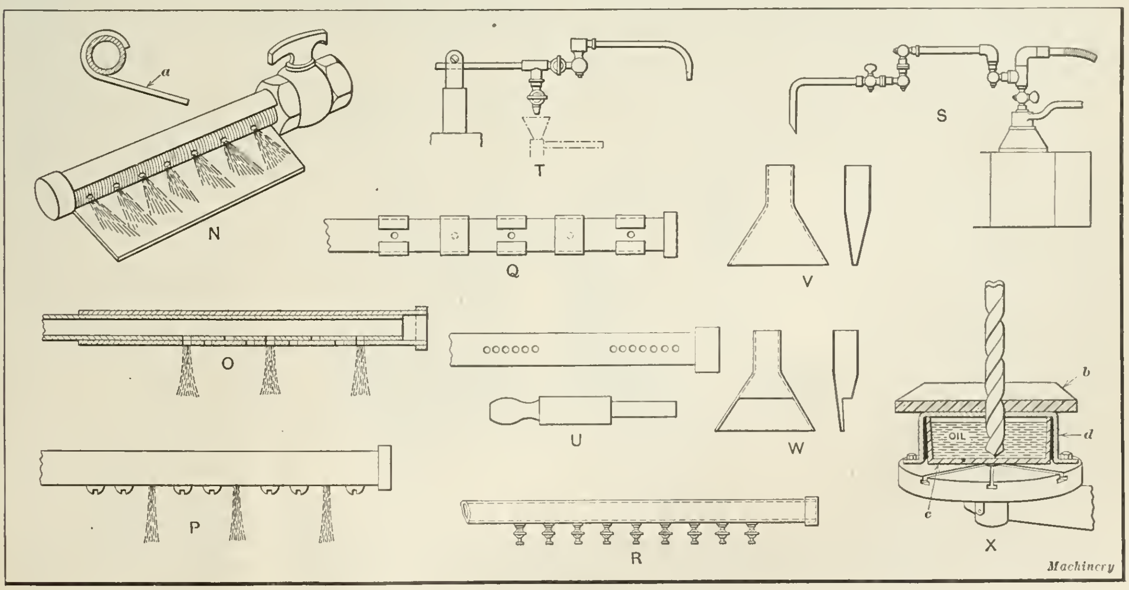


Fig. 23. Other Examples of Designs for Lubricant Pipe Nozzles and Delivery Tubes

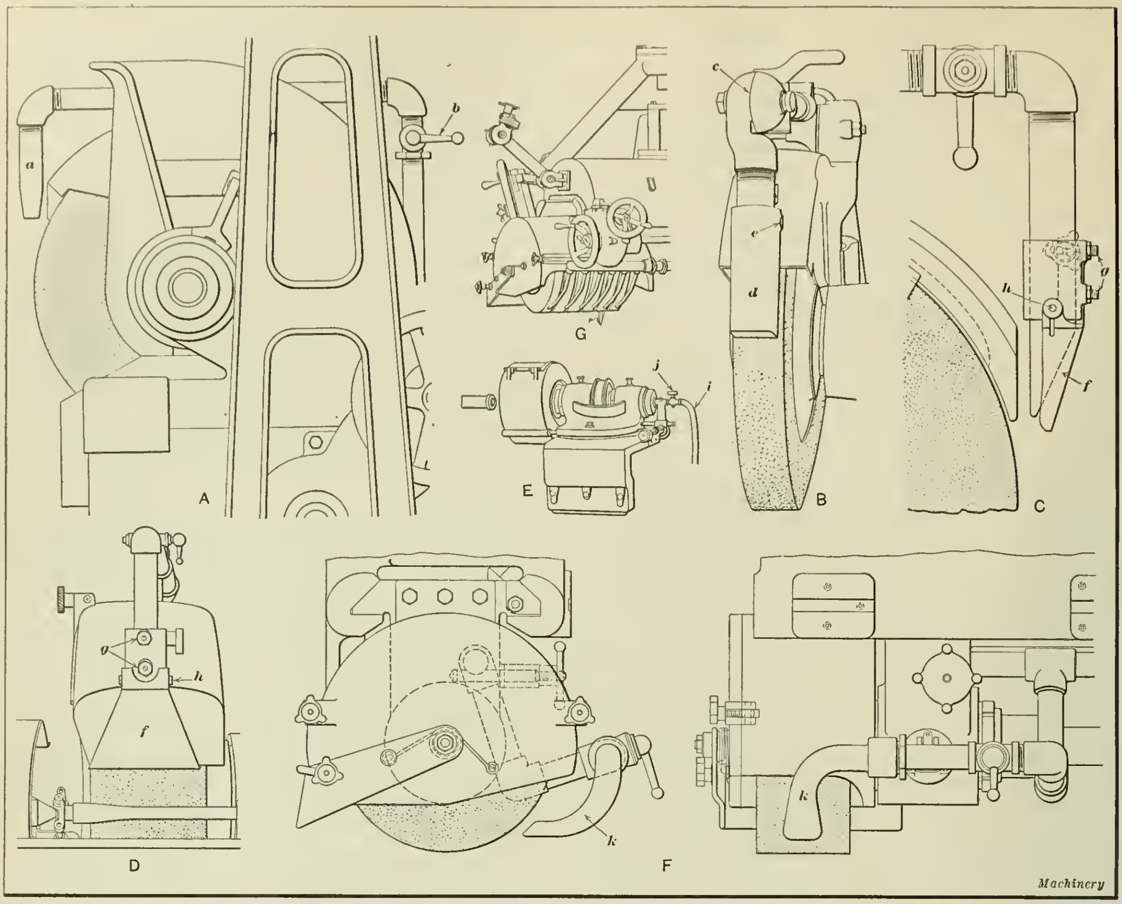


Fig. 24. Miscellaneous Examples of Distributors for delivering Coolants to Grinding Wheels

car wheel grinder made by the Norton Grinding Co. of Worcester, Mass., and is applicable for other classes of cylindrical grinding. In this case no attempt has been made to provide fine adjustment of the way in which the fluid strikes the wheel, and for machines working on those classes of grinding where such adjustment is necessary special devices must be provided. At *B* is shown a supply pipe and distributor used on cylindrical grinding machines built by the Landis Tool Co. of Waynesboro, Pa. Here it will be seen that the pipe is jointed at *c* so that the angle and position at which the fluid strikes the wheel may be adjusted. At the end of the pipe there is a distributor *d*, the position of which may be regulated vertically on the pipe by loosening screw *e*. At *C* and *D* are shown two forms of distributors used on Norton grinding machines; these are provided with means of adjusting the stream of fluid which strikes the wheel, and the design is the same in both cases except that a broad distributor is used at *D* to provide for spreading the fluid over a wide-faced grinding wheel. Distributor *f* may be adjusted vertically on the pipe by loosening screws *g*, and the distributor swings about a pivot *h* that enables it to be set at any desired angle. It will be evident that in the case of the nozzles shown at *B*, *C* and *D* a shut-off cock is provided to enable the flow to be stopped when so desired. Adjustment of distributor *f* governs the supply of water, the force with which it strikes the wheel and work, and the form that it takes after leaving the spout. The distributor is locked in place by the knob at the right-hand side.

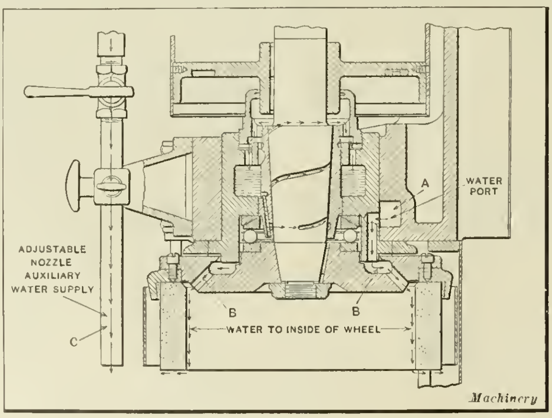


Fig. 25. Means provided for delivering Coolant to Surface Grinder made by Blanchard Machine Co.

For internal grinding it is the practice to deliver coolant to wheel and work through the hollow work-spindle, and at *E* are shown the means provided for this purpose on the internal grinding machines built by the Heald Machine Co. of Worcester, Mass. Coolant is carried to the hollow work-spindle through pipe *i*, and a cock *j* enables water to be turned on or off as required. On internal grinding, particularly on small work, it is highly important to provide for delivering the required volume of coolant at low pressure, because if the fluid were delivered under any appreciable pressure, it would be thrown out from the work with considerable violence. In grinding gasoline engine cylinders and similar work, the cooling action is provided in a different way; instead of delivering coolant direct to the wheel, water is circulated through the water jacket of the cylinder casting, which keeps the temperature of the work low enough so that it will not be burned. At *F* is shown the method by which coolant is delivered to Norton surface grinders. Here it will be seen that a pipe *k* delivers

the fluid to the wheel, and the position of this pipe may be readily adjusted to regulate the angle at which the fluid is delivered. A special application of such delivery pipes for use on a surface grinder where there are six wheels is shown at *G*. Here it will be seen that there are six nozzles leading from one manifold to provide for supplying each grinding wheel with the required volume of coolant.

On Blanchard surface grinders the work is carried on a rotating table which runs in the opposite direction to the cup-wheel, and in this case the method of delivering coolant to the wheel and work is provided in the design of the machine, as shown in Fig. 25. From the pump a 1-inch pipe runs to the wheel head, where it connects with a cored passage *A*, from which water passes down into the annular recess *B* in the faceplate and thence outward and downward inside the grinding wheel. The water in passing through the inclined holes in the faceplate is whirled at the full speed of the wheel, and issues from under the cutting face with considerable force, so that it thoroughly cleans the wheel face in addition to affording the required cooling action. An auxiliary adjustable pipe *C* is provided to deliver a heavy stream of water directly over the work table. Both inside and outside pipes have independent valves. A generous supply of fluid is particularly desirable in grinding dies and other hardened work where overheating would be very detrimental.

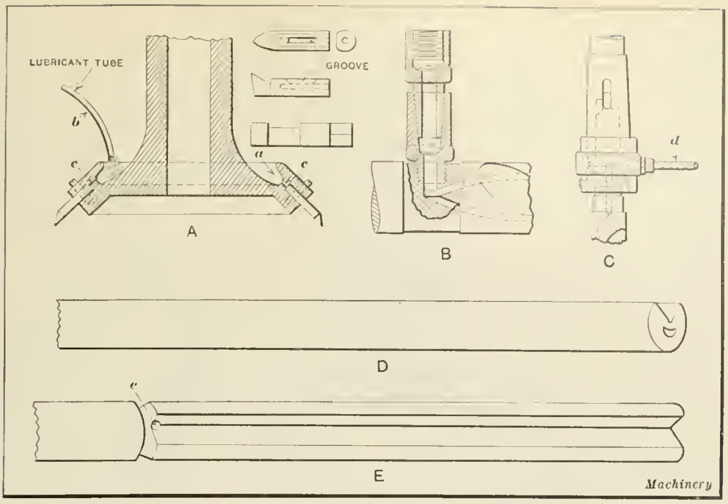


Fig. 26. Methods of delivering Lubricant to Oil-tube Tools—Drill and Reamer for Deep Holes

Designing Tools to Provide for Lubrication

In designing cutting tools it is sometimes possible to make provision for the delivery of lubricant which will be the means of producing more satisfactory results than would otherwise be the case. An example of this kind is shown at *A*, Fig. 26, which consists of an inserted-tooth milling cutter used on a vertical milling machine. It will be seen that a groove *a* is provided around the head of this cutter into which lubricant is delivered by pipe *b*. From this groove holes *c* connect with each of the inserted-tooth cutters, and these, in turn, have a hole drilled at the upper end and a groove cut in the side to allow lubricant to reach the point of the tool. In this way the fluid goes right to the cutting point, where it is most necessary.

At *B* and *C* are shown two typical methods of making connection with oil-tube drills and similar tools. At *B* the tool remains stationary and the work revolves, so that it is possible to deliver oil through a tube threaded into the side of the drill. At *C* the drill revolves while the work remains stationary, and in this case a collar which is a sliding fit on the drill makes connection with the oil-tubes in the drill, oil being delivered through small pipe *d* to an annular space in the collar. For deep-hole drilling and similar work the action of the oil in washing chips out of the hole is very important, and in order to be effective the oil should be delivered at high pressure. An extreme case in deep-hole drilling is seen in drilling rifle barrels, this work being done by a tool of the form shown at *D*. It is of the oil-tube type, the drill point being made of steel and brazed to the end of a steel tube. This tube is rolled in such a way that a groove is formed down one side; oil is delivered through the center of the tube and through oil-tubes in the drill point, and returns by way of the outside groove through which the chips are washed out. As the oil is delivered at a pressure of about 800 pounds per square inch, care must be taken to prevent it from splashing, and for this purpose a guard is furnished which surrounds the end of the work to catch the oil and chips and divert them into the pan of the machine, a guard for this purpose being shown at *C*, Fig. 20. A deep-hole reamer of the oil-tube type is shown at *E*, Fig. 26, oil for lubricating the tool and washing away chips being delivered through hole *e*.

Machine Design as Applied to Tool Lubrication

The forms of distributing tubes and nozzles shown in Figs. 22 and 23 may be connected to the delivery pipe on practically any form of machine, and do not involve alteration of the original design in any way. But there are many cases where it is necessary to work out the design of machine members in order to provide for delivering lubricant to cutting tools, and typical examples of this kind are shown in Fig. 27. A simple form of lubricating device for use in connection with oil-tube tools is shown at *A*. It consists of a flexible tube *a* attached to the oil pipe *b* leading from the pump. The flexible tube is attached to the back end of tailstock spindle *c* and the oil flows through the hollow tailstock spindle to the tool. This device is used on automatic screw machines built by the Cleveland Automatic Machine Co., Cleveland, Ohio. This firm also uses an automatic shut-off device, shown at *B*, which consists of an oil cock *d* having a special four-pointed star on its stem, which is turned to shut off or open the oil cock by adjustable pins *e* mounted on cam drum *f*. This is an extra attachment

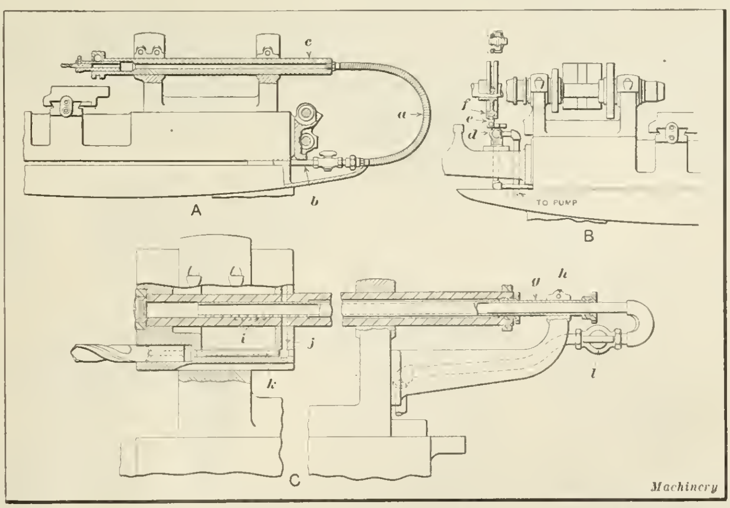


Fig. 27. Examples from Practice of Cleveland Automatic Machine Co. in delivering Lubricant to Oil-tube Tools

which is supplied with the oil feed when required, but the device shown at *A* meets all requirements in most cases, allowing the oil to feed through the cutting tool continuously.

At *C* is shown a lubricating device, which is also used on machines made by the Cleveland Automatic Machine Co., that provides for delivering oil to each turret hole, so that oil-tube drills, reamers, boring tools, counterbores, etc., may be placed in any or all turret holes as required. The valve mechanism which controls the flow of oil to different turret holes permits its flow only to the tool which is actually cutting, and automatically shuts off the oil from all the other holes. Starting and stopping the flow of oil is accomplished by forward and backward movement of the turret shaft. Oil-tube *g*, which extends inside the turret shaft, comprises the valve that controls the flow of oil, this tube being adjustable longitudinally and clamped in any position by screw *h* in the oil-feed bracket. At the forward end of tube *g* there is a series of holes *i* arranged in a single row at the lower part of the tube and extending over a length equal to the turret stroke. Oil-tube *g* is held stationary at all times, and when the turret shaft moves forward and backward on its regular stroke, hole *j* in the turret passes over this series of holes in the tube, allowing oil to flow through hole *j* and tube *k* to the turret hole and thence through oil-tubes in the tool. Oil is only delivered to the lowest turret hole, which is in line with the spindle of the machine; all other holes in the turret are shut off. The position in which oil-tube *g* is clamped determines when the flow of oil will commence; in other words, it is possible to have the flow of oil through the tool for the full length or any part of the stroke, the idea being that if the work is short, the oil will not start to flow until the tool has reached the work; it is for this reason that adjustment of oil-tube *g* is provided.. The supply of oil may be shut off by closing valve *l* if so desired, this valve being placed in the main delivery pipe leading from the pump.

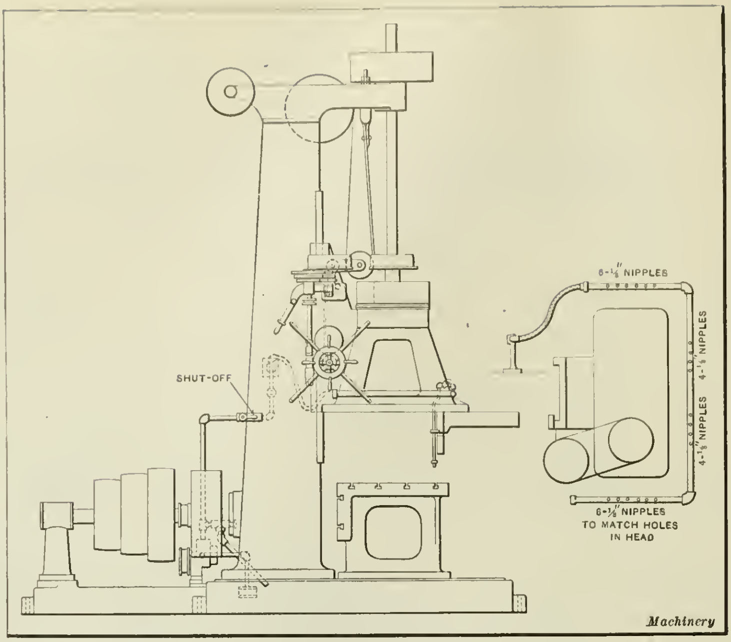


Fig. 28. Lubricating System on Baush Multiple-spindle Drilling Machine

Too much emphasis cannot be laid upon the desirability of having machine tool builders provide all the equipment necessary for delivering cutting compound to the tools on the machines which they manufacture. We frequently see machines of otherwise excellent design which the user has rigged up with most obvious makeshifts for the delivery of lubricant to the tools; but even under the most favorable conditions it cannot be expected that men in the user's factory, who are specialists in the production end of a business, can design devices for tool lubrication that will be as efficient or look as well as those worked out by designers in the machine tool builder's factory. It has been stated that practice in the lubrication of cutting tools is often far below the standard of manufacturing efficiency in other branches of the productive system in many factories, and the same condition is true of machine design, as the development of means for tool lubrication on many machines is far below the average of excellence attained in other branches of design.

The sort of devices with which machine tools should be equipped are illustrated in Figs. 28 and 29. The first of these shows a multiple-spindle drilling machine made by the Baush Machine Tool Co., Springfield, Mass. It will be seen that there is a flexible tube connecting the head to the piping system to provide for movement of this head. A distributing pipe runs around the lower end of the head with an individual tube

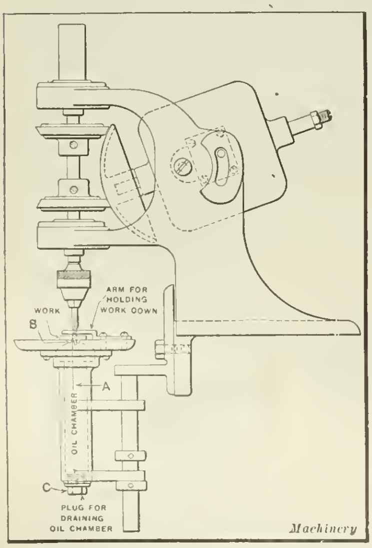


Fig. 29. Provision made for Tool Lubrication on Anderson Variable-speed Tapping Machine

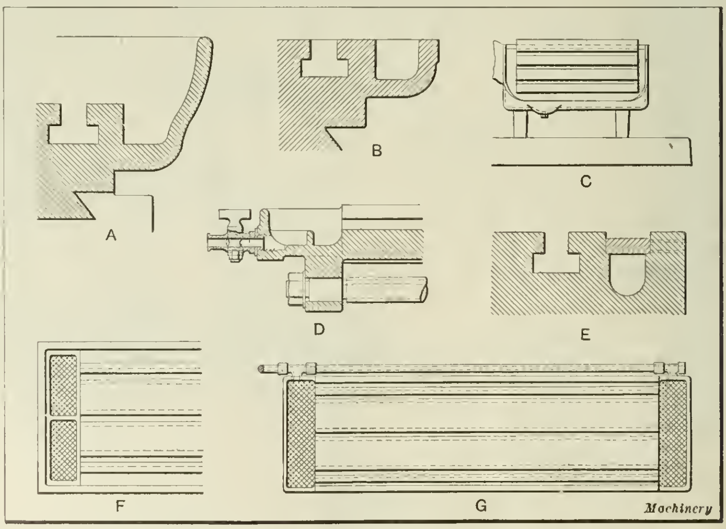


Fig. 30. Miscellaneous Examples of Table Trough Design, showing Means of separating Chips from Fluid

connected to each spindle; and each tube has its individual shut-off, so that lubricant is not delivered to those spindles which are not in use. Also there is a shut-off in the main supply pipe for shutting off the entire flow of lubricant, and a relief valve provides for maintaining the desired pressure at which lubricant is delivered to the drills.

Fig. 29 shows a device for lubricating small taps, used on a variable-speed tapping machine that has just been placed on the market by the Anderson Die Machine Co. of Bridgeport, Conn. It will be noticed that the vertical stem that supports the work table is made hollow to provide an oil chamber *A*. In this table there is a small hole *B* through which the tap passes, and the level of oil in chamber *A* is kept up to the top surface of the table. Each time the tap passes through the work it dips into the oil, thus washing off chips and providing the tap with a fresh supply of lubricant for the next cut. The chips drop to the bottom of the oil reservoir, and in addition to preventing damage of the thread while the tap is being backed out, tend to keep the level of oil in the reservoir high enough so that the tap will always dip into it. When the reservoir becomes filled with chips, threaded plug *C* is removed so that the reservoir can be washed out with kerosene ready to receive a fresh supply of oil.

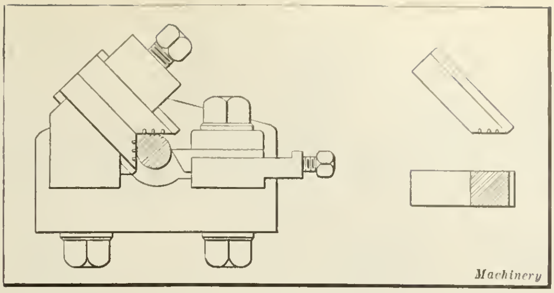


Fig. 31. Practice of grooving Jaws on Back-rests to facilitate Lubrication

Roller back-rests are superior to back-rests with adjustable jaws that do not rotate, provided the oil or cutting compound is of such a character that it will not gum the rollers and prevent them from moving freely. When stationary back-rests are used it is good practice to have the jaws grooved as illustrated in Fig. 31 to carry oil around the stock, so that friction will be eliminated and the jaws will not mar the finish produced by the tools. Users of cutting oil should not conclude that satisfactory results obtained from stationary back-rests that have not been grooved are due to a superior quality of oil or cutting compound, for as a matter of fact this is likely to be an indication of tendency of oil to gum, and the use of such oil should always be avoided.

Methods of Collecting Oil or Cutting Compound

In the discussion of methods of delivering lubricant to the tools and work, it was mentioned that one of the simplest means was to provide a drip can from which a small stream of oil or cutting compound is delivered to the tool. Similarly, the simplest means of collecting the fluid for subsequent use is to have a can suspended under the machine, into which the lubricant drains after running over the tools and work. This method is commonly used in connection with the drip can, and when the receiver becomes full its contents are poured back into the drip can from which lubricant is delivered to the tool. This system is inadequate when the supply of lubricant required is so great that it becomes necessary to empty the can at frequent intervals.

Necessity for tool lubrication is now generally recognized, and

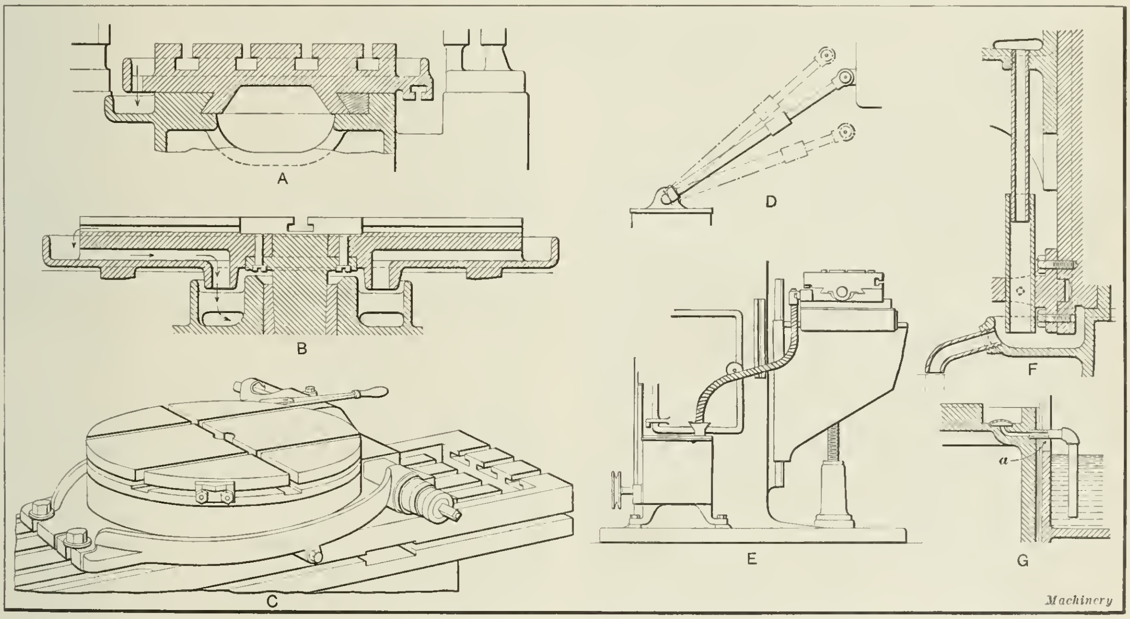


Fig. 32. Methods of making Connection between Trough on Moving Table and Reservoir in Machine from which Lubricant is pumped back to Work

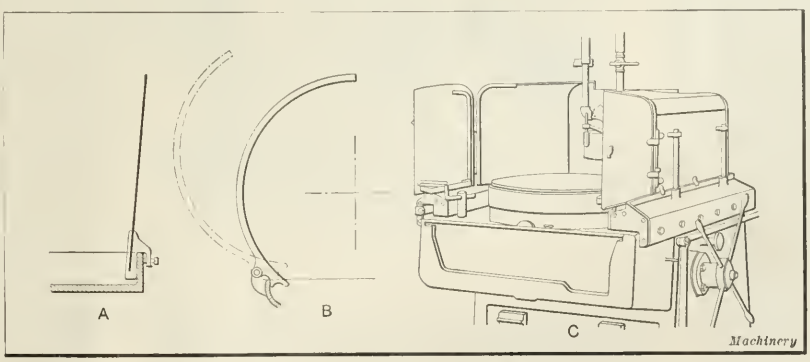


Fig. 33. Examples of Splash Guard Design; at C is shown Guard which affords Absolute Protection

provision is made on most machine tools for collecting the lubricant and pumping it back to the tools. The usual method of collecting fluid is to have the familiar oil trough surrounding the work table, and Fig. 30 shows different examples of this kind. At *A* the rim surrounding the oil trough extends up above the table level, which is a desirable feature where the work or fixtures do not project beyond the table. At *B* the same design is shown except that the rim surrounding the trough is made flush with the table surface to allow overhang of the work and tools. A similar construction is shown at *C*, which illustrates the oil trough surrounding a radial drilling machine table where there are both horizontal and vertical surfaces on which to clamp the work. It is important to prevent chips finding their way into the oil reservoir from which the pump draws its supply, and a simple method of accomplishing this is shown at *D*, where it will be seen that there is a small weir surrounding the outlet. The same purpose is served by the cover plate shown at *E*, which extends over the oil trough; and at *F* a screen is provided at the end of the trough from which oil is drawn off to be returned to the reservoir. A slight modification of the oil trough system is shown at *G*, in which it will be seen that a large reservoir is provided at each end of the table, connected by small oil troughs and also by a pipe through which the oil is drawn off to be returned to the reservoir.

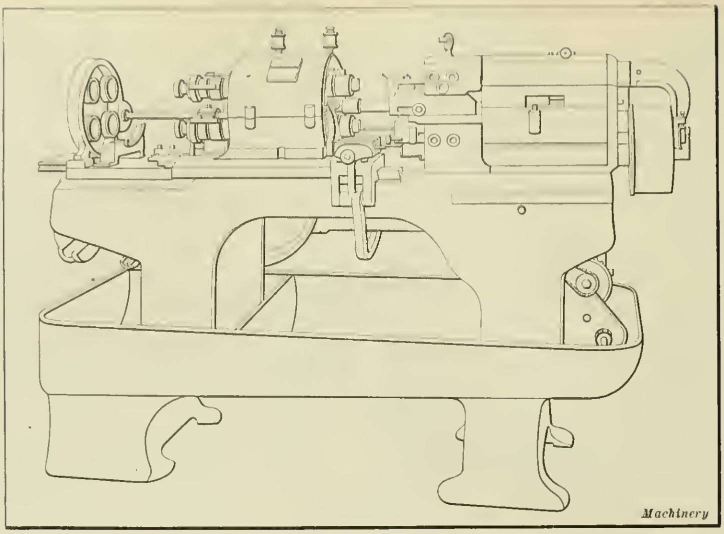


Fig. 34. "Radical" Automatic built by Fitchburg Automatic Machine Works—Chip Pan is of Ample Size to prevent Oil from dripping onto Floor

There are numerous methods of making connection between the oil trough in the table and the reservoir from which oil is pumped back to the work. At *A* and *B* in Fig. 32 are shown two simple methods of collection for use on reciprocating and rotating tables, respectively. Here it will be seen that drain channels on the moving tables are arranged in such a way that they are always located over fixed channels from which connection is made with the reservoir. At *C* is shown the method of draining lubricant from a rotary milling machine table. When the range of movement is too great to make it possible to apply the principles of design shown at *A* and *B* or when trouble may be experienced from splashing of the oil or cutting compound, some other form of construction must be applied. In many cases use may be made of telescopic tubes which provide for table movement in both a horizontal and vertical direction, an example of this kind being shown at *D*. In similar cases a flexible tube may be used, as illustrated at *E*, provided the length or position is not such as to inconvenience the machine operator. When it is merely necessary to take care of vertical movement, as in the case of tables on drilling machines, etc., the oil trough surrounding the table may be conveniently drained by a telescopic tube as shown at *F*, or by a tube which slides in a vertical slot *a* as illustrated at *G*.

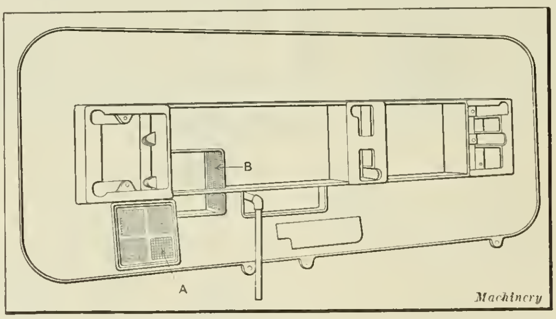


Fig. 35. Oil Pan used on Automatic Screw Machines built by Cleveland Automatic Machine Co., showing Efficient Strainers to insure Complete Removal of Chips

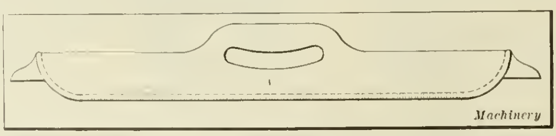


Fig. 36. Perforated Tray for Use inside Oil Pan to facilitate Removal of Chips

When trouble is experienced from the throwing of oil or cutting compound from high-speed machinery, splash guards must be provided, common examples of this kind being seen on most grinding machines. Fig. 33 shows three typical examples of splash guard design. At *A* the flat guard is secured by a clip which enables the guard to be removed for inspection or adjustment of the machine. At *B* a curved guard is shown which is hinged, and it is common practice to have two such guards located at each side on grinding machines, automatic screw machines, etc., so that the moving part is completely enclosed, making it impossible for oil to be thrown onto the floor or to soil the operator's clothing. The type of guard shown at *C* is used on grinding machines built by the Blanchard Machine Co., Cambridge, Mass. As the table moves out to remove finished work and reload the chuck, the doors open automatically and they close in the same way when the table moves back under the wheel. This excellent design makes it impossible for spray to be thrown from the wheel and does not delay the operator.

Arrangement of Oil and Chip Pans

To facilitate catching oil and cutting compound used on machine tools, it is now common practice to provide machine tools with pans which are familiar to all those who are employed in or have occasion to visit machine shops. It will not be out of place, however, to refer briefly to this feature of machine tool design. Many machine tool builders make a practice of constructing all machines with oil pans in order to standardize their designs, and a pump and oil circulating system can then be provided on those machines intended for work on which lubricant is used. In all cases the pans should be of sufficient size to make it impossible for oil and chips to fall on the floor. Many machinery builders do not pay attention to this point, with the result that their customers are forced to add unsightly extensions to oil pans on their machines. Buyers of machine tools should insist upon having oil pans extended well out from the machine, as shown on the machine illustrated in Fig. 34.

In designing oil and chip pans careful attention should be paid to the provision of means for removing all chips and grit from the oil before it is pumped back to the work. This is important for two reasons: first, chips and grit in the oil tend to damage both the lubricant pump and bearings of machine tools to which the lubricant is delivered; second, dirty oil is less efficient as a lubricant and

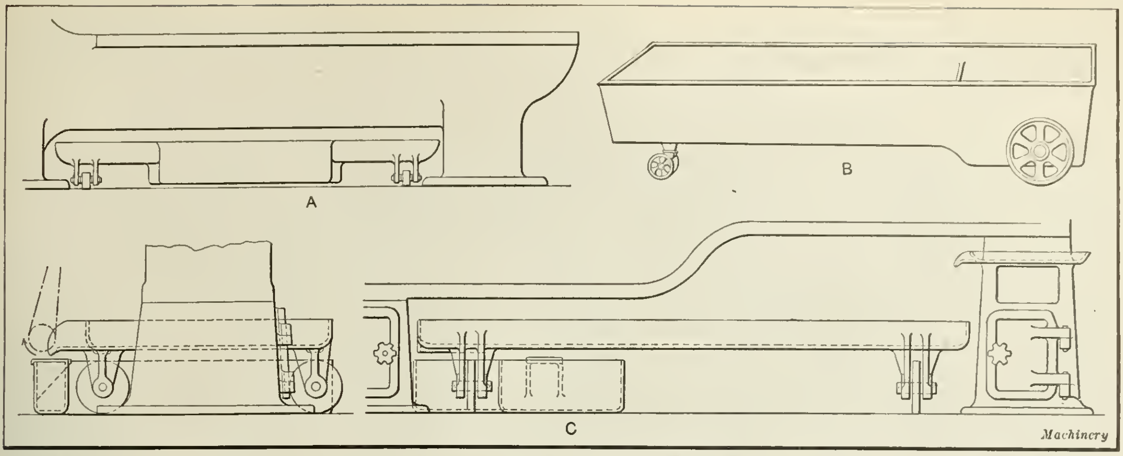


Fig. 37. Portable Oil Pans which can be used to Advantage under Automatic Screw Machines, etc., making Removal of Chips an Easy Matter

coolant. Buyers would do well to insist upon having suitable provision for cleaning the oil for subsequent use. Fig. 35 shows a good example of oil and chip pan design used on automatic screw machines made by the Cleveland Automatic Machine Co., Cleveland, Ohio. The strainer *A* is perforated with large holes, allowing lubricant to pass through freely. The screen *B* has small perforations through which the lubricant passes more slowly, thus allowing foreign matter to settle to the bottom. The pump suction pipe shown dipping into the well is fitted with another fine strainer. The consequence is that the oil passes through three strainers before reaching the pump and work, which means that it is pretty sure to be free from chips.

In showing examples of different manufacturers' practice in designing various machines, it is not the intention to imply that the examples shown are the best; but they have been selected at random to indicate the features of design that should receive careful attention in dealing with the problem of tool lubrication. In some cases straining of chips from oil or cutting compound is accomplished by placing a separate strainer in the chip pan or above the reservoir inside the machine. Such strainers should be furnished with handles, as in the case of the one illustrated in Fig. 36, so that they may be easily lifted out. The limitation of this practice is that unless particular care is taken a lot of lubricant is likely to drip onto the floor while dumping the contents of the strainer into a truck, thus tending to create an unsanitary and unsafe condition in the factory.

An alternative system is to use portable oil pans as shown in Fig. 37, which can be run into place under a machine and removed at will. Such pans are used in factories where certain classes of work call for the use of oil or cutting compounds, while other classes of work can be machined dry. In addition, many manufacturers prefer the use of portable pans on automatic screw machines and other tools that produce a large quantity of chips, as the use of such pans facilitates the removal of chips. Automatic screw machines built by the New Britain Machine Co., New Britain, Conn., are furnished with portable pans of the type shown at *B*, which, it will be seen, is furnished with a strainer and sump into which oil drains ready for pumping back to the machine. In making rounds with an oil-tight truck, the man employed to remove chips from the machine swings the shallow end of the pan out from under the machine so that he can easily shovel the chips into the truck. The pan is then pushed back and the whole operation takes but a few minutes.

Provision of Pump Reservoirs in Machines

The design of reservoirs in which oil or cutting compound is collected to be pumped back to the work is governed by the class of machine and kind of work to be done. In nearly all cases, strainers or other means provided in oil and chip pans for the removal of chips and coarse dirt from the fluid allow some finely divided material to pass, and provision should be made in the reservoir for the removal of as much of this suspended matter as possible. Common practice is to divide the reservoir into separate compartments by means of baffle plates over which the fluid must flow; and the first compartment into which the fluid comes from the chip pan should be of sufficient size to allow time for suspended matter to settle to the bottom before the fluid reaches the section of the reservoir in which the pump suction pipe is located. In cases where considerable heat is developed by the machining operation, which must be absorbed by the cutting compound, this large reservoir serves another purpose in that it exposes a considerable surface of the fluid and facilitates radiation of heat. In developing oil mixtures and cutting compounds a great deal of thought has been paid to the development of fluids which radiate heat readily. With properly designed reservoirs and fluids of this kind, tests conducted by suspending an accurate thermometer in the reservoir show that the temperature of the fluid does not rise appreciably during an entire working day.

With the evolution of machine design it became evident that in most cases the best location for the oil reservoir is inside the hollow frame casting on milling machines, drill presses, lathes and other machine tools, because this constitutes a space in which lubricant can be stored, and the position is such that the reservoir does not take up space that is not actually required for the machine. Fig. 38 illustrates a sectional view of a drilling machine column with a reservoir provided in this way; and Fig. 39 shows a similar sectional view of

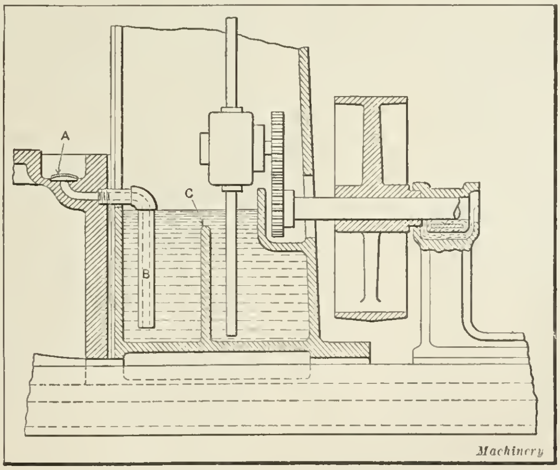


Fig. 38. Partial Sectional View of Frame of Drilling Machine built by Sibley Machine Tool Co., showing Arrangement of Lubricant Reservoir

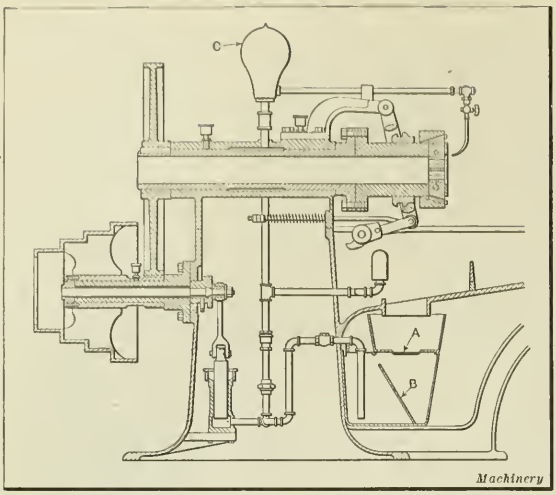


Fig. 39. Sectional View of Bolt Threader built by National Machinery Co., showing Means of distributing and purifying Cutting Compound

a bolt threading machine. In all cases of this kind it is of the utmost importance to provide for the removal of chips, dirt and other foreign matter from the fluid before it reaches the suction chamber from which the pump delivers it back to the tools and work. In the drilling machine column, Fig. 38, the lubricant collected in the trough surrounding the table runs through strainer *A* into drain pipe *B*, which extends down close to the bottom of the reservoir. Any fine material which gets through the strainer settles by gravity while the fluid runs over baffle plate *C* into the suction chamber. It will be noticed that the pump used in this case is direct-connected by gearing from the main driving pulley shaft.

In the bolt threader shown in Fig. 39, the lubricant runs back into the reservoir, which is furnished with a strainer *A*; in this case the strainer is made separate from the reservoir so that it may be lifted out for removing the chips. The pump suction connects with the lower section in this reservoir, and it will be noticed that an inclined plate *B* is located in such a way that any fine chips which pass through the strainer will settle at the right-hand side of this plate, while the pump suction located to the left is thus assured of obtaining a supply of clean lubricant. The pump, which is of the plunger type, is direct-connected to the driving shaft, and in order to equalize pressure as far as possible an air bell *C* is provided, which cushions variations that would otherwise exist.

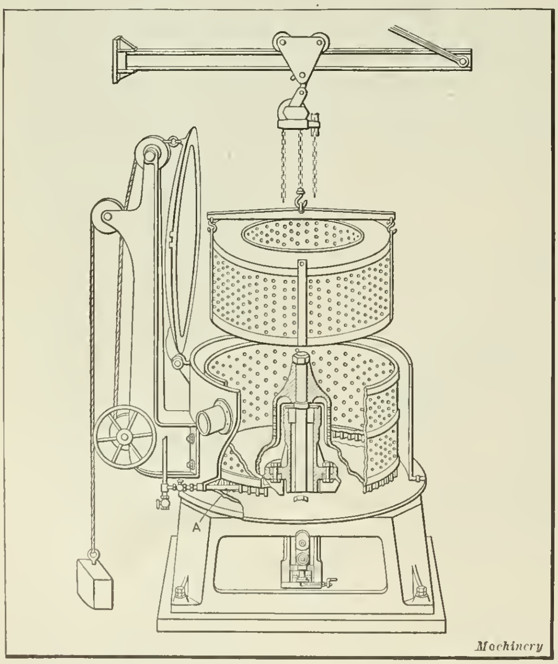


Fig. 40. Turbine-driven Centrifugal Chip Separator built by Oil & Waste Saving Machine Co.

Removal of Oil from Chips with Centrifugal Separators

There are many factories in which the management is prone to think that advantage is taken of every method of improving efficiency and reducing manufacturing costs, but in which chips are sent to the foundry that have a lot of oil sticking to them. This is apparent when the chips have been standing at the scrap pile for a sufficient length of time to allow a considerable amount of oil to drain off; and sometimes the oil becomes rancid, in which case its presence is made evident by the disagreeable odor. In most plants operating automatic screw machines or other tools which produce many chips, centrifugal separators are employed to remove oil before the chips are sent to the foundry to be melted. In the

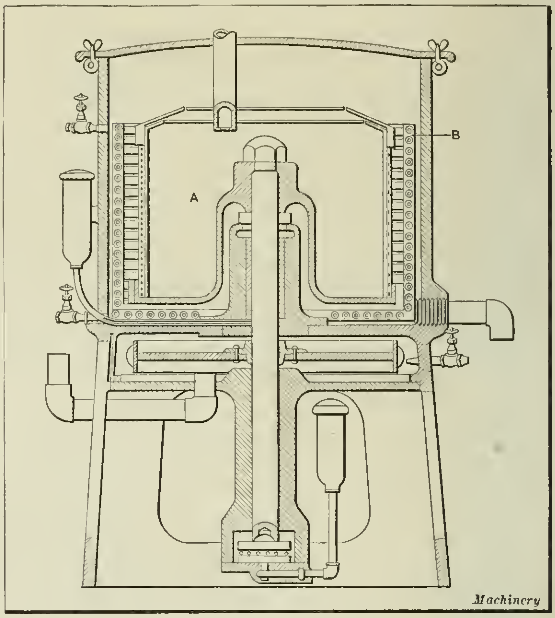


Fig. 41. Oil & Waste Saving Machine Co.'s Turbine-driven Centrifugal Filter and Drier for purifying Oil recovered from Chip Separator

operation of these separators there is another chance for the wasting of lubricant. If the chips are conveyed from the machines to the separator in a leaky wheel-barrow, there is every opportunity for part of the oil adhering to them to drain out onto the floor and be wasted. If workmen could be led to regard each gallon of oil as the equivalent of from twenty-five cents to one dollar, according to the class of oil and market conditions at the time of its purchase, it is certain that all conscientious men would be more careful in handling this material. Oil-tight trucks are available for carrying chips, and investment in one or more trucks of this kind is strongly recommended, both as regards oil economy and the maintenance of sanitary conditions in the shop.

The character of the chips will govern to some extent the efficiency of the separators for removing oil from them. The easiest chips to handle are those which are long and curly, so that the oil is not too closely confined in the mass of chips; conversely, it is most difficult to make a complete extraction of oil from fine chips, and saw swarf is about the most difficult material to handle. The consensus of opinion among manufacturers seems to be that the most complete extraction of oil is obtained with the smaller sizes of centrifugal separators, and probably this is due to the fact that there is not such a large mass of chips in the separator at any one time. On the other hand, the cost of handling chips and oil is greater in

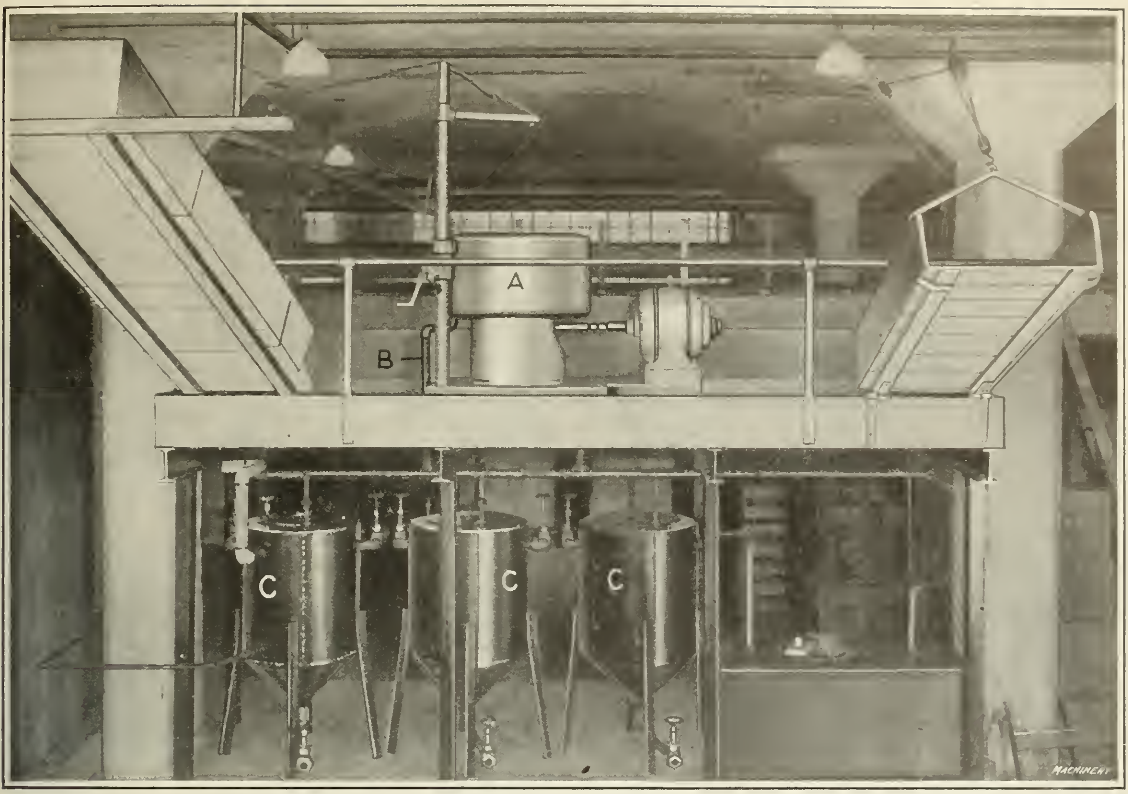


Fig. 42. Good Arrangement of Centrifugal Separator and Filters

the case of small separators, which must be stopped at frequent intervals to recharge. With kerosene, experiments have shown that 140 pounds of chips are capable of holding one gallon of oil, and for lubricants of higher viscosity the amount of oil held by the chips would be greater. For instance, thirty pounds of chips will hold about a gallon of mineral lard oil. This is sufficient to emphasize the importance of installing centrifugal separators to remove the oil, and in order to obtain a satisfactory degree of efficiency tests should be made at regular intervals to determine the time chips should be left in the separator and the speed to prevent unnecessary loss of oil.

Where a lot of chips are handled it is good practice to pile them on a grid so that the oil may drain through and be collected, thus reducing the time required for centrifugalizing. In some plants conveyors may be used to advantage for carrying chips to the department where oil is recovered. Settling tanks may be employed in making a preliminary purification of oil before it is filtered, and the centrifugal separator department should be conveniently located for sending chips back to the foundry.

Fig. 40 shows a centrifugal chip separator built by the Oil & Waste Saving Machine Co., Philadelphia, Pa., that is driven by a direct-connected steam turbine. The chips are contained in a rotating basket and the high speed of rotation results in removing the oil by centrifugal force. It will be seen that a special hoist raises the chip basket, making it easy to remove the dry chips and substitute a fresh charge. The nozzle through which steam is delivered to the turbine is shown at *A*, and after passing the turbine wheel the steam heats the chips, thus making the oil more fluid and facilitating the action of centrifugal force; it is also claimed that this raising of temperature serves to sterilize the oil. A minimum efficiency of 98 per cent is claimed for the turbine-driven separators. These chip separators are made in two sizes, with baskets which have capacities for holding 3½ and 8 cubic feet of chips, respectively. On the large machine the basket is 36 inches in diameter; the speed of rotation is 600 revolutions per minute; and the time required to remove the oil from a basketful of chips, including charging and removal, is ten minutes.

Condensed steam from the turbine forms an emulsion with the oil, and as this would have a detrimental effect on both tools and machines, it is desirable to remove it before the oil is used again. For this purpose the Oil & Waste Saving Machine Co. builds a centrifugal oil filter, shown in Fig. 41, which is also driven by a direct-connected turbine. Centrifugal force causes the oil to be driven through a series of filtering mediums composed of sawdust, cloth and paper, which line the chamber *A* in the machine, into which the oil is delivered continuously, thus removing all solid matter. The oil is sprayed upon steam-heated evaporating coils *B* which surround the filtering chamber, and in this way all water is removed and the oil is converted from an emulsion to a pure oil which is suitable for use under the most exacting requirements. This filter is made in two sizes, known as 15- and 20-inch sizes, respectively. In the 15-inch size the basket rotates at 1500 revolutions per minute. The cost of steam consumed per hour is two cents, based on coal at $4 a ton, and the filter has a capacity of purifying from twenty to thirty gallons of oil per hour. In the larger machine the filter runs at 1000 revolutions per minute; the cost of steam is three cents per hour, based on coal at $4 per ton, and the filter can purify from fifty to sixty gallons of oil per hour.

A good arrangement of centrifugal separator for the recovery of oil from chips is illustrated in Fig. 42. The scrap with oil sticking to it is thrown into the chute which will be seen at the left-hand side of the illustration, down which it descends to the separator platform, from which the chips are shoveled into the chip pan of the centrifugal separator *A* that is driven by an electric motor. The oil expelled from the chips by the separator flows down through pipe *B*, from which it is delivered to filters *C* which are steam-heated to increase the rate of filtering. After passing through these filters the clean oil is ready for use. The dry chips removed from centrifugal separator *A* are shoveled into the chute shown at the right-hand side of the illustration and dropped into a truck waiting to receive them. A run of from two to four minutes in the separator is usually sufficient to completely remove all oil from the chips.

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Douglas T. Hamilton, associate editor of MACHINERY for nearly seven years, has resigned to join the Fellows Gear Shaper Co., Springfield, Vt., as advertising manager. The increased value of MACHINERY'S reading pages during Mr. Hamilton's connection has been due, in no small measure, to his many practical articles on automatic screw machine practice, watch making, cartridge manufacture, motor car manufacturing practice, machine forging, grinding, electric welding, shrapnel and high-explosive shells, gages and other subjects. These thorough studies in manufacturing practice have set up a new standard in technical literature. Mr. Hamilton takes with him to his new work the cordial wishes of all his associates for his future success.

* * *

LUBRICATING AND COOLING CUTTING TOOLS

Important factors in the efficiency of metal cutting tools are the fluids used to lubricate and carry off the heat, and the means for applying them. It was known long ago that a burnished effect on wrought iron and steel could be obtained by dropping water on lathe tools when taking finishing cuts, but only within the past thirty odd years have some of the possibilities resulting from supplying a lubricant and coolant in quantity been recognized. During the past ten years "flood" lubrication to cool the tool and carry off the chips has received some of the attention that its importance demands.

The supplying of lubricant and coolant in large quantities to the cutting tools of machines requires considerable engineering ability, especially when a large department or plant has to be provided for. Hardly any two shops present the same problems; while in general it is conceded to be good practice to provide a common circulating system and reservoir from which the lubricant is forced through pipes to the machines and to which the used lubricant is returned for cleaning and purification, it is, nevertheless, sometimes preferable to provide an independent system for a machine or a group. Chip removal may be provided for in connection with portable chip and lubricant pans. Multi-story buildings present different conditions from those met with in single-story plants, and the fire hazard may be a serious matter which necessitates treatment of the problem in a way to minimize risk and reduce the insurance premiums.

The choice of a satisfactory cutting lubricant is not simple; it is generally conceded that there is no better commercial lubricant than pure lard oil, but the high cost of lard oil has made it imperative to use cheaper substitutes, of which there are a great number, differing in efficiency from very good to very poor. The chemistry of oils is complex and the physical characteristics of emulsions offer a field for investigation. Colloids may be discovered having the efficiency of deflocculated graphite but without its objectionable smut. In short, the need of low cost and effective cutting lubricants is likely to bring forth compounds much better than any now available.

The article on cutting lubricants and coolants in this number is the opening installment of the first adequate treatment of this important subject. It seems incredible that a subject so important to the metal-working industries has been so long neglected by engineers generally and that there should have been so little published data available. But it may be regarded as only one more of the factors in production efficiency that demands more attention of the factory engineer.

* * *

TREND OF MACHINE TOOL PRICES

The advances in selling prices which have been made by machinery builders during the past two years have led to considerable speculation concerning the trend of machine tool prices now that the demand for tools used in making munitions of war is less insistent. As this increase in price came at a time when practically all materials and equipment required for the production of munitions were selling at unusually high prices, a somewhat general belief exists that these so-called "war prices" will be materially reduced as the demand for munitions decreases.

Those who advance this theory overlook the fact that the recent increases in price of machine tools—which amount to from 25 to 50 per cent—may have been justified before the war demand existed, due to advances in the cost of the labor and material entering into machine tool manufacture, and to the increased value of investments in machine tool building plants. Bearing this in mind, machine tool users should make a careful study of the trend of prices of such equipment during the past ten or fifteen years before deciding that present prices are inflated. Allowing for the increased complexity of modern tools, it will be found that machinery builders have maintained a practically constant level for the prices of their product while facing heavy increases in the cost of production; and the only effort that has been made to meet this condition has consisted of improving the efficiency of manufacturing methods—which has only partially accomplished the purpose.

The profits made in many lines of manufacture using machine tools are far greater than those generally made by machine builders. This is due to a number of causes, among which is the policy that manufacturers in such lines have followed of advancing their selling prices whenever the cost of operating any department increased. It takes mechanics of no greater skill to make these products, but in order to market them successfully it is necessary to keep selling prices on a level that is commensurate with production costs.

The importance of this fact has been recognized by certain well-known machine tool builders who have reached the conclusion that their present selling prices were fully justified by existing industrial conditions before the outbreak of the European war and are far from being inflated. Other machinery manufacturers do not go quite so far, and concede that when the present costs of materials are reduced, a certain reduction from present selling prices may be expected. Both agree that the price level existing in the early part of 1914 was not consistent with production costs, and there is little reason to expect that any movement taking place in the near future will result in a drop to the former price level.

COOPERATION IN EXPORT TRADE[1]

METHODS EMPLOYED BY VARIOUS COUNTRIES FOR THE ADVANCEMENT AND CONTROL OF THEIR FOREIGN TRADE

IN the first three years of this century, the United States led the nations of the world in the amount of exports, but a decade later it had been displaced as leader by Great Britain, and almost surpassed by Germany. Its exports only increased from $1,410,000,000 to $2,290,000,000, or 62 per cent while Great Britain's jumped from $1,387,000,000 to $2,379,000,000, or 71 per cent, and Germany's from $1,120,000,000 to $2,155,000,000, or 92 per cent. This loss of leadership was partly due to the change in the goods the nation exported: its sales of foodstuffs decreased 13 per cent while its sales of manufactured products increased 124 per cent. Still the growth of its trade in manufactured products has not been as rapid as it might have been, because of the many restraints placed upon American trade by the cooperative methods employed by various countries for the control and development of their foreign trade.

In its report on the conditions existing in other lands the Federal Trade Commission says: "Exports are required to pay for foreign capital, services, and goods, irrespective of what locality utilizes the capital or enjoys the service." The value of foreign investments is shown by the control different countries have of the markets of South America. Railroads, street railways, light and power plants, etc. have been built largely by British capital; as a result, they are operated by men who favor British manufacturers. In many cases, the loans were made on the condition that all supplies should be bought from that nation; when this condition does not exist, the specifications are generally so fixed that none but British firms can supply the goods. One-half of the American trade to Argentine, which, in 1913, was only 15 per cent of the country's purchases abroad, consisted of goods in which foreign countries could not compete. Of the locomotives used on the railways of Argentine 75 per cent were sold by Great Britain, 20 per cent by Germany, and 2 per cent each by Belgium and the United States; while 57 per cent of the passenger and freight cars were supplied by Great Britain, 11 per cent by Germany, 19 per cent by Belgium, only 10 per cent by the United States. The activity of German capital in the promotion of electrical products resulted in 50 per cent of Argentine's imports of electrical goods being drawn from Germany, 34 per cent from Great Britain, and but 6 per cent from the United States. Through the assistance of the Deutsche Bank, which gives a bounty of $1920 to the Borsig Co. for every locomotive it sells abroad, German railway equipment has lately been sold to many of the South American state-owned railways. However, the marked increase in the use of goods of American origin, the efforts of American manufacturers to exert a larger measure of control over the distribution of their products, and the present and prospective investments of American capital in South American countries, especially in Brazil, Uruguay, and Argentine, will make a great change in the commercial relations of the American shipper and those countries.

The American exporter suffers from discrimination by railroads and vessels. Most of the European countries grant lower railroad rates to goods that will be exported than to those for domestic use. The export rate, per metric ton, for copper goods, lead in blocks, etc., between Cologne and Hamburg (a distance of 267.2 miles) in 1913, was $3.14 while the domestic rate was $6.38; the rates for machinery and machine tools were $2.52 and $4.86, respectively. Iron products, such as beams, etc. from Frankfort to Lubeck (a distance of 358.5 miles) were charged $1.79 a metric ton when exported and $5.09 when used at home. Belgium paid special attention to the development of through railway traffic to its ports from Germany, France, and Holland, and made combined railway and vessel rates.

Only 11.8 per cent of this country's water-borne exports was carried in American vessels, in 1915, and only 18.4 per cent of its imports. On the other hand, before the war, 66 per cent of the ships that entered British harbors with cargoes flew that nation's flag; one-half of Germany's foreign trade was carried in its own ships; one-half of France's exports were carried by French ships; and most of the trade of Italy and all of the trade of Norway and Sweden could be carried in their own vessels. Although Great Britain paid subsidies to ships of certain classes, less than 5 per cent of British ships received this aid; but subsidies or subventions have been freely granted by Germany, Japan, France, Italy, Austria, and Holland.

An exhaustive investigation by Congress has shown that foreign steamship companies are united in an intricate system of conferences and agreements for the purpose of stifling competition, determining sailings, fixing rates, dividing territory, alloting business, granting rebates, pooling earnings, and fighting competitors. British lines running from Canadian ports are giving preference to Canadian cargoes and receive American cargoes only when the Canadian cargoes do not fill all the available space. Besides, freight rates from Montreal to South Africa on some things are much lower than from New York to South Africa. When this difference is added to the 3 per cent preferential traffic concession granted Canadian products by the South African union, the Canadian manufacturer is given a great advantage over the American. Japanese ships also have given preference to their countrymen, with the result that thousands of tons of American freight have been piled upon the docks awaiting shipment. For some time the American consuls have been calling attention to the fact that the east coast of Africa enjoys direct connection with Europe through English, French, German, and Italian lines, while there is no direct service from America. As a result American goods suffer great delays in trans-shipment from European ports.

Many shippers claim that the foreign ship owners give the information they acquire to manufacturers of their own nationality, who at once become competitors for the future business. They also say that the steamships increase their rates whenever a nation's tariff is lowered to favor American goods, so that the American shipper gains no advantage from this reduction in the tariff. British shipping interests are also charged with deliberately trying to hamper American trade in South America by granting much lower rates on merchandise shipped from Great Britain than on similar merchandise from the United States and by not allowing enough British vessels to engage in carrying trade between the United States and South Africa. On some classes of goods, the American rates are from 30 to 40 per cent higher than the British, and the British shippers can make prompt deliveries while the Americans can not.

The ship owners, however, have the shippers completely in their power. According to the "conference agreement" of the British steamship lines running between the United States and Brazil, Uruguay and Argentine, a 10 per cent rebate on freight charges is made to all who ship only on boats of the "conference lines." These rebates, however, are paid only at six months intervals and are six months in arrears. So a shipper must prove that he has shipped only on these lines for a year, or lose all his rebates for that period. As a result, it has been impossible for independent boats to obtain cargoes, for any shipper who availed himself of these boats lost his rebates on the goods already sent.

The extent to which British bankers have helped in the development of British trade is shown by the fact that the Standard Bank of South Africa, established over fifty years ago, has 230 branches and agencies. Other British banks have nearly 150 branches and agencies throughout the country. Five of these agencies are in Abyssinia; while branches are at Leopoldville, 300 miles up the Congo;

[1] Extract from "Report on Cooperation in American Export Trade" of the Federal Trade Commission.

Zungeru, 400 miles up the Niger; Livingston, 800 miles up the Zambesi; and Khartum, 1000 miles up the Nile. Traders can find British banks in nearly any part of the world.

Since 1870 German banks have also been especially active. The charter of the Deutsche Bank, which was granted in that year, says: "The object of the company is the transaction of all sorts of banking business, particularly the fostering and facilitating of commercial relations between Germany, the European countries, and overseas markets." So widespread have become the interests of this bank that shortly before the war it was represented on the boards of 116 German and foreign concerns, some of them leading German and international cartels and combinations. France, Holland, Belgium, Portugal, Spain, Switzerland, Italy, Greece, Austria, Russia, and Japan, too, have established banks in foreign lands. Plans are now being made by Norwegian capitalists to establish a bank in New York so as to facilitate the financing of imports and exports with Scandinavia.

Commenting on the relations of the various German banks and industrial concerns, and the influence of the banks in promoting trade, a German economist says:

> The representatives of the banks on the supervisory boards of the industrial companies have always taken special care to fulfill one very effective part of the "advisory function" of the supervisory board; namely, to provide for the disposal of the products of the industrial companies in question to suitable industrial enterprises on which the banks were able to exercise some influence.

An official report from Honduras states:

> Heretofore European goods have been introduced because local importers or shipping agents have been, in reality, a combination of bank and manufacturing representatives, not making loans or financing enterprises except to secure the sale of goods produced by the manufacturers they represent.

Another advantage derived from these banks is that they supply their home offices with the ratings and characteristics of the firms and individuals of the place in which the bank is located. It is not to be expected that foreign banks will give credit information as readily to American concerns as to traders of their own nationality, except in cases where its possession results in no material stimulation of competition. The German banks have always given all possible particulars to their home office of business openings, and this information has always been available for the manufacturers and merchants in Germany. To Swiss banks is due, in large part, the growth of Swiss commerce and trade. One large Swiss bank instructs its branch managers that no business is to be transacted by which Swiss interests may be injured to the gain of foreign enterprises. Still, the value of foreign banks may be over-rated; Germany had an immense trade with Russia, in which country it had no banks, while France, which had many banks there, did comparatively little business.

The French government is especially active in the promotion of the country's foreign trade. Every department in France must have at least one chamber of commerce, which furnishes the government with information concerning industrial and commercial matters. They establish and manage various institutions, such as warehouses, permanent exhibits, departments for export information, associations for the encouragement of exports, and for locating young Frenchmen in foreign countries. In addition, the government grants bounties, subventions, and drawbacks, besides seeking the general tariff advantages by treaty.

Germany allows raw materials that are to be used in the manufacture of export goods to be admitted free of duty; also manufactured articles, in cases where it is expected to benefit German industry, that have been made from German materials and were sent abroad to be finished or improved.

In Great Britain, the Board of Trade, as it is commonly known, has the general supervision of commercial treaties, tariffs, customs duties, etc. In addition, it collects information from all available sources, which it generally publishes in its Journal, but some it gives confidentially to chambers of commerce or individual firms. For this purpose it keeps a register of all British firms desiring such information in trade openings abroad. It also has a sample room in which are shown goods competing with British products and raw materials that may be of interest to British manufacturers.

Belgium maintained a very elaborate commercial museum in which were shown samples of the products of foreign countries, both those which Belgium could export and those which it could import to advantage. It also showed samples of goods that superseded those of Belgian origin, showing why the domestic goods failed to succeed. In addition the government spent $1,000,000,000 a year as subsidies for commercial schools and industrial institutions.

Since 1896, the Japanese government has been sending agents to investigate trade conditions in other lands and has fostered the growth of its foreign trade in accordance with their reports. In order to raise the standard of Japanese goods, and thus improve their reputation, the government is now considering plans for the rigid inspection of all goods made for export.

The British Iron Trade Association was established in 1876 for the purpose of establishing communication between the members of the iron and steel trades of Great Britain upon all matters bearing upon the commercial interests of these industries. It circulates among its members detailed statistics of the trade at home and abroad and attends to matters connected with foreign tariff, commercial treaties, and home parliamentary business that may have a bearing upon the iron and steel trades. To advance the foreign trade in machinery, the British Engineers Association was organized in 1912. This association has representatives in Pekin and Petrograd. It publishes a directory of its members, in foreign languages, for the information of buyers, and selects agents in foreign countries for British firms. It also issues confidential bulletins to its members and has devised a trademark, or "chop", for use in China, where purchasers are being advised that articles bearing this chop are purely British products and that the association will aid in maintaining cordial relations. Since the beginning of the war other foreign trade associations have been formed.

As two-thirds of the German exports are manufactured articles, it was estimated seventeen years ago that one-fifth of the entire population participated directly in foreign trade. Nearly every manufacturer is a member of at least one association that is actively pushing German foreign trade. These associations give special attention to export trade, to the study of commercial treaties, tariffs, etc. The Association of German Machine Tool Manufacturers has made a study of export trade with special reference to the competition of American manufacturers and has actively opposed the trade of the latter. In addition, cartels and combinations are common and powerful; the banks have played an important part in the development of these. The Germans have published in Constantinople a daily paper, printed in both French and German, for the promotion of an interest in all things German and for the improvement of German trade in the Levant. They have educated promising young Chinese at schools and universities in Germany and established an engineering school in Shanghai, with German engineering equipment and instructors, for the training of Chinese in German engineering standards, methods, equipment, etc.

The ordinary French cartel has no central selling agency. Each member takes care of his own clientele, makes his own contracts, and ships under his own invoices; but he does this within the price and selling limitations of the agreement. The comptoir is an incorporated trading company composed exclusively of the manufacturers who turn over to it the sale of their products. Its purposes are usually the purchase from members and the sale to customers of a specified product, either in France or abroad, or both.

The combinations that exert the greatest influence on the American exporter, though, are those composed of buyers. The cooperative societies of Great Britain buy annually $40,000,000 worth of goods abroad. The influence of these societies, however, is beneficial rather than injurious. The metal buying combinations, on the other hand, have always exerted an adverse influence on American trade. Their ramifications are so great that they practically control the metal industry.

D. E. J.

ZINC PLUG INSERTING MACHINE

The hand-operated machine illustrated is another example of a large variety of time-saving contrivances which have had their inception in the rush of the munition business throughout this country. The final operations on a shrapnel consist of inserting a "fixing" screw in the side, screwing in the zinc plug, oiling the copper band, and packing.

The apparatus illustrated, although made largely of wood, is securely built and materially assists in reducing the time and labor on the first three operations mentioned.

Zinc Plug and Band Oiling Machine in Operation

The machine consists of a vertical shaft on the lower end of which is a large screwdriver blade and a three-pronged spider for centering the shell. As clearly shown at the upper end of this shaft there is a crank fitted with a knob for turning the shaft and screwdriver. A circular base is furnished for the shell, which is cupped to center the shell, and can be revolved. At the rear of the machine is an oil reservoir. Protruding from the base of this reservoir, through the back of the machine onto the copper band of the shell when in place, is an oil-feeding brush. The oil saturates through this brush and distributes just the right amount to the copper band when the shell is rotated.

Three men are employed on this operation. One starts inserting the zinc plug and the small screw by hand. The second screws the zinc plug and the small screw home and oils the copper band. The third packs and boxes ready for shipment. Without attempting to make any record, these three men ordinarily pack approximately 150 shrapnel per hour. The information and illustration were secured through the courtesy of the Vermont Farm Machine Co., Bellows Falls, Vt., who developed this machine for its own use. V. B.

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CATALOGUE INDEXING

With reference to the contribution by A. A. D. in the November number of MACHINERY on "Catalogue Indexing," I agree with him that catalogues could be indexed to much better advantage. Money is spent liberally for illustrations, high-class paper, several colors of ink, fancy envelopes, and everything else that might assist in eliminating every trace of "cheapness" from the catalogue, but, when the busy man gets hold of it he can't find what he wants without reading the whole book and that is too much to expect. Even purchasing agents are too busy to read all that comes in the mails. Several times I have assisted in making up indexes and have been limited by the owner or boss to one page or even less. If the manufacturer has another machine to show—a machine that looks good to him—he will put it in and cut out the index. Or, he will cut the index down to almost nothing. Before making up an index I would suggest that manufacturers look into the catalogues published by the large mail order houses. There they will find a most interesting type of complete index. Cross-indexing, bold type, small type, italics, lines, references, and everything else is used to make the index complete. Nothing is overlooked. W. F. S.

COPPER-ALUMINUM-IRON ALLOYS [1]

One of the properties which aluminum bronze possesses to a higher degree than other important bronzes is that of dissolving iron when melted and retaining this element in the solid alloy. The standard aluminum bronze made extensively for small and average castings by the Titanium Alloy Mfg. Co. contains 10 per cent aluminum and 1 per cent iron, but experiments have been made with larger amounts of iron in bronzes containing 7 to 10 per cent aluminum, inclusive. No alloys with less than 7 per cent aluminum were used, because they are too soft and weak for castings in which strength is necessary. Aluminum of 10 per cent was the higher limit adopted, because alloys containing more than this have very little ductility and are not used except where great hardness is required and brittleness is not ruinous. Alloys with over 8 per cent iron were not investigated, because of their unpromising character, judging from the other alloys tested, and also because of the difficulty of making such alloys and obtaining uniform castings. The tests consisted primarily of tensile tests on cast-to-size bars, and the Brinell hardness was determined on many of the stubs after pulling. A sufficient number of these alloys were examined with the microscope to indicate the general microstructures of all of them.

The tensile test bars were cast, in sand, about 8½ inches long and ½ inch in diameter between shoulders which were 2 inches apart. At least four bars of each alloy were tested without machining, the surfaces merely being smoothed where necessary with a fine file, so that the true average diameters could be measured with a fair degree of accuracy. Some of the bars from each heat were tested with the autographic mechanism on the testing machine, so that load-deformation curves were obtained from which the proportional limit could be read. From the other bars, the yield point was found by noting the load at which a deformation of 0.01 inch was produced on the 2-inch gage length, as measured with fine-pointed dividers. Results from test bars showing flaws or other unsoundness in their fractures were discarded unless the defect had no harmful influence on the physical properties. The hardness tests were made on cross-sections of the ends of the bars cut after they had been broken in tension. A standard Swedish Brinell machine was used for this determination, with a 10-millimeter ball, and a pressure of 500 kilograms was applied, in each case, for thirty seconds. The hardness figure was obtained from the usual table after measuring the diameter of the depression with a microscope containing a tenth-

[1] Abstract of paper by W. M. Corse and G. F. Comstock, presented at the annual meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio.

STRENGTH AND HARDNESS OF ALUMINUM-IRON BRONZE

Aluminum, Per Cent	Iron, Per Cent	Proportional Limit, Pounds per Square Inch	Yield Point, Pounds per Square Inch	Tensile Strength, Pounds per Square Inch	Elongation in 2 Inches, Per Cent	Reduction of Area, Per Cent	Hardness Number
7	1	14,300	15,700	53,200	56.0	54.2	70
7	2	17,400	18,900	63,000	39.0	35.6	70
7	3	21,300	23,300	74,500	38.0	32.2	80
7	4	22,100	23,600	76,400	38.5	35.7	89
7	5	21,600	24,700	73,600	29.0	26.9	...
7	6	21,500	25,300	77,500	31.5	27.6	...
7	8	23,600	25,600	74,600	27.5	27.6	...
8	1	16,400	19,500	57,100	45.0	43.4	70
8	2	18,200	20,600	63,800	39.0	39.2	80
8	3	24,200	26,000	81,100	36.5	32.9	109
8	4	24,800	26,300	82,100	35.0	32.0	109
9	1	18,500	23,300	69,500	43.0	35.7	77
9	2	22,400	25,800	78,300	30.5	27.4	109
9	3	25,600	28,300	81,700	26.0	26.9	109
9	4	26,400	28,500	83,000	23.0	23.8	109
10	1	19,800	24,000	77,000	24.5	25.2	94
10	2	22,800	26,700	82,600	21.0	19.2	100
10	3	26,100	28,800	86,400	20.0	20.5	109
10	4	27,400	30,000	88,600	17.0	18.5	119
10	5	29,500	33,000	80,600	12.5	16.9	...
10	6	31,000	33,500	85,500	13.0	14.7	...
10	8	31,900	35,900	86,500	11.5	12.4	...

Machinery

millimeter scale mounted in its field of view. The results of the tests are given in the accompanying table.

These tests show that for the same aluminum content there is always an increase of proportional limit, yield point and tensile strength with increasing iron content, up to 4 per cent, and, in general, a rather less substantial decrease in elongation and reduction of area. In the same way, with constant iron content, the proportional limit, yield point and tensile strength increase with increasing aluminum, while the elongation and reduction of area decrease. A study of the table shows, furthermore, that for a given strength, greater ductility can be obtained with a lower aluminum and higher iron alloy than with higher aluminum and lower iron. Thus the 8 per cent aluminum with 4 per cent iron is better in every respect than the 10 per cent aluminum with 1 per cent iron, and even the 7 per cent aluminum with 4 per cent iron is practically equal to the latter in strength, but far superior in ductility.

The excellence of the alloys with 4 per cent iron made it seem advisable to try still higher percentages, with the 7 and 10 per cent aluminum series. The difficulty of obtaining sound and homogeneous bars was not so successfully overcome with these higher percentages of iron, however, and the results were rather irregular and disappointing. Although the proportional limit and yield point increase fairly regularly with the iron content, the ultimate strength does not change much after 4 per cent iron, and the ductility drops decidedly. The best alloys, considering both strength and ductility, appear to be those containing between 3 and 4 per cent iron. With more than this there is considerable difficulty in obtaining sound and homogeneous castings, and there is only a slight gain in strength with too much decrease in ductility.

Changes in Alloys shown by Photomicrographs

It was noticed in pulling the bars with 7 and 8 per cent aluminum that those containing little iron roughen very markedly on their surfaces, so that the outlines of the crystal grains stand out prominently, some being raised above the others. With 3 per cent or more iron, however, the bars are round and smooth after testing. In the higher aluminum series, the round bars with 3 per cent or more iron have a more uniform, finer grained, and more fibrous fracture than those with less iron.

A photomicrograph shows that in the case of a 7 per cent aluminum bronze containing 1 per cent iron, the iron and aluminum are evidently in solid solution in the alpha crystals. Where the iron is increased to 4 per cent, there is a vast difference in grain size. When magnified 200 diameters, small bluish-gray crystallites, or "skeletons," are seen scattered sparingly through the yellow alpha; in an alloy with 8 per cent iron, these skeletons are well developed and much more numerous. Their composition is not known, but undoubtedly they are chiefly iron, with some aluminum, and possibly also a little copper. This constituent is the first part of the alloys to freeze, and the fine grain of the alloy with 4 per cent iron is probably caused not only by the addition of the third element, iron, to the solid solution, but also by the presence of the solid crystallites, which form many nuclei for the beginning of the crystallization. The alpha thus begins to crystallize around each little particle of the already solid iron compound, with the result that no grain can grow very large before meeting other grains which stop further growth. The alloy with 8 per cent iron does not have quite such a fine grain, doubtless because of the higher casting temperature necessary to keep the iron in solution so that the metal will remain fluid.

In the case of 10 per cent aluminum alloys with 1, 4 and 8 per cent iron, the iron crystallites do not seem to form such well developed skeletons as in the 7 per cent aluminum series, and occur either in rounded spots or in groups of spots arranged in a manner somewhat resembling clover leaves. With 10 per cent aluminum all the alloys show a duplex structure, with the dark-etching eutectoid separating the small bright alpha crystals. There is not much difference in structure between these alloys with 4 and 8 per cent iron, but both are quite different from the alloy with only 1 per cent iron, not only in respect to the presence of the black crystallites, but also in the shape and size of the alpha crystals. The addition of iron decreases their size somewhat, but the chief effect is in breaking up the Widmanstatten structure, or arrangement of elongated alpha crystals parallel with the cleavage planes of the large crystal grains.

* * *

HIGH COST OF DISCHARGING EMPLOYES

"Hiring and firing," all large employers of labor now recognize, forms the greatest leakage in modern business. In many establishments the men who do the employing have come to be known as "the fortune-tellers." It is the one place in which everything is haphazard. Magnus W. Alexander, one of the engineers of the General Electric Co., has demonstrated this great waste mathematically. Taking the employment statistics of twelve metal factories, located in six states, he has found that these places employed 37,274 persons at the beginning of the year, and 43,971 at the end. Their normal increase in employes, therefore, was 6697. Had matters worked efficiently, these factories should have employed only 6697 men—or slightly more, making due allowance for death, sickness, and other natural causes of dismissal. In reality, these factories had hired 45,571 new people. We must ponder these figures carefully to get their full significance. In order to obtain 6000 new employes, these establishments, all representative and "efficient" American concerns, had to employ 45,000! Out of seven men taken on, only one stayed. After making liberal deductions, Mr. Alexander calculates that these twelve factories employed 24,500 men and women whom they were unable to retain. Each person represented an expense ranging from $50 to $200. The companies had to keep a clerical force to hire these people and place their names on the pay-roll. They had to pay foremen and assistants to instruct them. They had to stand the expense of damaged and broken tools due to inexperience. The reduced rate of production represented another positive loss, and then there was the spoiled work which "new hands" turn out in such abundance. Mr. Alexander takes the lowest estimate, $50 per man, as representing this loss. At this rate, "hiring and firing" caused a waste in these factories of nearly $1,000,000 a year. At the highest estimate, $200, the practice resulted in a waste of $4,000,000.—*Harper's Magazine.*

* * *

It is said that statistics show that 84 per cent of the business failures of the country are merchants who did not advertise.

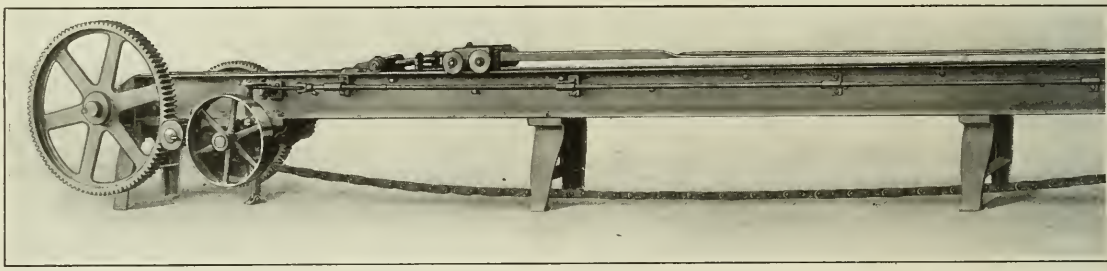


Fig. 1. Draw-bench of Typical Design built by the Loy & Nawrath Co., Newark, N. J., for Use in the Manufacture of Cold-drawn

MAKING COLD-DRAWN STEEL SECTIONS

EQUIPMENT FOR PRODUCING A VARIETY OF SHAPES FROM STRIP STEEL

BY EDWARD K. HAMMOND [1]

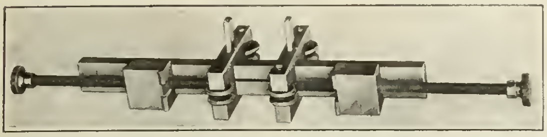
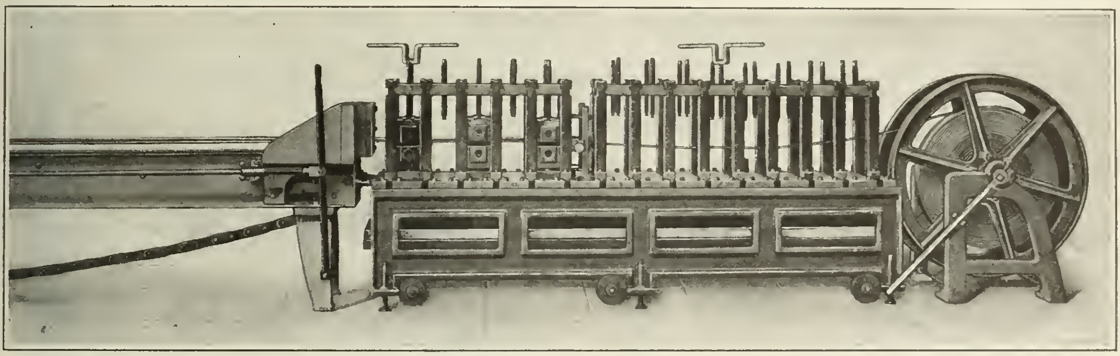


Fig. 2. Stock Guide, showing Means of Adjustment for Strips of Different Width

IN the construction of fireproof buildings, steel Pullman cars, etc., door moldings, chair rails, picture molding and similar trim are made of cold-drawn steel sections. Despite the similarity of names, these differ greatly from I-beams, channels, tees, etc., commonly known as "steel sections," both as regards form and method of manufacture. Structural steel sections are rolled out from hot billets, and the material is carried through the mill by the tractive action of the rolls which are driven by power. Cold-drawn steel sections are also made by bringing the material into the desired form by passing it between a series of rolls; but in this case the rolls are loose on their studs, and the material is drawn through them by the standard form of draw-bench used for wire drawing and similar operations. As in the case of hot-rolling, the rolls used for cold-drawing are grooved progressively so that the steel is gradually brought to the required form, but in cold-drawing the start is made from a strip of cold-drawn steel, and neither the thickness nor length changes materially during the entire operation, the only change consisting of gradually bending it into the required form. The Loy & Nawrath Co., 21-29 Runyon St., Newark, N. J., makes a specialty of building equipment for making cold-drawn steel sections and we are indebted to this company for the information presented in this article.

The type of draw-bench used in making cold-drawn steel sections is of practically standard design and does not require description. At the head of the bench is placed what is known as a roll head, in which are mounted the series of rolls used to bring the flat strip of sheet steel to the desired form. The rolls in this head are arranged in pairs, and the number of pairs necessary to complete the forming operation depends upon the complexity of the drawn steel section to be produced. The more complex the section, the greater will be the number of rolls required; but in any case, the section is completely formed before leaving the last pair of rolls. However, the general statement may be made that from one to eight pairs of rolls are required. In each pair both the lower and upper rolls are made adjustable, the vertical position of the upper roll in relation to the lower roll being governed by screws actuated by a handwheel located at the top of the head. As in ordinary rolling mill practice, the depth of the grooves in the rolls increases progressively; and it is important to have sufficient space between successive pairs of rolls in order that the metal may have time to flow easily into the new shape imposed upon it by each new pair of rolls.

The scope of this process is shown by Fig. 4, which illustrates a variety of cold-drawn steel sections. It will be seen that the forms produced vary from simple channels, vees, etc., to quite complicated sections, in many of which the two edges of the flat strip steel have been brought together to form a butt joint. When considerable strength is required or when the appearance of the product in which cold-drawn sections are used is of considerable importance, it is customary to weld the seam with an oxy-acetylene welding outfit, and when so desired the weld can be ground smooth so that the metal can be enameled, painted or given any other form of finish. In making cold-drawn steel sections, a circular swing saw is used in connection with the draw-bench. This saw is mounted at the rear end of the roll head and provides for cutting off the length of steel which has just been drawn through the rolls. The length of sections varies from 20 to 100 feet, according to the purpose for which they are intended, but in any case the steel is pulled along until the dog on the draw-bench comes opposite a gage mark; then the drawing operation is stopped and the swing saw is pulled down and cuts off the finished length of steel. The steel is under tension and a slight cut causes it to break before the saw completes the cut.



Steel Sections. The Draw-bench is equipped with Roll Head and other Special Features required for handling and forming Strip Stock

In starting work, a coil of flat cold-rolled strip steel is mounted on a reel at the head of the machine, and the end of this stock is passed between the rolls and gripped by the tongs or gripping jaws, on the draw-bench, the upper roll of each pair being raised sufficiently to allow the flat steel to pass through. The adjustable roll of the first pair is then screwed down to bend the steel to the form of these rolls. Having proceeded to this point, the steel is pulled for a sufficient distance to bring the formed section between the second pair of rolls. The draw-bench is then stopped and the adjustable roll

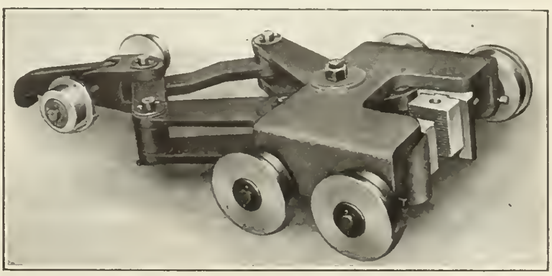


Fig. 3. Dog with Toggle-operated Jaws to grip Stock and pull it through Roll Head

[1] Associate Editor of MACHINERY.

of the second pair is screwed down to bend the sheet steel to the form of that pair of rolls. After this has been done, the draw-bench is again started and the steel is pulled along until the section formed by the second pair of rolls comes into position between the third pair, when the draw-bench is stopped and the upper roll of the third pair is forced down to make the metal take the form of this pair of rolls. Regardless of the number of pairs of rolls required to complete the rolling operation, this process must be carried on until all the rolls in the head have been screwed down one after the other; and then the machine is ready to start drawing steel of the required form. The stock passes through an oil bath before entering the roll head, and carries sufficient oil with it to thoroughly lubricate the rolls. Fig. 5 shows a set of three rolls for drawing a section of the form shown in Fig. 8, the latter illustration showing quite clearly the manner in which the steel is gradually brought to the desired form. The rolls illustrated in Figs. 5 and 6 were mounted side by side to show them more clearly, but they are not mounted in this way in the roll head; the method actually used is clearly shown in Figs. 1 and 7.

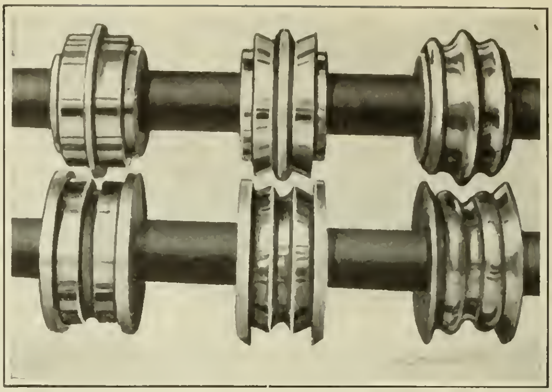


Fig. 6. Another Example of a Set of Three Pairs of Rolls

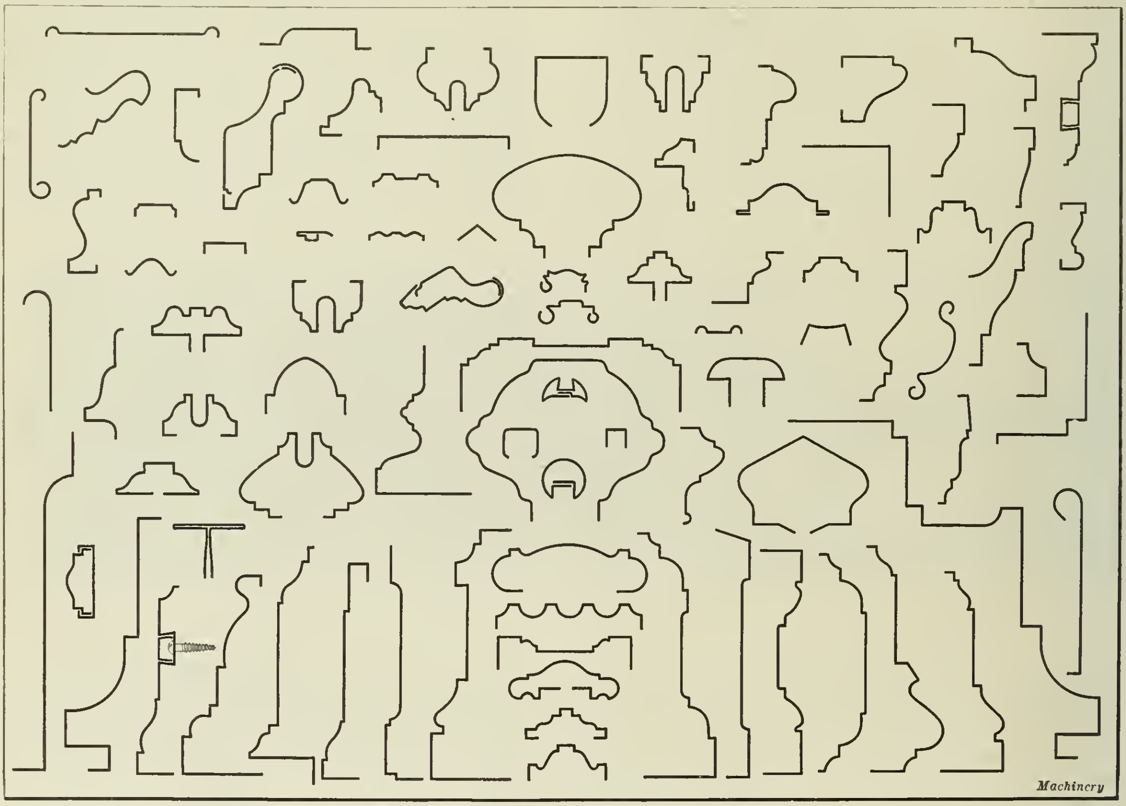


Fig. 4. Examples of Cold-drawn Steel Sections—note Range of Work

In preparing the roll head for operation, from four to ten feet of stock will be wasted while the rolls are being screwed down; and as the average length of a commercial roll of strip steel is about 150 feet, it will be obvious that the wasting of this amount of material would be entirely out of the question. To avoid loss from this cause, the expedient has been adpoted of using an oxy-acetylene welding outfit for butt-welding the beginning of a new coil of steel onto the end of a coil which has been almost drawn through the roll head. As practically any number of coils can be handled in this way, the loss of material involved in starting the machine is negligible; and on this account, when it is desired to start work on another job in shops which use a single draw-bench for drawing a number of different forms, it is found worth while to leave the end of a coil of steel in place between the rolls and replace the entire roll head with a new head equipped with rolls of the desired form. In this way, the old head may be put back in place, a fresh coil of steel welded to the piece that was left between the rolls, and the process of drawing started again without the loss of any material. When several heads are used in this way, they are mounted on wheels to facilitate handling.

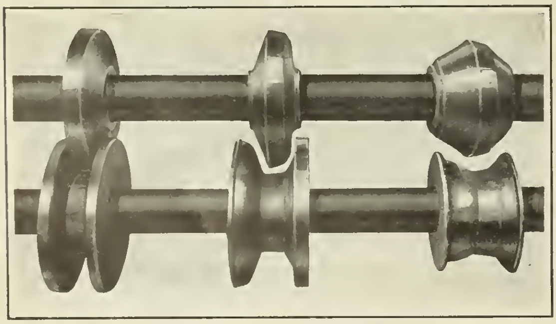


Fig. 5. Set of Three Pairs of Rolls for drawing Section shown in Fig. 8

It was mentioned that from four to ten feet of steel is lost

in the form of scrap while setting up the machine for any given drawing operation. This loss is unimportant because it only occurs at the beginning of the operation, after which the draw-bench can be run without further loss from this cause. But there is one other source of loss which cannot be avoided, *i. e.*, the amount of metal which goes into the scrap pile through the crushing of the front end of each length of cold-drawn steel by the gripping jaws on the draw-bench. About 6 inches of stock is lost from this cause on each "draw," and the percentage of loss naturally varies according to the length of the pieces being drawn, but the average will be about 1.66 per cent. During the drawing operation, however, the length of the metal is somewhat increased and this elongation just about offsets the loss due to crushing the end of each length by the clamp on the draw-bench.

Cold-drawn steel sections are commonly made in lengths of 20, 30 and 100 feet, although the 30-foot lengths are by far the most common. Drawing sections of more than this length is unsatisfactory for two reasons: first, longer pieces have

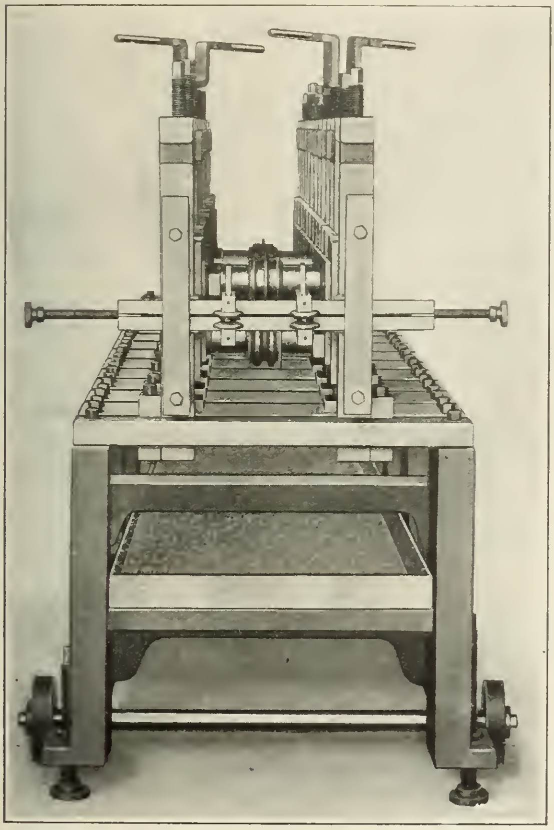


Fig. 7. End View of Roll Head, showing Arrangement of Guide and Rolls

a tendency to twist; and second, pieces of more than 30 feet in length are inconvenient to handle. It is difficult to place a limit on the scope of this process, but up to the present time the maximum width of cold-drawn strip steel which the Loy & Nawrath Co. has drawn in this way is 16 inches, and 10 gage is the maximum thickness of stock for which machines have been built.

* * *

BRASS AND BRONZE DIE-CASTINGS

At the beginning of 1913, all die-castings produced commercially were composed of either tin, lead, or zinc base alloys, and about 90 per cent were of the latter type. Because of the many limitations to the universal application of die-castings made from these alloys, the Doehler Die-Casting Co. of Brooklyn, N. Y., began a series of experiments having for their object the improvement and extended application of the die-casting. Their research was divided into four branches: improvement of the zinc alloys then in use, elimination of air holes, the die-casting of aluminum and aluminum alloys, and the die-casting of brasses and bronzes.

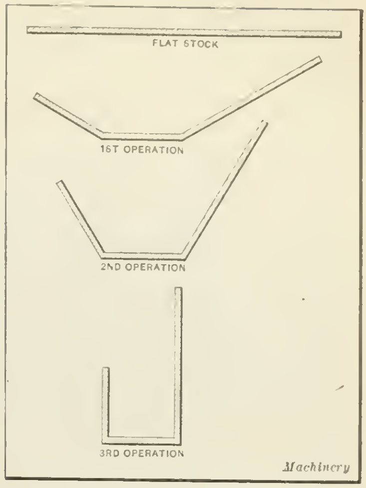


Fig. 8. Condition of Work after passing through Successive Pairs of Rolls

During the infancy of the die-casting industry very little attention was paid to the metallurgical phase of the process; alloys were mixed without regard to metallurgical principles. The chemical and physical testing of the raw materials entering into the alloys, or of the mixed alloys, was not dreamed of, nor was there any systematic control of temperature during mixing or casting. To the fact that these conditions still exist in die-casting plants must be attributed the serious difficulties that so many manufacturers have met in their attempts to use die-cast products.

It is well known, although reluctantly admitted by some manufacturers, that die-castings cannot be made as solid as sand castings. The reason for this is very simple. Die-castings are made by forcing metal into a steel mold under high pressure, and the steel mold, unlike the sand mold, does not allow the air to pass through it. The metal chills almost instantaneously in the metal mold, trapping air unless suitable vents are allowed in the die. Announcements have been made at various times that some manufacturer has devised a new process of die-casting whereby air holes are entirely eliminated. The manufacturer who publishes any statement of this kind is either guilty of an attempt to fool the consumer or lacks knowledge of the fundamental principles involved in the process of die-casting. Every part has its individual shape and requires individual attention and study. By careful and concentrated attention on some parts, the gates and vents may be so located as to insure a solid casting. Only by a careful study of the gating and venting of every individual die can a casting of maximum density be obtained. No die-casting process can be said to produce solid castings simply because a higher pressure or "vacuum pressure" is used. As a matter of fact, there are many cases in die-casting practice where low pressures will produce denser castings; also many cases where a vacuum is a decided disadvantage.

The Doehler Die-Casting Co. has developed a new process for die-casting brass and bronze from the experimental to the commercial stage. The process is not limited to any particular alloy; in fact, yellow brass, red brass, phosphor-bronze, aluminum bronze and manganese bronze can be die-cast. The castings are said to be solid and free from air holes of any kind. The claim is not made that all parts now cast in white metal can be die-cast in brass economically, but that brass die-castings are now a commercial possibility.

Fig. 9. Cold-drawn Steel Section in which Screws or Rivets are concealed by Insert

ALUMINUM CASTINGS AND FORGINGS[1]

In the manufacture of light castings the most desirable properties are: Low specific gravity, a fair amount of strength and freedom from brittleness, good machining properties, maximum resistance to corrosion, good casting qualities, and freedom from hot-shortness. As pure aluminum is entirely too soft to produce satisfactory castings for most purposes, it is alloyed with some element, usually 8 per cent copper. Zinc and tin are also frequently used. The addition of from 8 to 10 per cent of hardener, however, increases the specific gravity; besides, the hardened metal has a strong tendency to brittleness, and in most cases is less resistant to corrosion than either of the component metals. In the case of intricate castings, hot-shortness is another feature. The use of manganese in relatively small quantities, however, hardens and strengthens the alloy without destroying its ductility. The machining properties are excellent, and the specific gravity of the finished alloy is from 0.35 to 0.40 less than that of the ordinary No. 8 alloy. When properly made, these alloys are practically free from hot-shortness, and the most intricate castings can be produced with comparative ease.

The most dangerous impurities in aluminum alloys are carbon, silicon and iron. To prevent the introduction of these, either in the metal used or through the medium of crucibles and tools, carbonless manganese produced by the thermit process has been used exclusively. This manganese is alloyed with copper, when aluminum-copper-manganese is being made, by melting 60 per cent copper and introducing 40 per cent manganese in small pieces and heating until the two metals have combined, which is shown by the smooth condition of the surface of the metal. This alloy can then be diluted with an equal weight of aluminum, although it is feasible to use copper-manganese direct. In making the alloy of manganese without copper, 80 per cent aluminum is melted and brought to a bright cherry red; then 20 per cent manganese is added in very small pieces. The alloy should be poured as soon as all the manganese is dissolved.

In melting aluminum alloys, clay or clay-lined crucibles are preferable. No charcoal or carbonaceous covering is used, as carbon combines with this alloy, forming a very brittle compound. Gates and sprues from castings must be carefully cleaned and freed from sand, as practically all the sand introduced into the pot is reduced to silicon, which materially weakens the alloy. When there is danger of introducing sand into the crucible, a flux made by melting together 60 per cent potassium chloride and 40 per cent kryolite, powdered, may be used.

In preparing the alloy for casting purposes, the hardening substance is placed in a crucible that is brought to a bright red heat, and is melted as quickly as possible. The draft is then cut down and aluminum is added in small amounts as fast as it will melt, the temperature of the mixture being kept at a faint red heat. The crucible is drawn from the furnace just before the last of the aluminum is melted to prevent the metal becoming overheated. Overheated aluminum will absorb silica from the walls of the crucible, and when once overheated, the aluminum is practically worthless. Just before pouring, ¼ ounce zinc chloride is added to the contents of the crucible, and the metal is stirred with a clay-covered skimmer. This zinc salt tends to reduce the oxides and dross in the metal and produces an ideal condition for casting purposes. Alloys of aluminum containing manganese have a slightly greater shrinkage than those containing copper alone, and due allowance must be made by using ample risers and chill plates on intricate castings.

Tests of sand-cast aluminum castings taken at random heats showed the results given in the accompanying table. The aluminum was composed of manganese, 1.5 per cent; copper, 2 per cent; and aluminum, 96 per cent.

RESULTS OF TESTS ON SAND-CAST ALUMINUM CASTINGS

Tensile Strength, Pounds per Square Inch	Per Cent Elongation in 2 Inches	Tensile Strength, Pounds per Square Inch	Per Cent Elongation in 2 Inches
22,000	15.0	21,000	13.0
22,000	14.0	22,000	12.0
21,000	8.0	24,000	10.0
19,000	9.5	19,000	12.0
19,000	14.7	18,000	13.0
19,000	14.0	.....	....

Machinery

The elastic ratio of this alloy, as determined by the drop of the beam of the testing machine, will average about 60 per cent of the ultimate strength. The fracture of test specimens is silky and shows considerable toughness, instead of being granular and brittle, as is the case with many aluminum alloys. Castings are practically free from hot-shortness. Aluminum containing manganese will work very freely either by cold-rolling or hot-forging, and many intricate shaped drop-forgings have been produced.

For forging, the metal is as carefully prepared as for casting. The ingot mold is the same type as is used for bronze. These molds are heated to about 500 degrees F. and given a thin coating of orange shellac to produce a clean skin. The metal should be carefully skimmed and poured very quickly in order to prevent cold-shuts. In making drop-forgings, a little preliminary forging is desirable. The ingot can be cut or cropped to the desired lengths and forged to approximate shape at a temperature of from 1150 to 1400 degrees F., after which it can be finished in the dies. Dies of the type used for tobin bronze are perfectly satisfactory for aluminum work. The stiffness and strength of the forged material can be controlled by varying the finishing temperature. Considerable stiffness and elasticity can be imparted to the forgings by two or three blows of the forging dies at about 500 degrees F.

The physical properties of a bar forged to one inch square and turned to standard size tensile specimens, when composed of manganese, 1 per cent, copper, 2 per cent, and aluminum, 96.5 per cent, are as follows:

	Tensile Strength	Yield Point	Per Cent Elongation	Per Cent Reduction of Area
Cold-finished	27,750	27,750	12.0	47.0
Hot-finished	21,083	12,223	26.7	48.7
Intermediate	25,617	22,918	17.4	52.0

In the case of a hard alloy containing manganese, 2 per cent, copper, 3 per cent, and aluminum, 94.5 per cent, the physical properties are:

	Tensile Strength	Yield Point	Per Cent Elongation	Per Cent Reduction of Area
Cold-finished	31,930	30,000	9.75	35.30
Cold-finished	34,123	33,000	4.00	11.25
Cold-finished	30,405	30,000	11.25	30.78
Hot-finished	27,450	15,000	21.95	56.00
Intermediate	28,670	22,000	21.00	50.40

Sections cut from thin drop-forgings that were cold-finished have shown a tensile strength as high as 40,000 pounds per square inch. The forged material machines well and shows a fine silky fracture when broken. The increased density of the metal produced by forging makes it a great deal more resistant to sea-water corrosion than the cast alloy. Several drop-forgings of these alloys are now undergoing service tests on ships at sea to determine their resistance to corrosion, and reports thus far received are very promising. Considering the low specific gravity of these alloys, together with the strength and ductility obtainable, the material compares favorably with the heavier bronze and brass forging materials for many purposes.

* * *

In the building of the new open-hearth furnace at Vereeniging, Transvaal, South Africa, homemade products are being used almost exclusively. This furnace is to turn out 1000 tons of steel a month, or twice as much as the furnace it replaces. The magnesite and silica brick are made locally, and all castings, except the valves and chains, are made on the spot; the chrome ore hearth is made from Rhodesian material; the gas required to melt the charges will be made from local bituminous coal. At present, the foundry is working on scrap; but it is claimed that deposits of high-class iron ore lie within a few miles of the foundry.

[1] Abstract of paper by P. E. McKinney, read at the annual meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio.

THEORY OF ENLARGED HERRINGBONE PINIONS

FORMULAS FOR DESIGNING PINIONS TO AVOID UNDER-CUT

BY E. W. MILLER [1]

It is common to make the diameter of herringbone pinions having less than twenty teeth somewhat larger than the size indicated by the pitch and number of teeth. Some authorities advocate enlarging all pinions with less than twenty-five teeth. The object is to avoid under-cut, thereby insuring strong teeth and a maximum of involute tooth surface. Under-cutting is caused by interference of the generating tool with the teeth of the pinion being cut. The most pronounced case of interference is that caused by an unmodified hob or any other tool corresponding to a rack. Formulas for determining these pinion diameters have been set forth, and at least two are in use today. Apparently they have been determined empirically. The logical procedure is to derive a formula which will determine mathematically the necessary amount of enlargement and adhere to this figure. Any further increase is useless and may result in an excessive pressure angle.

In Fig. 1 is shown the extreme case of interference of a rack tool with a nine-tooth pinion. The tooth addendum is 0.8, dedendum 0.8, clearance 0.2, making a total depth of 1.8 inch. The distance from the pitch line to the bottom of the space is 1 inch, pressure angle, 20 degrees, and diametral pitch, 1. By diametral pitch is meant the pitch as measured in a plane at right angles to the axis of the gear. It should be distinguished from the normal pitch, which is measured in a plane normal to the helix angle. These planes may be referred to as the diametral plane and normal plane. The action of a pair of helical gears operating on parallel axes is identical to that of spur gears. This action should therefore be studied from the diametral plane, and is so considered in Fig. 1. It is to be noted that the end of the generating tool falls well inside the interference point, thus resulting in under-cut, weakened teeth and a shortened involute surface. In Fig. 2 the pinion has been enlarged until the cutting tool just reaches the interference point. No under-cutting occurs and the involute curve comes clear down to the base line. The pitch radius AD multiplied by cosine 20 degrees gives the base line radius AB; and cosine 20 degrees multiplied by AB determines the length AC. Obviously, if the tool addendum of 1 inch be added to AC, the nominal pitch radius is obtained; and this value multiplied by 2 gives the nominal pitch diameter. Formula (1), developed from the preceding considerations, determines the exact amount of enlargement required of the pinion to avoid interference and consequent under-cutting of the teeth.

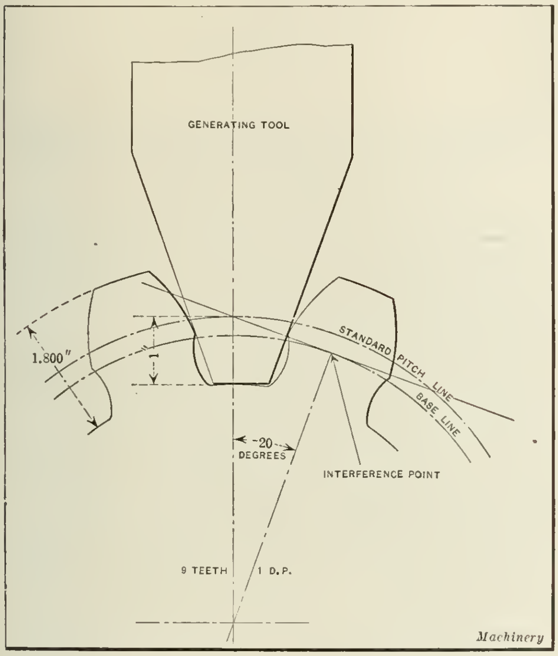


Fig. 1. Extreme Case of Interference between Rack Tool and Nine-tooth Pinion

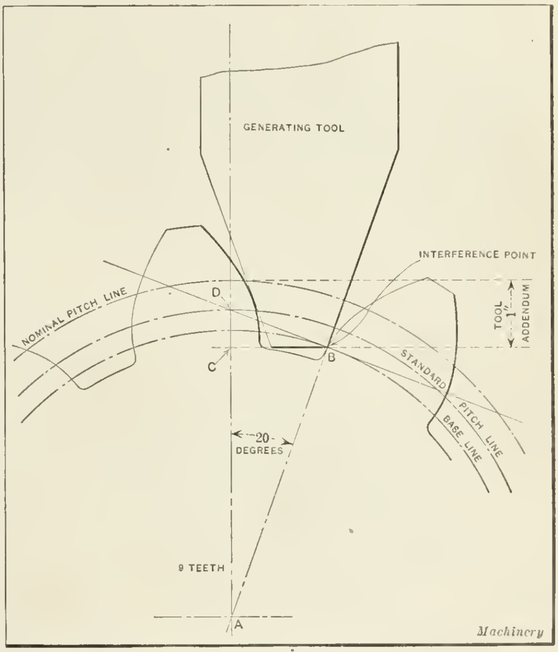


Fig. 2. Enlarged Pinion in which Interference between Tool and Teeth has been overcome

Suggested Formula

$$\frac{\text{Number of teeth}}{\text{Diametral pitch}}(\cos \text{pressure angle})^2 + \frac{2}{\text{Diametral pitch}} = \text{Nominal pitch diameter.} \quad (1)$$

Formulas Now in Use

$$\text{Pitch diameter (under 25 teeth)} = \frac{(0.96 \times \text{number teeth}) + 1}{\text{Diametral pitch}} \quad (2)$$

$$\text{Pitch diameter (under 20 teeth)} = \frac{(0.95 \times \text{number teeth}) + 1}{\text{Diametral pitch}} \quad (3)$$

The table gives nominal pitch diameters obtained by applying the three different formulas to pinions with from nine to eighteen teeth, inclusive. The newly suggested Formula (1) gives the greatest diameters for pinions

NOMINAL PITCH DIAMETERS IN INCHES OBTAINED FROM FORMULAS (1), (2) AND (3)[1]

No. of Teeth	9	10	11	12	13	14	15	16	17	18
Formula 1	9.947	10.830	11.713	12.596	13.479	14.362	15.245	16.128	17.011	17.894
Formula 2	9.640	10.600	11.560	12.520	13.480	14.440	15.400	16.360	17.320	18.280
Formula 3	9.550	10.500	11.450	12.400	13.350	14.300	15.250	16.200	17.150	18.100

Machinery

[1] Note: Diametral pitch, 1; pressure angle, 20 degrees; tooth depth, 1.8 inch.

[1] Chief Engineer, Fellows Gear Shaper Co., Springfield, Vt.

with less than thirteen teeth. At thirteen teeth, Formula (2) comes to the front with Formula (1) in second place. At fifteen teeth, Formula (2) indicates the greatest increase and Formula (1) the least. If it is conceded that Formula (1) is correct, the following comparison of Formulas (2) and (3) is of interest. For less than fourteen teeth, Formula (2) is nearer right; for fourteen teeth or more, Formula (3) is more accurate. It is noteworthy that at eighteen teeth no enlargement is necessary, as the size 17.894 inches is smaller than the standard pitch diameter. Herringbone pinions with less than fifteen teeth are rarely used, since long service is a requirement. This factor determines the minimum number of teeth, which is perhaps fortunate, since the greater increase in nominal pitch diameters of smaller pinions would result in excessive pressure angles. With fifteen teeth as the limit, we are spared this problem, the solution of which is at best a compromise of under-cut and pressure angle.

Formula (2) is apparently based on results obtained in using a hob with an axial pressure angle of 20 degrees. In this case the hob axis is perpendicular to the axis of the gear it is cutting. The hob lead angle is the complement of that of the gear being produced. This arrangement surely results in producing gears of 20 degrees pressure angle. The fact remains that many gears are being cut with the hob set at an angle corresponding to the helix angle of the gear plus or minus the hob lead angle, as the case requires. Usually the hob tooth angle, as measured in the normal plane, is 20 degrees. While the use of great helix angles is to be deplored, herringbone gears are in use with helix angles as high as 35 and even

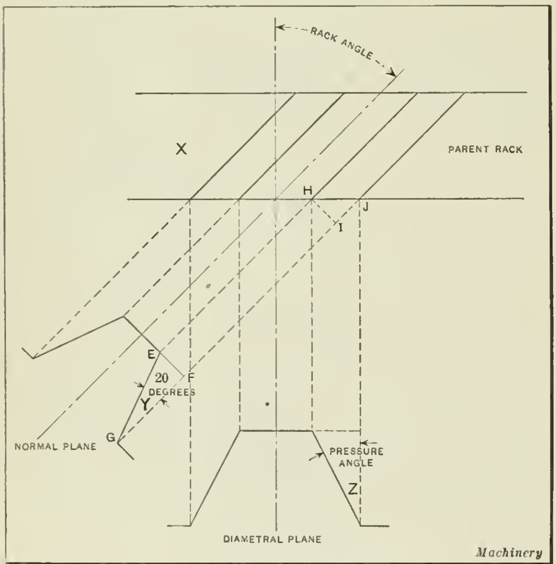


Fig. 3. Diagram showing Relation between Helix and Pressure Angles

45 degrees. There is a definite relation between the helix and pressure angles of a helical gear, and Fig. 3 illustrates this point. Let X be a parent rack from which helical gears may be developed. At Y is shown the end of the teeth as viewed in the normal plane, the angle of the tooth side being 20 degrees. A development of this tooth at Z in a plane perpendicular to the side of the rack shows graphically that tooth angle Z is greater than Y.

$$EF = \text{Tan } 20 \text{ degrees} \times GF = HI$$

$$\frac{HI}{\text{Cos rack angle}} = HJ$$

$$HJ = \tan Z$$

$$\frac{\text{Tan normal angle}}{\text{Cos helix angle}} = \text{tan pressure angle}$$

Using the preceding formula, we find that a 20-degree generating tool cuts a 23-degree helix angle gear with a pressure angle 21 degrees, 36 minutes, and a 45-degree helix angle gear with a pressure angle of 27 degrees, 14 minutes. These two

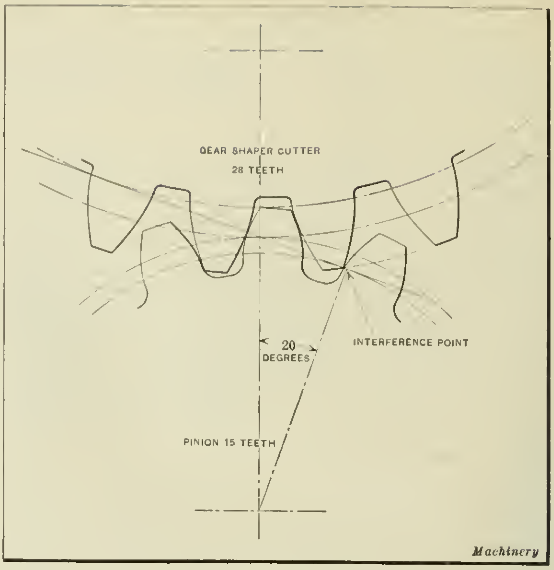


Fig. 4. Freedom from Interference when generating Teeth on Fellows Gear Shaper

cases are given to illustrate the great pressure angle difference. From the foregoing, two sound reasons may be advanced for the adoption of Formula (1): First, the exact amount of enlargement to accomplish the desired end is easily determined; second, the pressure angle, a very important factor in the matter of under-cut, is taken into consideration.

When cutting helical pinions by a certain process, namely, that of the Fellows Gear Shaper Co., Springfield, Vt., no enlargement is necessary. The cutter does not interfere with a fifteen-tooth pinion, a fact which is evidenced by Fig. 4. We have referred to the standard pitch diameter, which is understood to be obtained by dividing the number of teeth by the pitch; also to the nominal pitch diameter which exceeds the standard by the amount of enlargement. In action, an enlarged pinion never runs with the mating gear at its nominal pitch diameter unless the mating gear is given an equal percentage of enlargement; and it never runs with the mating gear at its standard diameter unless standard center distance is maintained.

Fig. 5 shows a fifteen-tooth pinion and a forty-five-tooth gear

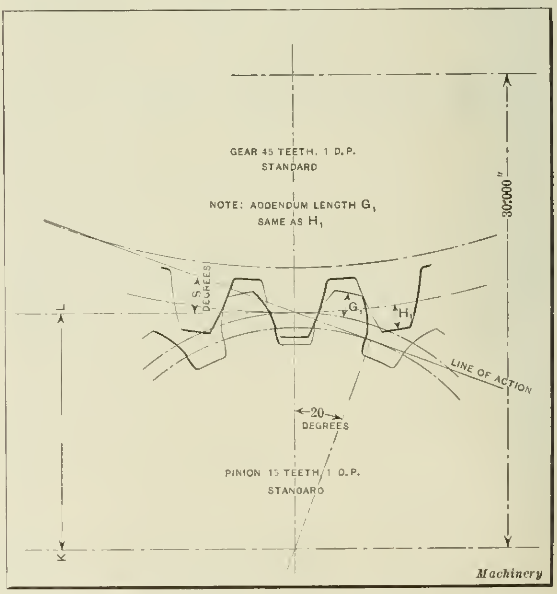


Fig. 5. Pinion with Fifteen Teeth and Gear with Forty-five Teeth generated by Rack Tool and in Engagement at Standard Center Distance of 30 Inches

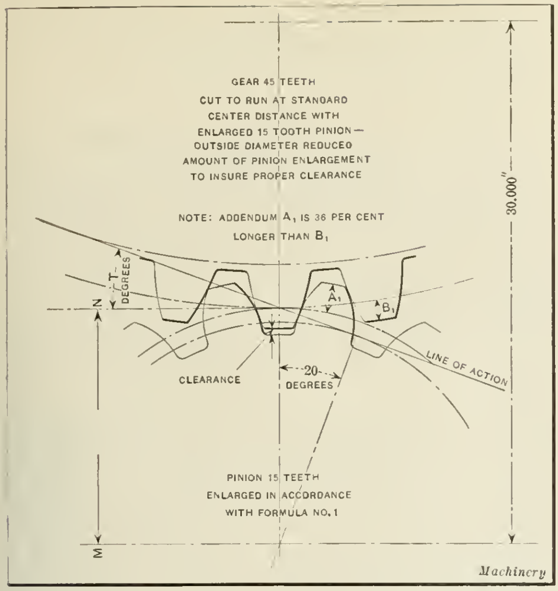


Fig. 6. Pinion enlarged according to Formula (1) engages Gear properly at Standard Center Distance of 30 Inches

of 1 diametral pitch, both of which have been generated from a rack tool and are in engagement at a standard center distance of 30 inches. In Fig. 6 a pinion enlarged according to Formula (1) is engaging the gear snugly at a standard center distance of 30 inches. The gear has, of course, been somewhat reduced. Fig. 7 shows an enlarged pinion running with a standard gear at a center distance of 30.122 inches, the standard center distance having been increased one-half the amount of pinion enlargement. In Fig. 8, the gear has a percentage of enlargement equal to that of the pinion and the center distance of 30.490 inches is greater than standard by exactly one-half the sum of gear and pinion increase. In each of the last four illustrations, a line tangent to pinion and gear base circles crosses the line of centers. This is the line of action. The intersections of various lines of action with center lines are measured from the pinion centers by lines *KL*, *MN*, *OP* and *QR*. Distances *KL* and *MN* are equal; *OP* is greater and *QR* is greatest. Angles *S* and *T* are equal; *U* is greater and *V* is greatest. The intersections are pitch points and the circles passing through them are the pitch line of the gears as they

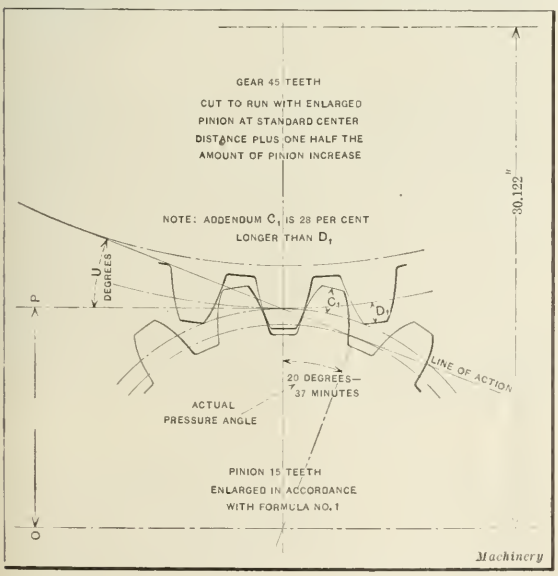


Fig. 7. Enlarged Pinion running with Standard Gear on Center Distance of 30.122 Inches, i. e., increased One-half of Pinion Enlargement

run together or the actual pitch lines. The angles of the lines of action are the actual pressure angles. It is evident from this that the actual pressure angle is dependent upon the center distance at which the gears run and independent of the enlargement. Mathematically, the actual pitch diameter, diametral pitch and pressure angle may be determined by the following formulas:

Pinion

$$\text{Actual pitch diameter} = \frac{\text{Center distance} \times 2 \times \text{number of teeth in pinion}}{\text{Sum of teeth in gear and pinion}}$$

Gear

$$\text{Actual pitch diameter} = \frac{\text{Center distance} \times 2 \times \text{number of teeth in gear}}{\text{Sum of teeth in gear and pinion}}$$

$$\text{Cos actual pressure angle} = \frac{\text{Base line diameter}}{\text{Actual pitch diameter}}$$

$$\text{Actual diametral pitch} = \frac{\text{Number of teeth}}{\text{Actual pitch diameter}}$$

A study of the four diagrams, Figs. 5, 6, 7 and 8, makes plain that in Figs. 5 and 8 the addendum circles of gear and pinion are greater than their respective actual pitch circles by equal amounts. This is not true in Figs. 6 and 7. At the

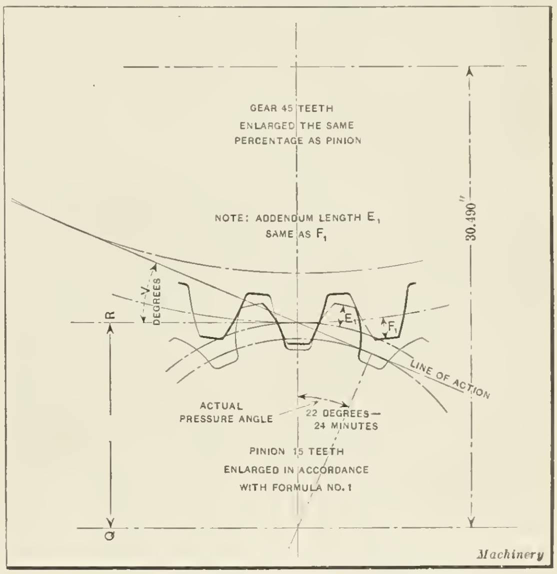


Fig. 8. Gear and Pinion with Same Percentage of Enlargement, and with Center Distance of 30.490 Inches, i. e., increased One-half of Gear and Pinion Enlargement

actual pitch line the action is purely rolling, but away from this pitch line slippage occurs. This means wear, which is destructive to the tooth shape so necessary for smooth, quiet gearing. Properly designed helical gears have the virtue of always being in contact in some plane at the pitch line. But a certain amount of tooth length is necessary for serviceable gearing, as although a large part of the load is taken near the pitch line, a certain portion is carried by the remaining tooth surface. It follows then that the sliding action may be better distributed if addenda of gear and pinion, as measured from actual pitch circles, are of the same length. This, of course, can only be accomplished when using an enlarged pinion, by enlarging the gear in the same percentage and running the two members at correspondingly increased center distance, as illustrated in Fig. 8.

* * *

During the last week of December the seventieth meeting of the American Association for the Advancement of Science was held in New York City. The forty national societies affiliated with it met at the same time. In the decade that has passed since the association has met in New York, its membership has grown from 5000 to 11,000.

CUTTING LEAD-SCREWS WITH BOLT DIES

Chasing accurate lead-screws on the engine lathe is one of the most particular and difficult jobs encountered in the machine shop. The work requires experience, a first-class lathe and tools that are correctly ground and set. Chasing a long screw in the ordinary way is a long, tedious job, and it is small wonder that during the period of abnormal demand for lathes, new and more rapid methods have been employed for producing these parts quickly. Most mechanics doubtless would recoil from the proposition of cutting an engine lathe lead-screw with a bolt die, but it can be done and is being done expeditiously and accurately.

One machine tool shop in the Middle West took a large contract for building engine lathes. Not having been builders of lathes before the outbreak of the war, it was not bound by precedent, and did not hesitate to resort to an improved and quicker way of producing lead-screws. A lathe was rigged up with a heavy Landis bolt die on the carriage, preceded by a bushing to guide the stock centrally into the die. The Landis bolt die is provided with tangent cutters, which are ground on the end without changing the shape. The chasers are similar in this respect to the well-known milling cutters which can be ground without changing their form. The tangent chasers also facilitate the cutting and getting rid of the chips. The lathe was provided with a long center in the tailstock that projected through the die and entered the center of the stock, guiding it at the beginning of the cut, as well as supporting it after the cut was well under way. The stock was centered at the headstock end also, and was gripped by a four-jaw chuck which acted as the driver.

The carriage was traversed by the lead-screw, so that the die was relieved of the drag. The dies were ground so that the chips curled and ejected from the front of the die. The chips curled in the same way as though cut with a single-point tool, and no trouble whatever was experienced by clogging. A copious supply of approved emulsion compound was provided to lubricate the die and work and keep them cool.

After considerable experimenting, a production rate of about one foot per minute was secured on lead-screws of six pitch Acme thread, 1¼ inch diameter, about six minutes being required to cut a lead-screw having six feet of thread. After being cut with the bolt die, the screws were taken to another lathe and chased in the ordinary manner with a single-point tool; from 0.012 to about 0.015 inch was left for the two chasing cuts required to finish the screw.

The objection to cutting lead-screws in this manner is that the torsion of the stock introduces an angular error or distortion of the lead of appreciable magnitude. But chasing the screws in the ordinary manner afterward should correct errors of this kind and produce commercial lead-screws, that is, screws of commercial accuracy. Distortion due to the torsion is present in all lead-screws cut with a single-point tool. The amount of angular distortion depends on the depth of the cut, and it is usual practice to correct it by taking very light finishing cuts. The same practice in this case should have the same results and produce approximately correct screws.

Another practice of cutting lead-screws with bolt dies, perhaps not productive of as accurate work as that just described, is taking two cuts—roughing and finishing—with the die. The die is carried along by the lead-screw of the lathe in the same manner as described, so that it is relieved of the drag due to pulling the carriage, and has only to cut the threads. This method has been used successfully for cutting the elevating screws of boring mills and planers, which must be even in lead, although not necessarily accurate in pitch, when measured with a scale; it is essential that two screws or a pair shall raise both ends of a cross-rail the same number of inches and parts of an inch for a given number of turns. If a bolt die used in the manner described serves to cut these screws with commercial accuracy, the practice should not be far astray when applied to cutting lead-screws of engine lathes. Probably a compromise would be to cut the screws with a roughing cut and finishing cut in the die, leaving a few thousandths inch for finishing with a single-point tool in the ordinary manner. Either of these methods is more rapid than milling in the thread milling machine. The thread milling machine produces accurate and satisfactory screws, but many complain that the method is too slow in rush times, when customers clamor insistently for machines.

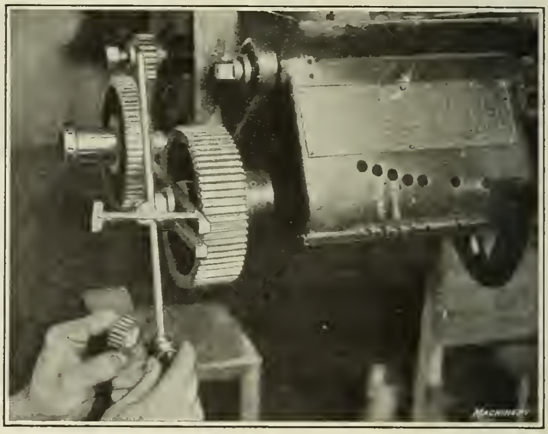
* * *

LATHE FEED-SCREW FOR INDEXING TOOL CARRIAGE

At the plant of the Black & Decker Mfg. Co., Baltimore, Md., the press of business has made it necessary to use some ingenious makeshifts in order to turn out the work. One of the jobs which the company had to do recently was the making of Whitworth threading hobs of the type having parallel grooves instead of a helical groove. The Whitworth shaped grooves are spaced 1/14 inch apart, or fourteen per linear inch. Thus there are fourteen individual grooves per inch of length on the hob instead of one groove of helical form with a lead of 1/14 inch.

The hobs are mounted on an arbor in a 14-inch Flather lathe and a form tool is placed in the tool-holder just the same as though a thread were to be cut. The idler gear connecting the feed-screw and gear train is disconnected. On the leg of the lathe, just below the lead-screw gear, is temporarily clamped an angle iron with its leg approximately parallel to the center line of the lead-screw and spindle. The nut on the lead-screw gear is backed off a sufficient distance to slip two parallel strips between it and the gear.

The gear shift lever is thrown into the position which would be correct for cutting a thread of fourteen turns per inch.



Gaging for indexing Tool Carriage Even Number of Revolutions to Cut Hobs

After cutting the first groove in the hob, the relative location of which is secured by throwing the compound slide around at the proper angle, the tool carriage is moved along exactly 1/14 inch by the operator's revolving the feed-screw gear the proper number of turns—in this case, two. To be assured of getting exactly two turns with no fraction more or less, the height gage fitted with the indicator is employed. With the contact end of the surface indicator resting on the parallel strip, which is clamped tightly to the gear, the gear is brought to a standstill when the indicating needle rests at zero. This process is repeated every time a new groove is cut, and the results obtained are very satisfactory in spite of the fact that this is a makeshift method of doing the job. A little ingenuity on the part of shop men will often easily overcome what would otherwise be a difficult job. V. B.

* * *

The British Minister of Munitions has partly removed the embargo on machine tools, etc. It is now possible to sell, to persons who have a permit to resell them, lathes, milling machines, drilling machines, planers, shapers, screw machines, chucking machines, boring machines, slotting machines, grinding machines, boring and turning mills, power presses, punching and shearing machines, forging machines, cutting-off machines, gear-cutting machines, and centering machines.

INTERNAL SPUR GEARING

DESIGNING AND MACHINING INVOLUTE AND CYCLOIDAL INTERNAL SPUR GEARS

BY REGINALD TRAUTSCHOLD[1]

REDUCED to fundamental principles, all toothed gearing may be likened to plain curved surfaces rolling together, the teeth simply acting as members for the transmission of the power. In other words, all gears may be compared to friction wheels, the pitch surfaces of the toothed gears representing the contact surfaces of the friction wheels. Furthermore, the curvature of a plain curve is measured by the reciprocal of the radius of curvature, and as the curvature of a straight line is zero, comparison of the curvature of two arcs is most conveniently expressed in terms of relative curvature—the straight line being the basis of comparison. These basic laws govern all gearing, but a clear conception of the fundamentals is necessary in a consideration of internal gearing, as it is in this type of gearing that the limitations and inaccuracies of the comparatively universal involute system are most apparent.

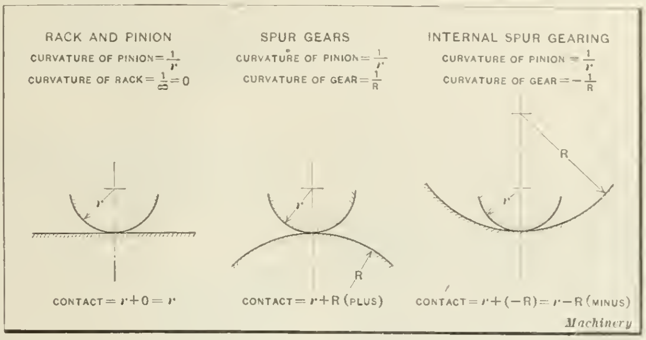


Fig. 1. Diagrams of Contact between Curved Gear Profiles

Fig. 1 illustrates diagrammatically the three general types of spur gearing: the rack and pinion, the ordinary spur gears, and internal spur gearing. As the amount of contact between the plain curved profiles is measured by the reciprocal of the relative curvature, the amount of contact for the rack and pinion is measured by the pitch radius of the pinion; the amount of contact for ordinary spur gears, by the sum of the pitch radii of the two gears; and the amount of contact for internal gears, by the pitch radius of the pinion minus the pitch radius of the gear. The contact of internal spur gearing is minus, compared to that of a rack and pinion, and that of ordinary spur gearing is plus. The effect of this, in the practical design of gears, will be apparent by a study of the interference of teeth in a rack and pinion.

From Fig. 2 it is quite evident that interference will occur between the teeth of a rack and a pinion when the point A—the intersection of a pinion radial line with the line of pressure or the point of tangency of the line of pressure with the pinion base circle—falls inside of the true rack addendum line. In the case of the rack and pinion, this interference is customarily overcome by shortening the rack teeth by the amount of this interference measured normally to the plane of the rack. The interference naturally increases in amount with the number of teeth in the pinion; and for the true involute form of tooth, with a pressure angle of 14½ degrees, it begins with a pinion of thirty-one teeth.

As the curvature of the ordinary spur gear is equivalent to a certain reduction in the height of the rack tooth, interference is somewhat delayed, and can frequently be overcome by rounding off the corners of the gear teeth. Shortening the gear teeth by the amount of interference would have the same effect, but this is usually a more expensive operation. In the case of internal spur gearing, on the other hand, interference is aggravated in this way, and can only be avoided by a certain modification in the form of the gear tooth.

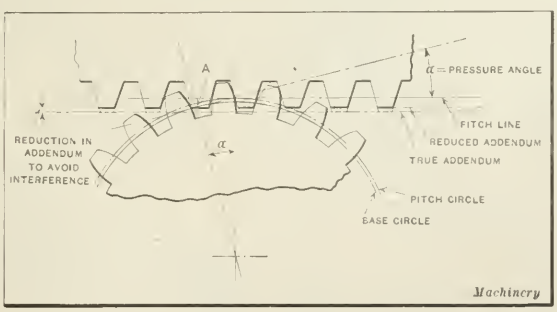


Fig. 2. Interference of Rack and Pinion

Form of Internal Spur Gear Teeth

Fig. 3 is a typical section of an internal spur gear, and shows the alterations in the shape of the regular involute tooth by which interference of teeth is avoided, for any combination of gears in which the pinion has less than fifty-five teeth. Should the pinion have a greater number of teeth, other modifications of the standard involute form of tooth are necessary, and frequently some other system of gearing must be adopted. Such combinations of internal spur gears are comparatively rare, however, and may be considered as special problems, which are advisably solved by laying out the gearing to a suitable scale and modifying both the shape of the pinion and of the gear tooth. A further requisite for the satisfactory operation of involute internal spur gearing is that the difference between the number of teeth in the gear and the pinion is at least fifteen.

For internal spur gear combinations in which the pinion has less than fifty-five teeth, the regular standard involute pinion may be employed, and the modifications required in the shape of the gear teeth may be resolved to definite relationships, which can be expressed in simple and convenient formulas. The dedendum part of the gear-tooth space must be the conjugate of the addendum section of the pinion tooth, plus the clearance. It differs in outline from the tooth space of an ordinary gear in that the profile of the tooth is a concave curve extending past the pitch circle to a point midway between the base and pitch circles of the gear, the location of the interference circle, Fig. 3. The curve bounding this lower section of the gear tooth closely approximates the arc of a circle having a radius equal to one-eighth the pitch diameter of the gear struck about a center located on the base circle. This approximation of a section of an involute curve is very nearly exact for gears with thirty or more teeth; and as the gear almost invariably has more teeth than this, the method is sufficiently accurate for all practical purposes. When the gear has less than thirty teeth or when extreme accuracy is required, a true involute should be developed for that section of the tooth profile lying between the interference circle and the base of the tooth, as this is the true profile of the lower section of the internal spur gear tooth. This refinement, however, is only required when laying out templets, the simpler method being sufficiently accurate for "picturing" internal spur gears.

The modification of the gear tooth to avoid interference is limited to the section within the interference circle. It consists in making the end of the addendum profile conform to the convex arc of a circle, the radius of which is equal to the square root of the sum of the squares of one-eighth the pitch diameters of the respective gear and pinion. This

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is known as the "addendum cutting radius," and the arc is struck about a center on what is known as the "correction circle." The diameter of this correction circle is equal to the pitch diameter of the gear divided by the cosine of the pressure angle.

The location of the interference circle is such that an arc having a radius equal to one-eighth the pitch diameter of the gear, struck about a center on the base circle of the gear, will be tangent at a point on the interference circle, to an arc having a radius equal to the square root of the sum of the squares of one-eighth the pitch diameters of the gear and pinion, struck about a center on the correction circle. The position of the interference circle midway between the base and pitch circles of the gear is naturally dependent, to some extent, upon the relative curvature of the two gears; this accounts for the limitations as to the number of teeth in the pinion.

A pinion with more than fifty-five teeth will so interfere with any practical internal gear that interference will commence at some point on the gear-tooth profile in closer proximity to its pitch circle than midway between the base and pitch circles. This will necessitate an increase in the diameter of the correction circle, and will result in cutting away the ends of the internal gear teeth in order to avoid interference.

Interference of a pinion having but a few teeth with an internal gear having a comparatively large number of teeth would not commence at a point midway between the base and pitch circles of the gear, but the proper correction is cared for by the variation in the length of the addendum cutting radius. This radius is obtained from the sum of the respective proportional pitch diameters of both the gear and pinion, so that when their ratio is comparatively high and the interference correspondingly reduced, the addendum cutting radius is also comparatively large, and but little of the corners of the internal gear teeth are removed. When the ratio between the number of teeth in the gear and pinion is low, provided there is a difference in the number of teeth of at least 15, the addendum cutting radius is correspondingly shortened, and more of the corners of the internal gear teeth removed. This variation in the addendum cutting radius has the same effect as altering the diameter of the interference circle and maintaining constant the length of the addendum cutting radius. The variation in the addendum cutting radius should not be made, however, if there is a difference of less than 15 in the number of teeth in the gear and pinion, as this will ordinarily mean such a low ratio that the addendum cutting radius will be so reduced that the ends of the internal gear will be cut away.

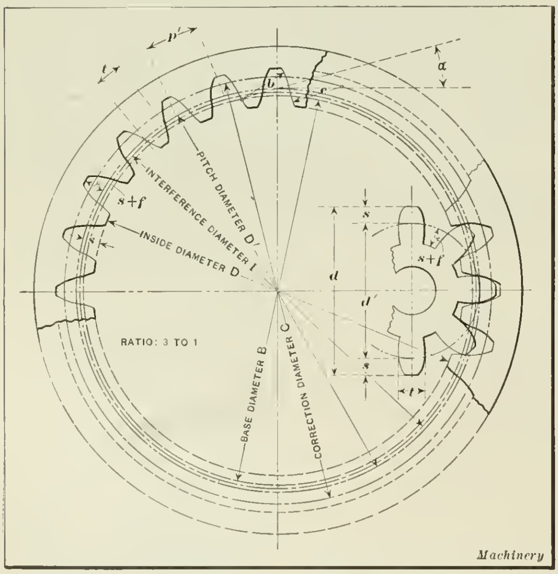


Fig. 3. Lay-out for Internal Spur Gearing

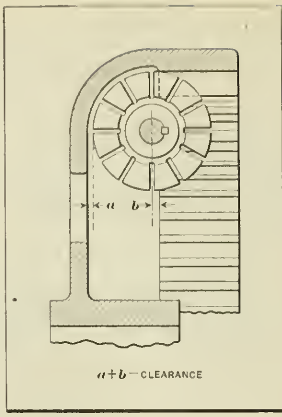


Fig. 4. Internal Spur Gear cut with Rotary Cutter

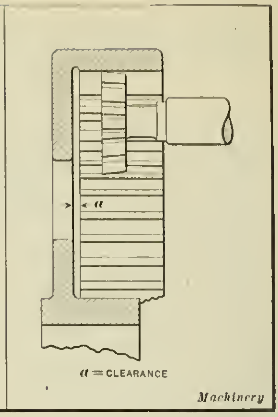


Fig. 5. Internal Spur Gear cut with Fellows Gear Shaper

Notation for Internal Spur Gearing

	Gear	Pinion
Pressure angle	α	α
Diametral pitch	p	p
Circular pitch	p'	p'
Number of teeth	N	n
Pitch diameter	D'	d'
Outside diameter		d
Inside diameter	D	
Dedendum diameter	D''	
Thickness of tooth on pitch circle	t	t
Addendum	s	s
Dedendum	$s+f$	$s+f$
Clearance	f	f
Working depth of tooth	$2s$	$2s$
Total depth of tooth	$2s+f$	$2s+f$
Base circle diameter	B	
Interference circle diameter	I	
Correction circle diameter	C	
Dedendum cutting radius	b	
Addendum cutting radius	c	

Formulas for Internal Spur Gearing

$$p = \frac{N}{D'};\ \text{or}\ p = \frac{n}{d'} \quad (1) \qquad p' = \frac{3.1416}{p} \quad (2)$$

$$D' = \frac{N}{p};\ \text{or}\ D' = 0.3183Np' \quad (3)$$

$$d' = \frac{n}{p};\ \text{or}\ d' = 0.3183np' \quad (3a)$$

$$d = \frac{n+2}{p};\ \text{or}\ d = d' + 0.6366p' \quad (4)$$

$$D = \frac{N-2}{p};\ \text{or}\ D = D' - 0.6366p' \quad (5)$$

$$D'' = \frac{N+2.314}{p};\ \text{or}\ D'' = (0.7366 + 0.3183N)p' \quad (6)$$

$$t = \frac{1.5708}{p};\ \text{or}\ t = \frac{p'}{2} \quad (7) \qquad s = \frac{1}{p};\ \text{or}\ s = 0.3183p' \quad (8)$$

$$s+f = \frac{1.157}{p};\ \text{or}\ s+f = 0.3683p' \quad (9)$$

$$f = \frac{0.157}{p};\ \text{or}\ f = 0.05p' \quad (10)$$

$$B = D'\cos\alpha \quad (11) \qquad I = 0.5(B+D') \quad (12)$$

$$C = \frac{D'}{\cos\alpha} \quad (13) \qquad b = \frac{D'}{8} \quad (14)$$

$$c = \sqrt{\left(\frac{D'}{8}\right)^2 + \left(\frac{d'}{8}\right)^2} \quad (15)$$

Discussion of Formulas

The formulas presented for the pinion member of an internal spur gear combination are similar, of course, to the well-known formulas for the ordinary type of spur gear. The main difference, other than the special formulas for the curves of the tooth profile, lies in the fact that the teeth are in an

opposite position as compared to those of the ordinary variety of spur gear. That is, the dedendum diameter of the internal spur gear is as much greater than its pitch diameter as the addendum, or outer, diameter of an ordinary spur gear of the same number of teeth and similar pitch is greater than its pitch diameter, plus twice the clearance.

The importance of the inner diameter of an internal spur gear is, therefore, as great as that of the outer diameter of the more common type, so that twice the addendum is subtracted from the pitch diameter of an internal spur gear to obtain its inner diameter, just as twice the addendum is added to the pitch diameter of an ordinary spur gear to obtain its outer diameter. The thickness of the tooth on the pitch circle, addendum, dedendum, and clearance for internal spur gears is obtained in a manner similar to that employed for spur gears of the customary type.

Example in the Design of Internal Spur Gearing

Example:—Required, an internal spur gear combination; 8 diametral pitch, 64 teeth in gear, 20 teeth in pinion; 14½-degree pressure angle.

$$p' = \frac{3.1416}{8} = 0.3927 \text{ inch} \quad (2) \qquad D' = \frac{64}{8} = 8 \text{ inches} \quad (3)$$

$$d' = \frac{20}{8} = 2.5 \text{ inches} \quad (3a) \qquad d = \frac{20 + 2}{8} = 2.75 \text{ inches} \quad (4)$$

$$D = \frac{64 - 2}{8} = 7.75 \text{ inches} \quad (5)$$

$$D'' = \frac{64 + 2.314}{8} = 8.28925 \text{ inches} \quad (6)$$

$$t = \frac{1.5708}{8} = 0.19635 \text{ inch} \quad (7) \qquad s = \frac{1}{8} = 0.125 \text{ inch} \quad (8)$$

$$s + f = \frac{1.157}{8} = 0.144625 \text{ inch} \quad (9)$$

$$f = \frac{0.157}{8} = 0.019625 \text{ inch} \quad (10)$$

$$B = 8 \times 0.96815 = 7.745 \text{ inches} \quad (11)$$

$$I = 0.5\ (7.745 + 8) = 7.8725 \text{ inches} \quad (12)$$

$$C = \frac{8}{0.96815} = 8.261 \text{ inches} \quad (13)$$

$$b = \frac{8}{8} = 1.000 \text{ inch} \quad (14)$$

$$c = \sqrt{\left(\frac{8}{8}\right)^2 + \left(\frac{2.5}{8}\right)^2} = 1.048 \text{ inch} \quad (15)$$

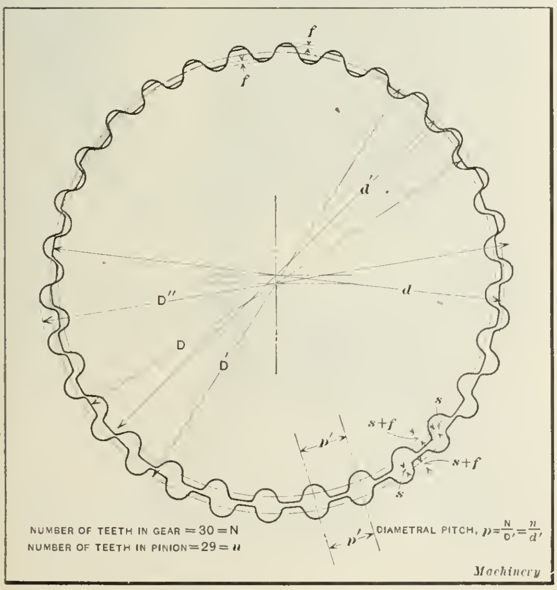


Fig. 6. Lay-out for Cycloidal Internal Spur Gearing

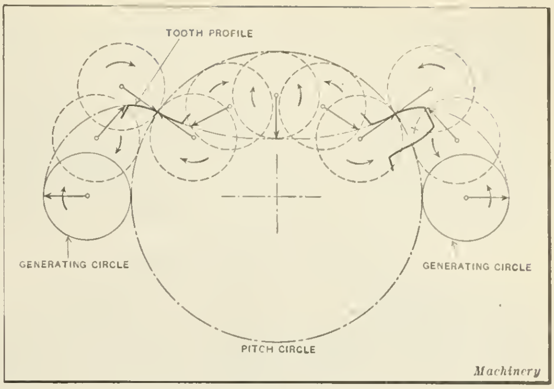


Fig. 7. Generating Cycloidal Tooth

Machining Internal Spur Gears

The teeth of internal spur gears are awkwardly located for machining operations, unless the gear is of the ring type, or composed of segments of a ring, with lugs protruding from the outer circumference of the gear ring by which the gear can be attached to some supporting structure. The gear teeth may be cut with a rotary cutter, milled, or cut with a machine of the Fellows gear-shaper type, depending on the general design of the gear.

Fig. 4 shows the variety of gear for which the rotary cutter may be employed and indicates the clearances that must be allowed. A special cutter is usually required, but when accuracy is not absolutely essential, a No. 1 standard rotary cutter may be employed for gears of 4 diametral pitch and finer, provided the gear has sixty or more teeth. The greater the number of teeth and the finer the pitch, the more satisfactory is the standard cutter for internal teeth. The operations involved in milling internal spur gear teeth are similar to those for cutting ordinary spur gears, but the rate of production is not usually as high, owing to the greater difficulty of interior work and the necessity of exercising more care than when working on an exterior surface.

Machining internal spur gears on a shaper permits a much more compact design of gear, as is shown in Fig. 5. Clearance for the tool is required, but this can be kept as low as 3/16 inch with a Fellows gear shaper. This is naturally a decided advantage, but it is gained only through the sacrifice of speed in production, the rotary cutter being by far the more efficient tool.

Internal Spur Gears of Low Ratio

The involute system of internal gearing, requiring a difference of 15 in the number of teeth in the gear and pinion, does not lend itself to many installations where the difference in the number of teeth must necessarily be slight. In such cases, the cycloidal system of gearing is usually adopted. Its freedom from the drawbacks of interference permits the successful solution of many problems where the difference in the number of teeth in the gear and the pinion is so slight as to prohibit the use of gears with teeth resembling in any way the involute form. Fig. 6 illustrates an installation in which the gear has thirty teeth and the pinion twenty-nine.

The profile of the cycloidal tooth is traced by a fixed point on the circumference of a "generating circle" which is rolled above and below the pitch circle of the gear. The rotation of the generating circle is always in the same direction when tracing the profile of one side of the tooth and in the other for the opposite side, as is shown in Fig. 7. As the diameter of the generating circle is the same for the teeth of both pinion and gear, the interference that is so noticeable in internal gears of the involute variety can be entirely obviated.

In the cycloidal system of gearing, a generating circle of half the size of the pitch circle develops teeth with radial flanks; one of less than half the pitch circle, teeth which spread out toward the root and which are, therefore, of greater strength; while teeth developed by a generating circle of a diameter less than one-half the pitch diameter curve in toward

one another and are weaker and more difficult to cut. The standard size of generating circle has a diameter equal to the radius of the pitch circle of a gear having twelve teeth of the same pitch as the gear to be developed, providing, of course, that the gear for which the generating circle is adopted has twelve or more teeth. This standard is not fixed, however, as many gear makers use the pitch radius of a gear with fifteen teeth as the base. The twelve-tooth standard will be used, however, in the derivation of the following formulas for obtaining the diameter of the generating circle.

Generating Circle Formulas

N = number of teeth in cycloidal base gear = 12;
p' = circular pitch;
p = diametral pitch;
G = diameter of generating circle.

$$G = 0.5\ (12 \times p' \times 0.3183) = 1.9098p' \qquad \text{(A)}$$

$$G = 0.5 \times \frac{12}{p} = \frac{6}{p} \qquad \text{(B)}$$

The formulas employed for the solution of internal spur gearing of the involute type also govern the calculations for cycloidal internal gears, but no modifications for avoiding interference need be made. Formulas 11 to 15, inclusive, therefore, do not have to be employed. The pitch diameter of the pinion should be equal to or greater than twice the diameter of the generating circle to insure a tooth of adequate strength. If care is taken to see that the minimum pitch diameter of the pinion is at least equalled, which will result if the formulas for the generating circle are used, the calculations involved in the design of cycloidal type internal spur gearing are no more laborious than those necessary for a problem in the design of an ordinary pair of external spur gears.

Example:—Required, an internal spur gear combination with cycloidal teeth; 8 diametral pitch, 32 teeth in gear and 24 teeth in pinion.

$$G = \frac{6}{8} = 0.75 \text{ inch} \quad \text{(B)} \qquad p' = \frac{3.1416}{8} = 0.3927 \text{ inch} \quad (2)$$

$$D' = \frac{32}{8} = 4 \text{ inches} \quad (3) \qquad d' = \frac{24}{8} = 3 \text{ inches} \quad (3a)$$

$$d = \frac{24 + 2}{8} = 3.25 \text{ inches} \quad (4) \qquad D = \frac{32 - 2}{8} = 3.75 \text{ inches} \quad (5)$$

$$D'' = \frac{32 + 2.314}{8} = 4.28925 \text{ inches} \qquad (6)$$

$$t = \frac{1.5708}{8} = 0.19635 \text{ inch} \quad (7) \qquad s = \frac{1}{8} = 0.125 \text{ inch} \quad (8)$$

$$s + f = \frac{1.157}{8} = 0.144625 \text{ inch} \qquad (9)$$

$$f = \frac{0.157}{8} = 0.019625 \text{ inch} \qquad (10)$$

* * *

BULLARD INSURANCE PLAN

The Bullard Machine Tool Co., Bridgeport, Conn., has issued a statement to its employes of an insurance plan based on length of service, which became effective November 14, from which the following was taken:

> An insurance certificate for $500 will be given to an employe upon the completion of six months of continuous employment.
>
> After one year of continuous employment has been completed, the value of the certificate will be increased to $600.
>
> For each year of continuous employment thereafter, $100 shall be added to the value of the certificate until a maximum of $1500 has been reached.
>
> This plan shall be retroactive so that all individuals who have been continuously in the employment of the company for ten years or more will at once receive a certificate for the maximum amount of insurance under this plan.

The new insurance plan, which will affect about one thousand employes of the company, provides for insurance in case of total disability as well as death; it provides for payment in installments over a term of years, in order to safeguard the recipients from unwise investments and to assure them of the maximum benefit to be derived.

THE TELEGRAPHONE

The telegraphone is an apparatus invented by Valdemir Poulsen, the Danish inventor, which makes use of the principle of electromagnetism for recording and reproducing sound waves. It may be defined as an apparatus for reproducing at a distance the sound which produced a graphonic record; also as an apparatus for producing a graphonic record at a distance by means of a telephonic circuit. A wire is used for recording the sound waves, the wire being magnetized so that the sound waves are impressed in the form of energized poles of varying intensity. This principle was developed by the inventor several years ago, but it is only lately that it has been possible to produce an instrument which would give entire satisfaction.

There were two requirements that had to be satisfactorily met before the device could be a success. One was the manufacture of a fine wire sufficiently coarse-grained and porous to be easily magnetized and in which the magnetism would remain permanently, and at the same time have sufficient strength to withstand a tensile stress of eighteen to twenty pounds. The other was to produce a winding device which could be instantly reversed, started or stopped without producing slack in the wire. The wire found most satisfactory was 0.010 inch diameter piano wire having a carbon content of 1.20 to 1.30 per cent. It is wound on spools, in lengths of about six miles, which permits the instrument to run for thirty minutes without changing reels.

Principle of Telegraphone

In principle, the telegraphone consists of a mechanism comprising two vertical shafts carrying spools on which the steel wire 0.010 inch in diameter is wound or unwound. One of the shafts is rotated at the desired speed by means of a fractional horsepower motor. The wire, in passing from one spool to the other, is guided by a German silver bushing and passes in close proximity to an electromagnet which converts the sound waves transmitted to the instrument into the form of magnetic poles in the wire of varying intensity, depending on the pitch of the sound. The "sweeping" magnet is carried on the other side, so that by reversing the direction of rota-

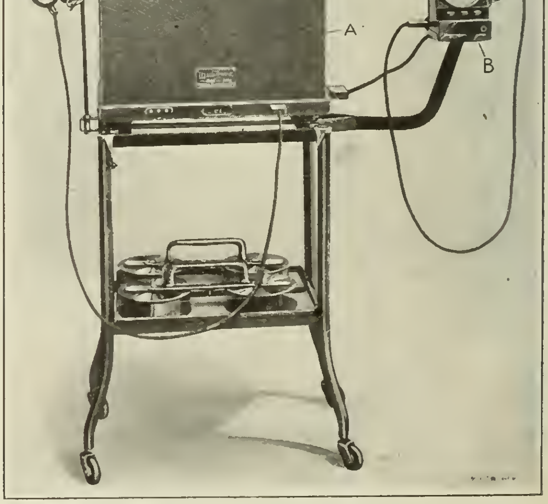


Fig. 1. Dictating Machine made by the American Telegraphone Co., which employs Principle of Electromagnetism for Sound Reproduction

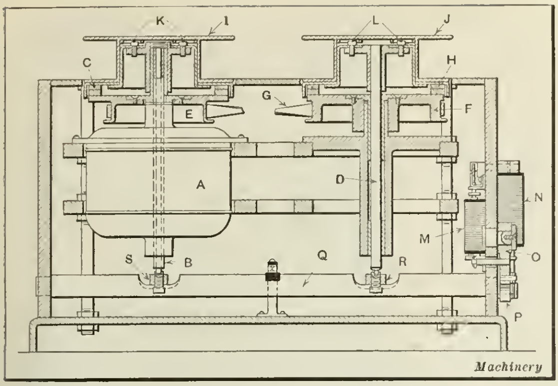


Fig. 2. Diagram showing how Wire Reels on Machine shown in Fig. 1 are reversed without producing Slackness in Wire

tion of the wire, the intensity or height of the magnetic poles can be equalized. Complete demagnetization does not take place, but instead of putting up or raising a series of electric poles in the wire of varying intensity, all these poles are reduced to the same intensity, and hence no reproduction is given off.

As shown in the illustration, Fig. 1, the instrument *A* is operated by an extension set *B* which carries three buttons; one is for starting or stopping the machine, one for rotating it backward, and the other for rotating it forward. This extension set also carries an electric buzzer which rings about one-half minute before the spool of wire is exhausted. The extension set can be located, if necessary, a mile away from the telegraphone proper and used like a telephone, having both a transmitter and receiver *C*. The other connection between the extension set and the telegraphone proper is the switchboard, not shown, which is almost identical with the ordinary telephone switchboard. The switchboard can be plugged with the extension set and the telegraphone, and records can be made on the machine or taken off, as desired.

Applications of Telegraphone

As will be understood from the preceding, the telegraphone can be used for recording a telephone conversation. In addition, it can be used as a dictating machine, and it is superior to the present dictating machines in several ways: (1) There are no records to shave or break. (2) The constant rasping noise so annoying in the wax record machine is entirely removed. (3) The strain on the transcriber is no greater than when listening to the telephone. (4) It can be used for carrying on telephone conversations between departments. (5) The machine is remote from the dictator, permitting him to concentrate, as there is no machine to attend to. (6) It requires thirty instead of ten or twelve minutes for one reel to unwind. (7) The record is permanent and is not affected by temperature changes. (8) The spoken words are reproduced clear and distinct. (9) Corrections can be easily made, by simply reversing the instrument and dictating over the portion to be corrected. (10) The system is entirely electrical.

In the musical field, the development is not yet complete, but it is anticipated that the next few years will see a great advance in the application of this instrument to the reproduction of operas and music of all kinds. In fact, it is reported that the Automatic Electric Co. of Chicago, Ill., maker of the automatic telephones, is at present offering the use of this instrument to its subscribers for a small additional charge. The telegraphone is installed in the distributing or central station, and subscribers can have music for one hour every evening over the telephone. An amplifier can be located in a flower vase or any place in the room and connected with the telephone. In this way records can be reproduced without the subscriber's having to do anything but remove his receiver from the hook.

Another application which is being developed is the use of the telegraphone in connection with the motion picture machine. The talking picture has never been made a success because of the difficulty of obtaining perfect synchronism between the pictures thrown on the screen and the recording of the voice. With the telegraphone, perfect synchronism is possible. This is accomplished by depositing a strip of pulverized iron filings directly on the film itself. The sound waves are thus carried directly on the same film as the pictures. In reproducing, an amplifier can be located behind the curtain and connected telephonically with the motion picture machine.

Method of Operating Telegraphone

The telegraphone is operated, as previously mentioned, by an extension set which has three buttons: one for starting and stopping, one for making the machine run forward, and the other for making it run in the opposite direction. These buttons are wired to magnets which serve to operate the driving mechanism. One of the most interesting points in connection with this mechanism and the one that was most difficult to control is the means provided for automatically stopping and reversing the spools on which the wire is carried, without breaking the wire or allowing it to slacken. Reference to Fig. 2 will show that a motor *A* inside the box drives shaft *B* through a friction clutch *C*. When it is desired to wind the wire in the opposite direction, the other shaft *D* is connected by a cross belt *G* operating on pulleys *E* and *F*. Both spools *I* and *J* are driven in a similar manner by means of screws *K* and *L*, respectively, fitting in projecting lugs on the lower inner surface of the spools.

In order to prevent slackness in the wire, it was necessary to provide a means for rotating alternately first one shaft and then the other, the shaft carrying the spool on which the wire was being wound being the driven shaft. In order to accomplish this, it was necessary to lift the member that was not driven from the clutch, and thus depend on the driven shaft to pull or unwind the wire from the spool held on the opposite shaft. This lifting of the different spools is controlled both magnetically and mechanically, and is effected through magnets *M* and *N*, segment gear *O*, and pinion *P*, respectively. Pinion *P* is fastened to shaft *Q*, which has flattened surfaces coming in contact with levers *R* and *S* that carry supports for the spindles carrying the spools. Movement of this shaft lifts one spool or the other, depending on the direction in which the wire is being wound.

In operation, the pressing down of the button shown to the left on the extension set in Fig. 1 energizes a relay magnet from the battery. This magnet attracts an armature which closes the contact and allows alternating currents to flow to the operating magnet *N*. Magnet *N* is instantaneously energized and attracts its armature, thereby rocking shaft *Q* in a counter-clockwise direction. This action lifts lever *R* and thereby spindle *D*, thus removing the driving drum from the friction clutch *H*, and releasing reel *J*. Mechanical means are provided for holding shaft *Q* in the position in which it is operated by the mechanism, so that further energizing of the magnet is unnecessary. At the same time that lever *R* is lifted, motor *A* is connected with the source of power and drives shaft *B*, pulley *E* and reel *I*. When it is necessary to stop the machine, the operator pushes the central button, Fig. 1, which closes the circuit and stops the operation of the motor.

To operate the apparatus in the reverse direction, the button on the right of the control *B*, Fig. 1, is depressed. This operates a relay and magnet and closes the contact whereby magnet *M* is momentarily energized and rocks shaft *Q* in a clockwise direction. This actuates lever *S* and consequently lifts shaft *B*, removing reel *I* from driving pins *K*. Thus this reel is allowed to run loosely. The reel or spool *J*, however, is still in contact with the friction element and positively driven by pulleys *E* and *F* through cross belt *G*. Thus the wire is unwound from reel *I* and rewound upon reel *J*. The mechanism can be again stopped when the end of the wire is reached by operating the middle button of the three on the control set. D. T. H.

* * *

An imitation gold alloy consists of 81 per cent copper, 9 per cent nickel, and 10 per cent zinc.

JAPANNING CUSHION SPRINGS BY THE AIR-DRYING PROCESS[1]

EFFICIENT SYSTEM OF HANDLING SPRINGS IN AN AUTOMOBILE PLANT

BY E. F. LAKE[2]

COIL springs that go into the seats and backs of automobiles are japanned to prevent rusting and to give them a better appearance than they would otherwise have. As such springs are covered with upholstery, their appearance is not of great importance, but it is essential that the steel be prevented from rusting, for rust does not have to eat very far into wire of such diameters in order to seriously reduce its strength and resiliency. Cushion springs for automobiles are made and used in large quantities, and the cost of production has become an important factor. Those who install the most automatic machinery are the ones that do away with the greatest amount of hand labor and reduce manufacturing costs to a minimum.

Some novel and efficient automatic appliances are part of the equipment of the Detroit Wire Spring Co., Detroit, Mich., whose practice in making automobile cushion springs was described in the November number of MACHINERY. On the third floor of the factory are made the springs for the back of the seat in Ford cars, and an air-drying japanning process is installed there, which will be described in the following.

Coil spring makers have always considered that it was necessary to heat springs to about 450 degrees F. to remove any internal strains that might have been set up in the wire when it was twisted into coils and then knotted at each end. The wire makers harden the wire used in such springs and give it the proper temper for cushion or bed springs, before it is shipped to the spring maker; but the spring makers say the coil springs would break quickly if they were not tempered after they had been coiled and knotted, and when baking japan on these coil springs, the temperature used is nearly always about 450 degrees F. In that case the steel in the spring is heated enough to overcome internal strains, and the springs are tempered while the japan is being baked. With an air-drying japanning process the springs do not get this heat-treatment, however, and thus it requires a separate operation for tempering the steel.

When the air-drying process was started in this shop arrangements were made for tempering the coil springs in bundles, before they were assembled for the seat or back cushion; and Fig. 1 shows the oven or furnace that was installed for tempering these springs. A trolley system like that on the lower floor, described in the article in the November number, is used to deliver the springs to this tempering oven, hold them while in the oven, and afterward deliver them to the assembling benches. The single track, over which the springs travel to the oven, branches into three parts while going through the oven, and these converge into one track again just outside the opposite end. The bundles of coil springs can be seen in the wire baskets that are just rolling over the trolley system and into the oven. The carrier is merely a 2-inch gas pipe that hangs by two 5/8-inch bolts from a set of roller-bearing wheels which are inside the trolley tracks.

Each track in the oven holds six of these baskets, so that a full charge means eighteen baskets loaded with approximately twenty-seven gross of coiled springs. With this method a full charge of springs can be put in the oven in about one minute, after which the doors are closed and the springs are held in the oven until they absorb all the heat that is necessary for correct tempering. This should not take over ten minutes, if the furnace or oven is maintained at the correct temperature. Then the doors at the opposite end of the oven are opened, and the springs are made to travel on to benches, where they are assembled into seat and back springs.

Fuel oil is used for heating this oven, and the burners are shown at *A*. These shoot the flames into the lower part of the oven, which is brick lined and forms the combustion chamber. The heat radiates from here into the upper compartment, where the springs are located. The walls of this upper compartment are built like an ordinary japanning oven, from two sheets of metal, between which is about 2 inches of corrugated asbestos board. Pipes *B* vent the tempering chamber of the oven, while pipe *C* vents the lower combustion chamber. These carry the spent gases or fumes to the outer atmosphere, through a single opening. The wire reels shown in front of this oven are connected with part of the bank of wire straightening machines shown in Fig. 2. From these reels the wire is fed into the machines, which roll it out into straight wire, cut off pieces of the desired length, and drop them into racks *D*. The straightened wire is taken from racks *D* to the benches at *E*, where it is bent into shapes such as shown at *G*. These wire frames form the top or bottom of assembled seat and back springs and give them their proper size and shape.

The coils of wire are brought from the freight cars to these reels by elevators, roller conveyors and an overhead trolley system. A covered platform extends along the outside of the building and the freight cars are unloaded onto this platform. The elevator shown in Fig. 3 is used to carry the wire coils to the upper floor of the building. Roller conveyor *F* can be extended into the freight cars and pulled out again when the cars are unloaded; and the coils are sent over these rollers from the freight car to the platform *H*. The elevating part

[1] See also "Manufacture of Automobile Cushion Springs," in the November, 1916, number of MACHINERY.
[2] Address: 352 Belvidere Ave., Detroit, Mich.

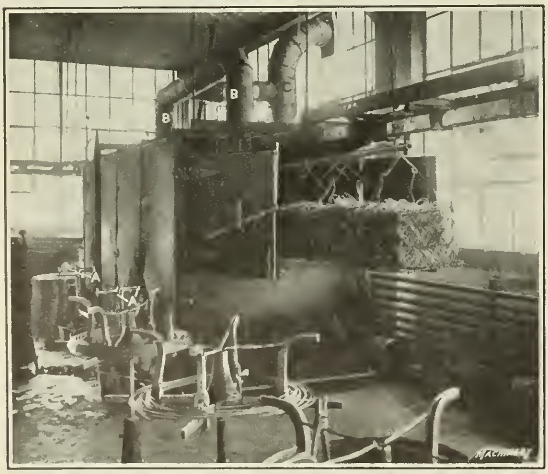


Fig. 1. Oven for tempering Springs in Bundles before they are assembled

Fig. 2. Straighteners for preparing Wire for Cushion Spring Frames

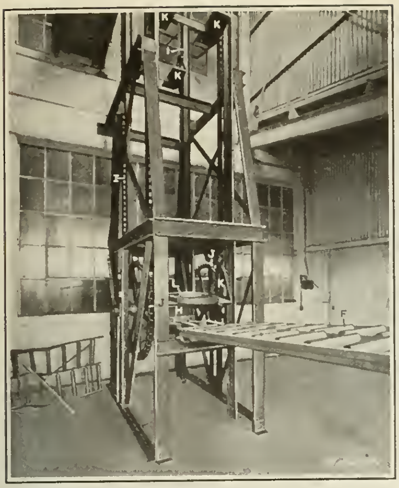


Fig. 3. Elevator used to carry Coils of Wire to Upper Floors

of the mechanism consists of chains I which travel over sprocket wheels J and carry the arms K. As arms K travel upward they straddle platform H and pick up the wire coils or rolls of band iron shown at L. Chains I travel over another pair of sprocket wheels at the top of the elevator. The load is carried over the top and down the opposite side. On the way downward, arms K straddle extensions of roller conveyors that are located on each upper floor of the building. To drop the coils of wire or rolls of band iron at the floor desired, it is only necessary to swing the conveyor extension on that floor into place. When dropped on this extension they enter the building as shown in Fig. 5, through the window at M. The coils then travel over these rollers to different parts of the conveyor and are dropped to the floor close to the machines that use them. At O there is a joint in the conveyor, and here the rollers can be lifted enough to allow the wire or band iron to drop to the floor through chute P and over rollers R. Similar breaks can be made wherever it is desired to bring the material to the floor.

In Fig. 4 is shown an ingenious device used for assembling the coil springs that pass through the tempering oven shown in Fig. 1, and the wire foundation frames shown at G in Fig. 2. The men work so close together they had to be moved from this bench while the picture was being taken. There are ten of these benches placed side by side across the shop. It is quite a sight to see the speed at which the men work while standing elbow to elbow, and also the number of springs that they can assemble in a short period of time.

On these benches are assembled all the back springs for the seats in Ford motor cars. At the far end of each bench the men start with the wire foundation frames. One of these is placed over the wooden pins in a rack like that shown at N. This rack then starts a continuous movement along the bench on wheels S which line both sides of the opening in the bench. As it travels from one man to the other, each one does his part, and when it arrives at the near end, the back spring is completely assembled as shown at Q. When thus completed, the spring is hung on a carrier which travels over the trolley system with tracks over the gangway at this end of the benches. As fast as the springs are taken from the racks at N, the racks drop through an opening in the bench and roll down an inclined set of wheels to the far end of the bench, where they are again raised to the top to start carrying work through another assembling operation. The finished springs are carried by the conveyor to the japanning department.

Efforts are continually being made to reduce the cost of the japanning process. The japans are continually being experimented with to reduce the amount of heat and time that is required to produce a hard, smooth and lustrous coating. The ideal condition for this work would be to dip the piece in liquid japan that would dry the instant it was removed but we are a long way from attaining this ideal. In most cases the japan is baked in ovens, after it has been coated on the work by dipping, spraying or brushing. The same effect might be obtained if the japan coat were allowed to stand in the air until it dried, but a greater hardness and wearing quality is obtained if the baking time is not too long or too short and the correct temperature has been maintained. The baking process also makes the work ready to use in from twenty to sixty minutes, and thus is cheaper than a slow air-drying process, because of the storage space and time that is saved.


Fig. 4. Bench on which Cushion Springs for Seat Backs are assembled

Japans have been greatly improved during the past few years, and quick air-drying japans are now being produced that give satisfactory results for some classes of work. The use of such air-drying japans is rapidly increasing with the makers of cushion springs, and the most modern application of this process is herewith described and illustrated. It does away with the use of heat insulated ovens for baking the japan coat and the cost of the fuel and apparatus that is required for heating these ovens. When a carrier is fully loaded with springs at the benches shown in Fig. 4, it travels over the trolley track, shown at T in Fig. 6, which curves over the japan dip tank. This tank is located at the end of the gangway which passes the assembling benches. Here the springs are coated with japan by lowering them with an air hoist until they are completely submerged in the liquid japan. At U will be plainly seen how a loose piece of track and the load of springs is lowered with the air hoist. When coated, the springs are again raised to the track level and sent over the drain board as shown at W, where they stop long enough to allow the excess japan to drip from them and flow back into the dip tank.

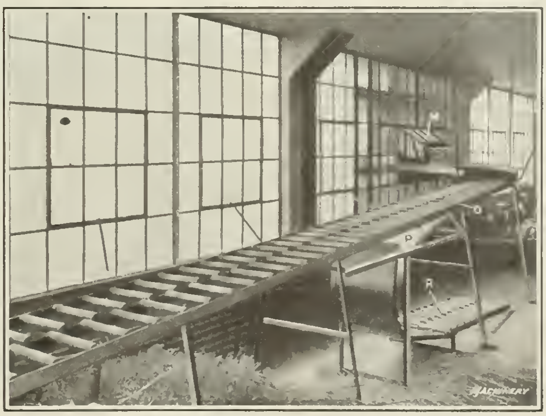


Fig. 5. Conveyor for carrying Coils into Shop and delivering them to Machines

In Fig. 7 will be seen how the springs then travel along the trolley system to the craters. The japan dipping tank is located at the far end of the track shown at V, and while the springs are moving over this 250 feet of track, the air has had time to dry the japan and make it hard enough to handle when it reaches the craters. Track X has plenty of work to do, even though it did not carry any springs at the time this picture was taken. At the far end it curves over the dip tank and conveys the work from other parts of the shop to the japanning apparatus. It is usually loaded with work. The two craters shown in the foreground crate most of the

springs that have been through the air-drying process. They take the springs off the trolley system at this point and stack them to the top of and between the four posts of the framework shown. Then they place the top of a crate over the springs and throw the wooden platform *Y* on top of it. After that, they sit on the platform handles as shown and compress the springs into a small bundle before nailing on the side strips which hold the crate together. Back springs do not have the coils as close together as seat springs, nor do they have as many rows. Thus when the loose springs are thrown in between these posts, they occupy approximately four times as much space as they do when in the crate, and it requires the weight of two men to compress them that much.

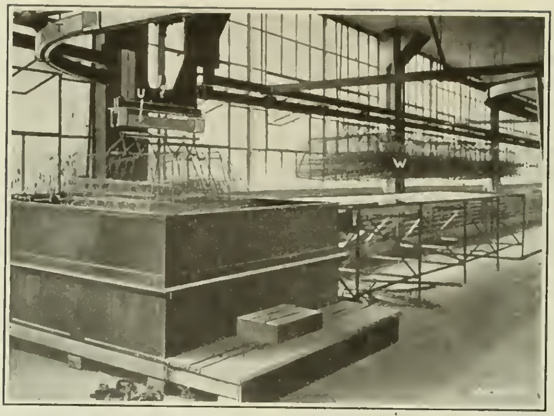


Fig. 6. Arrangement of Dip Tank in which Springs are japanned

In Fig. 8 will be seen a conveyor which serves the entire third floor through the center of the building, and an elevator which lowers the work to the shipping room on the ground floor. The trolley system for air-drying the japan runs along the wall to the right of this view, and the craters are located some thirty feet to the right of the elevator. The pile of crates they have stacked up ready for the elevator is shown at *A*. This conveyor is operated by an electric motor and other apparatus located at *B*. It brings the work from both ends of the shop and delivers it to platform *C*, which is located directly in front of the elevator.. All the springs that are made on this floor do not go through the air-drying japanning process, and this conveyor brings to the elevator the springs which are not japanned. Arms, like the two shown at *D*, project out from the elevator apparatus at certain equally spaced positions; and on these either the crates or loose springs are loaded and lowered to the shipping room. From here the loose springs can be loaded on a trolley system and sent through the japan baking process described in the November number.

While the men were removed from the different views in order to make better pictures, it was only at the assembling bench shown in Fig. 4 that many men had to be removed. This is due to the fact that so much automatic and semi-automatic machinery has been installed that it does not require very much labor to turn out the large production of springs that the Detroit Wire Spring Co. manufactures in its new shop. The cushion springs that go into the Ford cars alone would make a large production for any shop; but, in addition, this company manufactures the cushion springs that are used in the Packard cars, and also has contracts that call for a large production of springs for other automobile manufacturers. With its present equipment the company is enabled to manufacture such springs at a very low cost, but the management is continually looking for and inventing other appliances that will still further reduce the cost of production.

* * *

STEEL WELDING

The constantly increasing price of high-speed steel now makes it almost prohibitive for the average shop to use cutting tools composed wholly of such material. Furthermore, with high-speed steel at present prices, it is very costly for a shop to have to scrap worn-out tools. Such problems, however, can now be solved and noticeable economies effected by welding high-speed steel tips to ordinary machine steel shanks. Thus old worn-out high-speed steel tools can be cut to proper size and utilized for tips at a great saving.

The high-speed steel tip is first "tacked" to the machine steel shank and the whole preheated. After fluxing with borax, welding is started. After welding, the tool is immediately laid in mica dust to cool gradually. It is then rough-ground and tempered, after which the finish-grinding is accomplished, when the tool is ready for use. Reinforcing metal is built out and around the tip, which serves both to give larger radiating surface and to afford a larger conducting path back to the butt of the tool, thus keeping down the temperature at the cutting edge. The machine steel shank may be of any length desired, and of cold-rolled, hot-rolled, or carbon steel, while the high-speed steel tip should be short.

The Westinghouse Electric & Mfg. Co. of East Pittsburg, Pa., which is at the present time using cutting tools with high-speed steel tips and machine steel shanks for many of its planers and lathes, has found the electric arc process of welding very satisfactory and much cheaper than any other process. This conclusion has been reached after tests employing oxy-acetylene and forging methods. The ordinary electric arc welding equipment made by the company is used, and is the same as that required for the welding or repair of castings. For best results, the current for this work should be approximately 100 amperes, and the voltage of the welding circuit 60 to 70 volts. A 5/32-inch Norway iron electrode should be used. The work should not be hurried, but a good operator should be able to make between twenty-five and thirty welds for tools of 1½-inch cross-section in a day of nine and one-half hours.

Fig. 7. Conveyor leading to Packing Room, and Method of crating

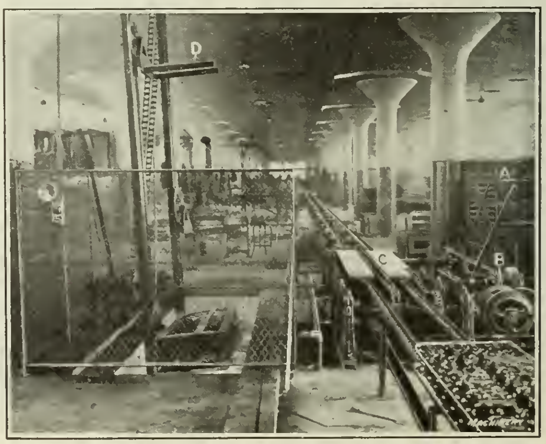


Fig. 8. Conveyor System for Third Floor, and Elevator to Shipping Room

A SIMPLE AND ACCURATE BALANCE FOR THE SHOP[1]

METHOD OF CONSTRUCTING, USE AND ADVANTAGES

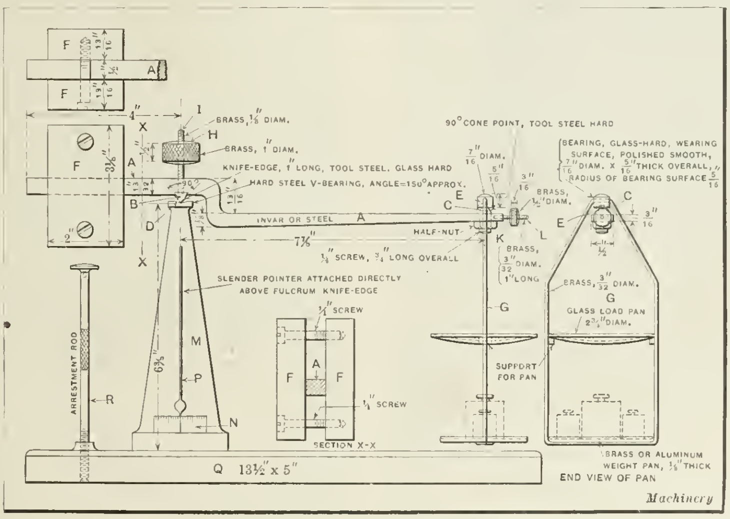
BY F. J. SCHLINK[2]

IT is often necessary, in the shop or engineering office, to weigh small quantities of materials with a rather high degree of precision, and yet the amount of work to be done may not be great enough to warrant the purchase of an analytical or similar balance. The price of an accurate, sensitive, chemical balance is rather high, and the theoretical and technical knowledge required for its manufacture precludes its being made successfully by anyone not expert in that line. The simple and inexpensive balance here described, however, can be made easily and at small cost, is easily adjusted, and will give satisfactory precision for such work as the weighing of small samples, moisture determinations, and a number of other uses for which an accurate balance of small capacity is required.

The beam *A* should be made of steel or invar; the latter, which is a comparatively inexpensive nickel-steel alloy, is preferable on account of its negligible coefficient of thermal expansion. If machinery steel is used, it should be carefully lacquered or enameled to prevent rusting. In the case shown, the beam is 1/2 inch wide; its short arm is 13/32 inch thick throughout, but its long arm tapers from 3/8 to 3/16 inch at its outer end. Its fulcrum *B* may be either two cone points spaced about an inch apart along a line perpendicular to the plane of the beam or a knife-edge an inch long. If the latter is used, which is the preferable form, it should be absolutely straight, and finished, by smooth grinding, to a clean, sharp edge having an included angle of approximately 90 degrees. The load pan is suspended from a cone pivot *C* at the end of the beam. Both the knife-edge *B*, if one is used at the fulcrum, and the cone pivot *C* should be made of tool steel, carefully hardened and ground; the cone pivot should be perfectly sharp and have an apex angle of approximately 90 degrees. The knife-edge, the cone, and their bearings must be glass-hard, and the wearing surfaces of the bearings must be polished smooth. The V-bearing *D* of the knife-edge has an approximate angle of 150 degrees and the cup bearing surface *E* of the cone pivot *C* has a radius of 5/16 inch. The utmost care must be taken in finishing the knife-edge, cone pivot, and bearings that co-act with them; the sensitiveness and accuracy to be obtained in the use of the balance depends more directly on these factors than on any other parts of the instrument. Both the knife-edge *B* and the cone pivot *C* should be set snugly and firmly into the beam *A*. For this purpose dowel pins or short screws may be used at the knife-edge.

A movable weight *F* is provided at the left side of the fulcrum to counterbalance the weight of the long arm of the beam and the load pan *G* at its end. It consists of two machine-steel blocks held in place by screws, which may be moved horizontally and vertically; its construction is shown by the top view and the section at X–X. As this weight is movable vertically, it is possible to increase the sensitiveness of the instrument by bringing the center of gravity of the loaded beam close to the knife-edge. This weight should be a neat fit on the arm on which it slides. After adjustment it should be tightly locked in place by the clamping screws shown. A finer adjustment may be obtained by means of the knurled nut *H* traveling on a fine threaded screw *I* immediately above the knife-edge *B*. The movement of this nut raises or lowers the center of gravity of the loaded beam in its relation to the knife-edge. The movement of the brass nut *K* that travels on the screw *L* inserted in the end of the beam is usually the only adjustment necessary when the balance is in use.

The pillar *M* that carries the hardened fulcrum bearing *D* should be firmly attached to the base of the balance. Near the bottom is placed a scale *N*; in the case shown, this has ten graduations, spaced 1/16 inch apart, on each side of the zero mark. The pointer *P* that travels over this scale is a slender rod that is attached directly above the knife-edge. The base *Q* may be made either of well seasoned, varnished wood or of a light hollow casting. The one requirement is that it shall be rigid and firm.



Construction of a Simple and Accurate Balance

The load pan *G*, an end view of which is shown, carries both the load to be weighed and the set of weights. Its construction should be as light as practicable in order that the load on the cone pivot *C* may not be unnecessarily great. In the present case it is made of brass wire 3/32 inch diameter passing through a piece of hardened tool steel that acts as a bearing for the cone pivot *C*. The load to be weighed is placed on the upper tray and the weights on the lower. The upper tray may be flat or slightly concave; a large watch glass, about 2¾ inches in diameter, for instance, serves the purpose very well. At a convenient distance below is a brass or aluminum tray or rack, which carries the set of weights. This should provide for the arrangement of the weights in the order of their value.

In order to protect the bearings, knife-edge, and cone from wear when the balance is not in use, an arrestment rod *R* is provided directly under the counterbalance weight *F*. This is a straight rod, with a flat cap at its upper end that is screwed into the base of the balance with a coarse-pitch thread. Turning the rod, by the knurled part, raises it into contact with the bottom of the counterbalance weight and lifts the latter so that the pan is brought down upon the base and the cone is relieved from contact with its bearing. When it is desired to use the balance, the rod is simply screwed down again so that it is no longer in contact with the beam.

The weight denominations should be so chosen that any weight value up to the weighing capacity of the balance can be determined. For example, if the weighing capacity of the instrument is to be about 0.5 pound—and a balance of this type will serve very well for that load—the set of weights may be the following decimal fractions of a pound: 0.2, 0.1, 0.1, 0.05, 0.02, 0.02, 0.01, 0.005, 0.002, 0.002, 0.001, 0.0005, 0.0002, 0.0002, 0.0001, 0.00005, 0.00002, 0.00002, 0.00001. For much of

[1] See also "Weighing-scales," in the January, 1916, number of MACHINERY.
[2] Assistant Physicist, Bureau of Standards, Washington, D. C.

the work for which a balance of this sort will be used, however, it will probably be advantageous to have weights in the metric system; in this case the weight set should include 100 grams to 10 milligrams, in the same 5-2-2-1 series. The weights should be handled with wooden or horn-tipped tweezers or pincettes. The Bureau of Standards will supply suitable specifications for weights of this sort if the inquirer will state the nature of the work for which they are to be used.

Adjusting and Using Balance

The adjustment of this balance, unlike that of the usual type of precision balance, is very simple, and consists of adjusting the position of the center of gravity of the loaded beam until it lies vertically below and very near the knife edge line. This operation is performed in the following manner: After the parts are assembled, the weights are placed on the pan, and the whole brought into approximate equilibrium by moving the balancing weight F to the left or right as required. If the equilibrium is unstable, the center of gravity is too high, and may be lowered by lowering the balancing weight without changing its position in a horizontal direction. If, on the other hand, the balance oscillates quite rapidly, the center of gravity is too low, and may be changed by raising the balancing weight F without moving it horizontally. When the balance oscillates with a period of five seconds, or more, after the large balancing weight is securely clamped upon its stem, the final adjustment can be made with the adjusting nut H above the fulcrum. The occasional adjustment of the balance which may be required, in service, to cause the pointer P to oscillate about and come to rest at the zero of the graduated scale will be made by changing the position of the nut K at the right end of the beam.

To use the balance, bring it into equilibrium by turning the adjusting nut K at the right end of the beam until the pointer vibrates through equal distances on each side of the zero graduation. Then carefully place the object to be weighed in the upper tray and remove weights from the lower tray until the pointer again swings about the zero graduation. The sum of the values of the weights removed from the pan to produce equilibrium will be the weight of the object sought. (This method of weighing is called the method of substitution.) The value of the weight of the object should be recorded, the weights again placed in the lower tray, and the object weighed, removed; the pointer should again swing about the zero graduation, affording a check on the determination.

Care must be taken in the use of the balance to avoid all unnecessary shock and jar, thereby reducing the wear and dulling of the pivots. In addition, reasonable care should be taken to protect the balance from sudden and irregular changes of temperature, especially just before or during the time it is in use. The balance must also be carefully protected from dust and moisture, as these will cause rapid deterioration of any knife-edge or pivot.

If much careful work is to be done on the balance, it should be protected from dust and air currents, and to some extent from temperature disturbances, by a glass case. It will be impossible to weigh more closely than to about 1/5 grain (or 15 milligrams) on any balance in which the moving parts are not protected from air disturbances and radiation. A rider may be added to the beam to provide a more convenient method of determining the last figure or the last two figures of the weight. This is a modification that can be easily worked out to suit any particular case, as the rider scale is simply a uniformly divided linear scale, securely mounted on the beam, that carries a sliding weight the value of which will be adjusted by trial against a weight in the pan. The value of such weight is equal to the total interval of the rider scale.

Advantages of Balance

This type of balance has the advantage of ease of construction and adjustment. The common or so-called "equal-arm" balance has three knife-edges in the beam, and the accuracy of weighing depends on these knife-edges being constructed and maintained straight and parallel; also, if the balance is to be used in the usual manner, they must be spaced exactly equal distances apart. The satisfactory attainment of these conditions is a matter of great manufacturing difficulty and requires considerable skill and care. In balances for careful work, the spacing of these knife-edges will be adjusted to within one or two parts in one hundred thousand. In the highest grades of precision balances, such as are used for standardization work, equal spacing is sometimes attained to a precision of one part in a million, or less. This adjustment is obtained by almost infinitesimal shifts of the several knife-edges through a long and tedious process of trial and adjustment. The difficulty and expense of these adjustments will be readily appreciated.

In the balance here described, the knife-edge need only be straight and the cone point sharp and reasonably free from deformation under the load it carries. The effective length of the balance arm is always the perpendicular distance between the apex of the cone and the contact line of the knife-edge. This distance cannot change, as when three knife-edges are used, by the shifting of the point of resultant pressure along a knife-edge which is a trifle warped or out of parallel. (It should, however, be noted that for much work the cone pivot is not at all satisfactory; if the service is frequent and severe and the loads applied quite large, the high local stresses developed will cause rapid deterioration.) Another and very important advantage is that the sensitiveness of the balance is constant for all loads within its capacity, since the gross load carried by the beam is at all times constant during weighing.

With reasonable care, the balance should last a long time; but if after a period of use the cone pivot becomes dull, it is easily taken out and resharpened; at the same time the cup bearing should be repolished. When the pivot is replaced the balance is ready for use as soon as it is rebalanced to compensate for the changes which have been made in the weight of the parts by the repair. This easy repair, without the necessity of a complete realignment of parts, is a great advantage. The cone point when replaced should project the same distance from the beam as before, so that the balancing plane and sensitiveness will not be altered too much.

Results Obtained with Balance

An experimental balance of this type, made in accordance with the foregoing description in the instrument shop of the Bureau of Standards, showed a surprising precision and convenience. Its sensitiveness, as it was first adjusted, was so high that its readings were seriously affected by the slight air currents which prevailed in the room, although kept at a very nearly constant temperature and protected from drafts of every sort. It was necessary to remove the disturbing influences occasioned by the heat convection and radiation from the observer's body by reading it through a telescope mounted on a stand about five feet away. The readings then checked very well and weighings could be made and repeated within 0.006 grain (0.4 milligram, approximately). This difficulty due to air currents would have been practically eliminated, of course, had the balance been provided with the enclosing case usually supplied with balances used for accurate work.

Of course, for much work such precision is not required, and the balance can be adjusted to a lower sensitiveness and used in the open air, if reasonably well protected from drafts, serving even under these conditions a very useful purpose. However, for those who may wish to obtain the highest possible accuracy, the writer recommends the construction of a case of wood and glass, having a single sliding glass door in the front which can be opened for the removal and addition of weights. There is no reason, if this is done, why this balance will not perform as well, though perhaps lacking somewhat in convenience, as any analytical balances save those of very high grade and cost.

* * *

In 1892, vanadium was listed as the rarest metal and was valued at $4792 a pound, or twenty times as much as a pound of gold. The discovery of the rich deposits in the Peruvian Andes, 16,200 feet above sea level, in 1905, caused the value of vanadium to drop rapidly; it is now sold at $3.50 a pound. It is being used, however, much more extensively than formerly, and new uses are being constantly found.

ELECTRIC SEAM-WELDING[1]

METHODS OF JOINING SHEETS AND TUBES BY THE RESISTANCE WELDING PROCESS

BY DOUGLAS T. HAMILTON[2]

THE seam-welding of sheets and tubes is a process which is used quite extensively in the sheet metal industry, particularly in the manufacture of utensils which must be made with steam- or water-tight joints. There are two methods in use for making a joint by this process—one is to lap the joint and the other is to butt it. Tubing is usually butt-welded, whereas sheets are generally lap-welded. Seam-welding is extensively employed in the manufacture of tubing which is used in place of cold-drawn seamless tubing, as it is not so costly to manufacture. In making a seam or lap weld it is absolutely necessary that clean pickled stock be used in order to get the best results. When a copper roller is used, a slight amount of scale adhering to the rolls will produce a puncture when it comes in contact with the piece to be welded. In the following, several different methods and machines for making seam- and lap-welded joints will be illustrated and described.

Possibilities of Seam-welding

The art of seam-welding has not as yet reached the same stage of development as that of butt- or spot-welding, and hence very little practical data on this subject are available. As previously mentioned, this process is extensively employed in the manufacture of sheet metal utensils, tubing, etc. The Toledo Electric Welder Co., Cincinnati, Ohio, finds that this process can be commercially employed on sheet steel of 22 gage (0.0253 inch) and thinner. The stock is lapped for a distance equal to its thickness, and when the copper rolls pass over the lap, the metal is mashed down to the original thickness of the sheet. In order to avoid buckling and distortion, the material being welded should be clamped along the seam. It is difficult in some cases, however, to entirely prevent buckling, especially when the sheet is over 14 inches in length or greater than 22 gage in thickness.

Materials such as pickled mild steel, tin, terne plate and sheet brass are easily seam-welded. Zinc, aluminum and copper, however, are more difficult, and are not electric seam-welded on a commercial basis. In the case of utensils, such as coffee pots, pails, pans, etc., which require coating with enamel, this process is of considerable advantage. After the enamel is applied and the article baked, it is impossible to detect the seam.

[1] For information on electric welding previously published in MACHINERY, see "Electric Spot-welding Practice," September, 1916, and articles there referred to.
[2] Associate Editor of MACHINERY.

Fig. 2. Special Toledo Electric Seam Welder used principally for welding Teapot Spouts

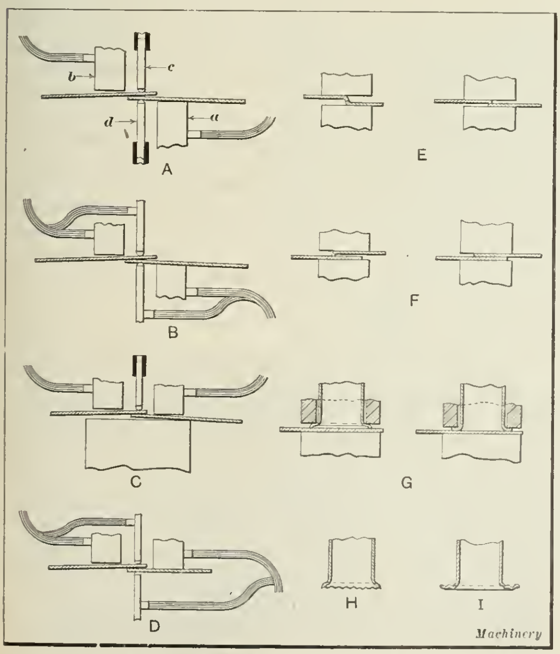


Fig. 1. Diagram illustrating Various Methods of accomplishing Lap-welding Operations on Spot-welding Machine

Lap-welding on a Spot-welding Machine

For joining steel sheets which do not require a water- or steam-tight joint, a spot-welding machine can be employed by making certain modifications, depending on the character of the work and the class of weld desired. Several methods of accomplishing this work are illustrated in Fig. 1. When making a lap-welded joint by means of spot-welding in the ordinary manner, the welded spot generally covers so much surface as to distort the metal. In Fig. 1, *A* shows a method of avoiding this. Here two sheets are shown overlapping each other and resting on poles *a* and *b* which are connected to an electric circuit. Above and below the lapped joint are two punches c and *d* placed in line with each other and surrounded with insulating material. These are brought in contact with the sheets at the point where the weld is desired, and when the current is turned on it passes through the poles *a* and *b*, and is localized at the point where the two punches come in contact with the work. Fusion takes place at this point of resistance, and when the correct temperature is reached, the two punches are brought together, forcing the heated material into a coalescent mass.

A slightly different application of this method is shown at *B*. Here the current, in addition to passing through the two poles, also passes through the punches. This method is particularly suitable for welding comparatively thick sheets. *C* shows still another modification. In this case, a large lower anvil, not connected with the electric circuit, and two poles located in

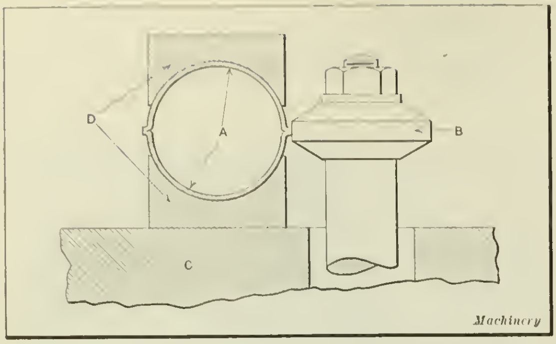


Fig. 3. Diagram showing Method of welding Teapot Spouts on Machine shown in Fig. 2

the same position are used. Only one punch is used, the required pressure being received on the lower anvil, and it is not connected with the electric circuit. A modification of the methods shown at *B* and *C* appears at *D*. In this case the two poles are also connected with the electric circuit.

Several other methods of accomplishing lap-welding operations on a spot-welding machine are shown at *E* to *H*. At *E* both sheets to be welded are bent over at the ends so as to localize the current. After the correct temperature has been reached, pressure is applied, resulting in a weld as shown at the right-hand view of the same illustration. Still another method is shown at *F*, in which only one strip has a turned-over edge. Here the welded junction takes place at a considerable distance from the edge of the strip. A method which can be used for welding a tube to a sheet is shown at *G*. In this

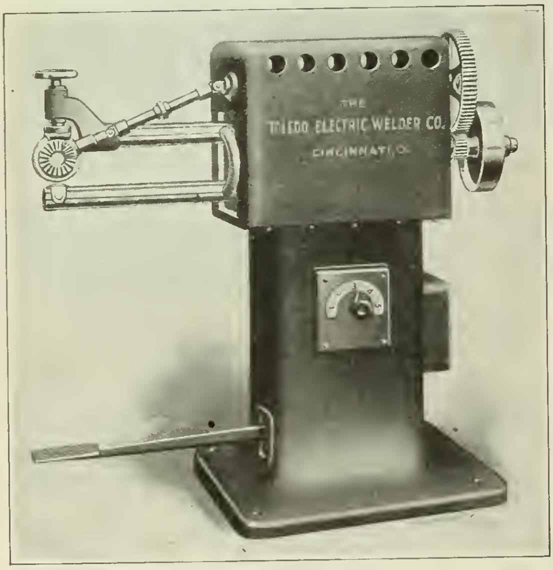


Fig. 4. Special Toledo Electric Seam Welder used for welding Sheet Steel of Light Gage

case the lower electrode is made flat and the upper electrode is in the form of a ring surrounding the tube as shown. The lower end of the tube is expanded, so that when heat and pressure are applied the lap-welded joint as shown at the right is produced. Two other methods of forming the lower end of a tube to be welded to a sheet are shown at *H* and *I*, the form shown at *H* giving what might be called a projection weld, and that shown at *I* giving a ridge weld.

Seam-welding Teapot Spouts

A special seam-welding machine used principally for welding kitchen utensils and similar work is shown in Fig. 2. This is a comparatively small machine, and is adapted particularly for welding teapot spouts. The diagram shown in Fig. 3 illustrates how this machine operates. The two halves of the spout *A* are stamped to the proper shape in a press and trimmed so that a slight projection is left extending from the edges as shown. One electrode of the machine is a copper roll *B*, mounted on a shaft that carries the current, rotating at 100 revolutions per minute. The other electrode is the top of the table *C* which carries the other side of the circuit.

In operation, the two halves of the spout *A* are clamped in copper die-holders *D*, and as these rest on the top of the copper table, the current passes through them, forming the second electrode. Therefore, when the edges of the spout are brought up against the copper roll *B* and passed before it, the thin metal in the edges is quickly fused and pressed down so that a smoothly finished surface is produced. The dies are then

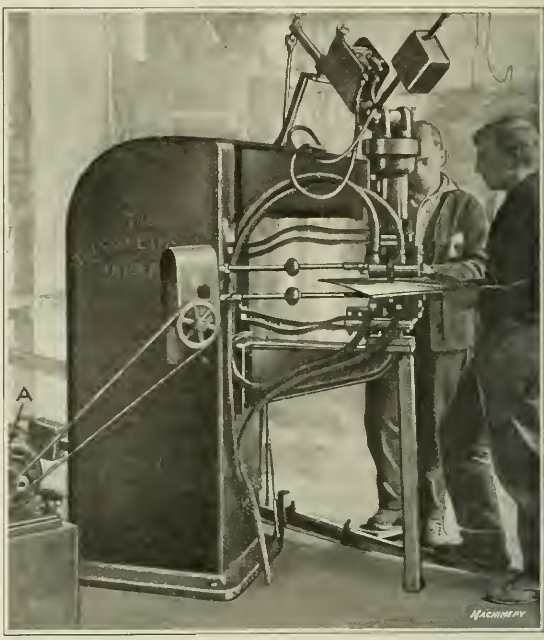


Fig. 5. Toledo Spot Welder especially fitted up for seam-welding

turned around, presenting the other edge or side of the spout to the roll, and the operation repeated. One boy can weld an average of 800 spouts in ten hours, and after the spout leaves the welding machine, it is ready for enameling. The machine shown in Fig. 2 is driven by a belt, the pulley rotating at 200 revolutions per minute. The maximum capacity is 5 kilowatts, or approximately 7½ horsepower.

Another seam-welding machine for welding sheet steel is shown in Fig. 4. This machine is also power-driven and can be used on various classes of light gage stock that is pickled and clean. The edges of the stock are made to overlap a distance equal to the thickness of the sheet, and are placed under a copper roll, which is mounted in an adjustable holder as shown. Pressure on the foot-treadle starts the machine, the current being automatically turned on and the stock carried through between the revolving rolls. As the stock emerges

Fig. 6. Sample of Lap-welding accomplished on Machine shown in Fig. 5

from the rolls the current is automatically turned off. This machine cannot be used on galvanized iron or rusty and scaly sheet steel or iron. The upper roll is operated by power from a pulley at the rear through a flexible shaft and bevel gear and pinion at 100 revolutions per minute. The maximum thickness of stock that can be satisfactorily welded is 1/16 inch.

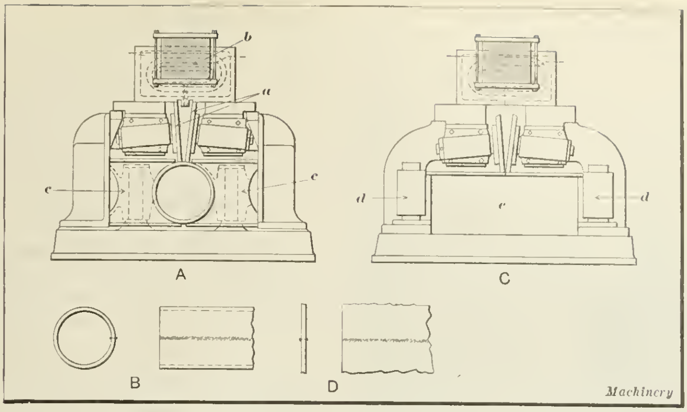


Fig. 7. Diagram illustrating Two Types of Butt Seam Welders built by the Thomson Electric Welding Co.

Spot-welding Machine Adapted for Lap-welding

In Fig. 5 is shown a Toledo electric welding machine fitted up for lap-welding sheet steel. The regular spot-welding electrode holders have been removed and special holders substituted. These holders are water-cooled and carry copper rolls which are driven by a flexible shaft from a two-horsepower motor *A*. The work to be welded is placed between the copper rolls, and the foot-treadle operated; the electric current is turned on at the same time, and as the sheets pass under the rolls they are heated and pressed together to form a weld. Fig. 6 shows a sample of lap-welding as accomplished on this machine. The joint, as will be noticed, is mashed down, but the sheets were under considerable tension and buckled to a considerable extent. The reason for this is that the local heating of the edges of the sheets causes them to stretch considerably, and hence buckle. In order to avoid this it is necessary to clamp the sheets close to the weld.

Special Machine for Electric Seam-welding Tubes and Sheets

Several different types of machines have been designed for seam-welding tubing. One of these, shown by the diagram at *A* in Fig. 7, is of comparatively simple construction. Its chief advantage is that the working terminals are located close to the turns of the secondary, so that the work is kept outside of the space enclosed by the conductor constituting the secondary of the transformer. The working terminals of the secondary of the transformer are copper disks *a*, which are located in such a position that the working faces converge toward the side farthest from the secondary *b*. These terminals are carried on axles which, in turn, are journaled in bearings located in such a position that disks *a* give a full bearing on the tubes to be welded. The tube is fed into the machine by rolls *c* as illustrated, being held in such a way that the seam is located equidistantly between the two copper electrode disks.

In operation, the welding current passes from one pole of the secondary through one of the disks *a*, then across the seam of the tube and through the adjacent edge of the tube to the other disk, and so back to the turns of the secondary, forming a complete circuit. With this machine a continuous traveling weld is made, as shown at *B*.

A seam-welding machine embodying the principles illustrated by the diagram at *A* in Fig. 7 is shown in Fig. 8. In this case the feeding rolls, which are located in a horizontal instead of in a vertical position, have been dismantled to show the construction. The pressure rolls are located directly beneath the electrode disks, and supply pressure to butt the edges of the tube together. This machine is provided with an oil transformer, and the working terminals are outside the magnetic field. The machine is adapted for welding sheet steel edge to edge to make tubing up to 2 inches diameter with 1/8 inch thickness of wall. The speed of welding is from 20 to 30 feet per minute.

A modification of the machine shown at *A* in Fig. 7 is shown at *C* in the same illustration. In this case the machine is adapted for seam-welding flat sheets. The only change is the elimination of the rolls *c* for applying pressure to the tubing and the substitution of small rolls *d* and a flat table *e*. Rolls *d* press the abutting edges of the work together, and at the same time feed it past the welding electrode disks. A weld made in this machine is shown at *D*.

Special Machine for Lap-welding

Fig. 9 shows a special seam welder which is employed principally for lap-welding coffee pots and similar articles. This machine, as shown by the diagram, Fig. 10, has one disk electrode *A* which is used for carrying one side of the current and applying pressure, and a horn *B* with a copper strip *C*, which forms the other side of the circuit. The work to be welded is placed on horn *B* with the joint lapped, as shown. The machine is then started by operating one of the foot-treadles shown in Fig. 9, and the welding commences. The platen carrying the horn is driven forward by power at the rate of 25 feet per minute and is returned by operating the handwheel shown at the front of the machine. The maximum length that can be welded in this machine is 12 inches.

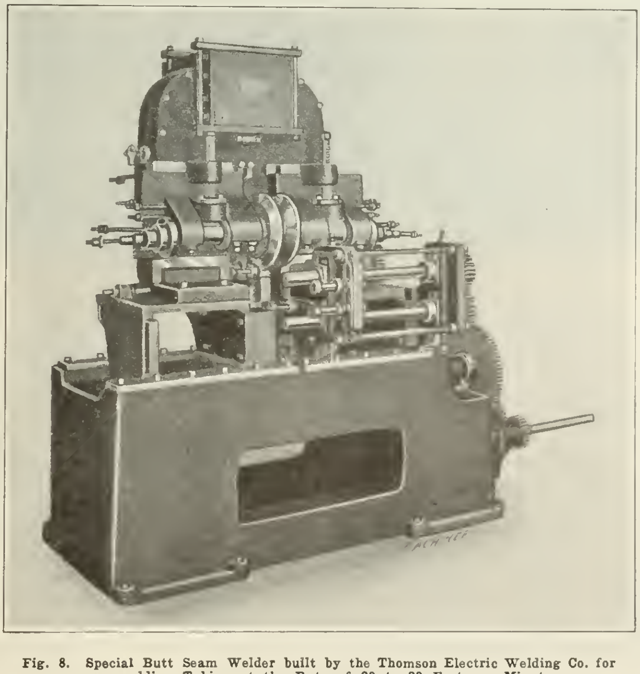


Fig. 8. Special Butt Seam Welder built by the Thomson Electric Welding Co. for seam-welding Tubing at the Rate of 20 to 30 Feet per Minute

Manufacturing Seam-welded Tubing

As has been previously mentioned, tubing is made by several different processes. One method is to pierce a heated billet, and then by successive redrawing operations form this into a tube of the required length and diameter. Another method is to roll out sheet metal into the form of a skelp, then bend it up into a tube and electrically or

autogenously weld the seam where the two edges meet, either in the form of a lap or a butt weld. The third method, and the one which will be described in detail here, is to take the heated skelp directly from the furnace and weld it electrically without any additional heating or annealing. This method has been patented by Elias E. Ries, and makes use of a rolling machine in connection with a series of electrodes for uniting the heated skelp; the original heat remains in the skelp after

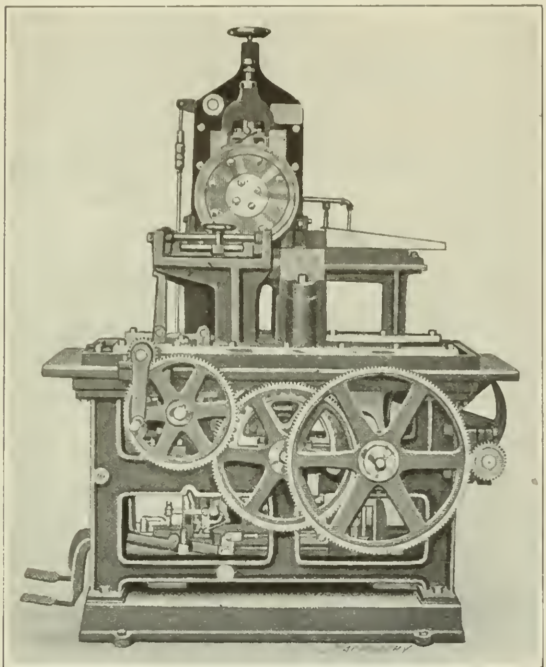


Fig. 9. Special Thomson Electric Seam Welder used principally for lap-welding Coffee Pots, etc.

it leaves the furnace, being increased to such a point that fusion between the edges of the tubing is possible.

The diagram shown at A, Fig. 11, illustrates in a general way this process of manufacturing tubing. Referring to the illustration, a represents the bull-head or skelp finishing mill, b and c the skelp bending rolls, and m the guiding bell through

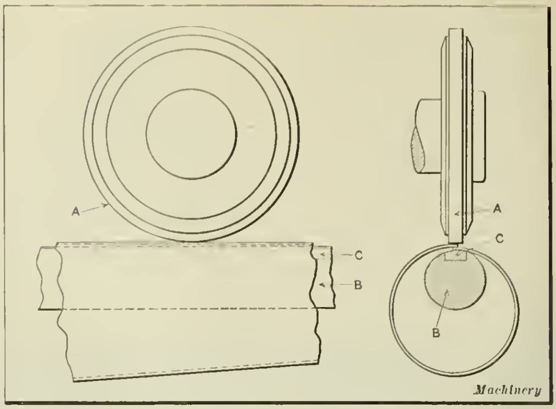


Fig. 10. Diagram illustrating Method of lap-welding Coffee Pots on Machine shown in Fig. 9

which the bent skelp is fed into the several sets of current conducting shoes or contact rollers; each set consists of a number of upper contactors d that are in electrical connection with one pole of the heating circuit; also two side bearing contactors or rolls e that are in electrical connection with the opposite pole of the heating circuits. The secondary terminals of the heating transformers f are connected with the contactors d and e through the insulated roll-supporting framework mounted on the cover of the transformers, the sets of contactors for each transformer being connected in parallel. Another guiding bell is shown at g that has a tapering throat which brings the highly heated edges of the partially opened skelp toward each other or in contact so as to close it into tubular form preparatory to welding by rolls h. Between these rolls passes a mandrel i shown at B supporting the skelp. The welded tube passes directly from the rolls h to the finishing and reducing rolls k, which have a smaller mandrel l. The rolls k give a higher finish, and practically produce a seamless drawn tube from the welded pipe.

Another adaptation of this method of electric welding is shown at C, where it will be seen that a series of electrodes form an electric arc and are arranged in tandem along the meeting edges of the tubular skelp. The current passing through these electrodes is independently adjustable by means of a special resistance, and the skelp, when properly heated, is welded in its passage through the welding bell n which

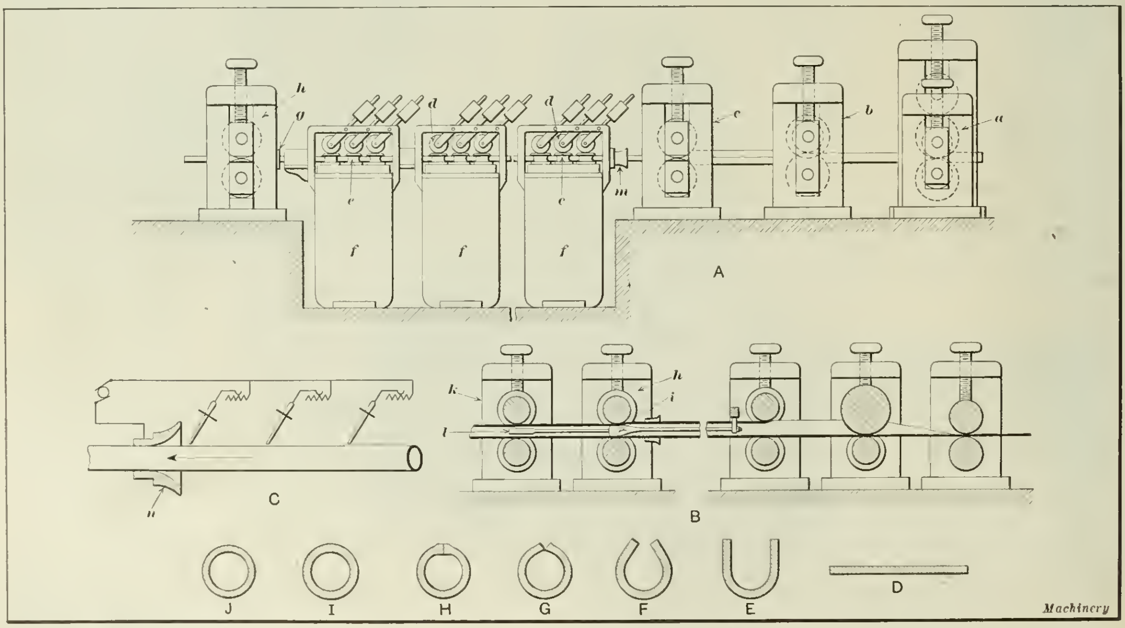


Fig. 11. Diagram illustrating Special Electric Welding Process used in converting Skelp to Electrically Welded Tubing in One Continuous Operation at the Rate of 400 Feet per Minute

constitutes the opposite terminal of the heating generator. The longitudinal movement of the frame carrying the electrodes can be varied so as to alternately increase or diminish the heating effect on the metal, depending upon whether the arc travels with or against the direction of the travel of the skelp. By arranging the heating electrodes in this manner, overheating and burning of the skelp is avoided.

The views from D to J, inclusive, show the sequence of operations performed to convert the material from skelp to tube form. The skelp leaves the furnace at a white heat, and after passing through the various operations up to point F, will be found to still retain a temperature varying between 2100 and 2200 degrees F. This residual heat represents about four-fifths of the heat required for welding, so that the heat which it is necessary to add to the abutting edges of the tubular skelp is only about one-fifth of the total. In other words, to weld the hot traveling skelp, the transformers are called upon to develop on the edges of the skelp a temperature of 500 to 550 degrees F. Usually the skelp travels at the rate of about 6 feet per second, but by this method it has been found practical to weld skelp at rolling speeds, averaging 400 feet per minute. Continuous lengths of tubing 60 feet in length have been electrically heated and welded in from nine to ten seconds.

* * *

BREAKING STEEL BARS WITHOUT WASTE OF METAL

A United States patent has been granted to P. V. L. Bellanger, of Paris, France, for a quick method of breaking steel bars without waste of metal. By this process the cross-section where the bar is to be broken is submitted momentarily to the action of a blowpipe flame which may be oxidizing and which has a temperature of about 700 degrees C. The bar is then placed on two supports and a sharp tool is applied by pressure, or a blow is struck opposite the affected part of the bar; in either case, a clean, square break is produced without tearing or wasting the metal. The blowpipe flame should have the shape of a lance-head and should be applied normal to the length of the bar, so only the point acts on the metal. The flame action renders the metal brittle in an extremely narrow zone, so that the bar can be broken cleanly without the metal being harmed.

* * *

Experiments conducted by the British Committee of the Ministry of Munitions fully justify the recommendations of the committee that a week's work, for men, should not exceed 65 to 67 hours; and for women, 60 hours. They also show that for many cases less hours give better results. In the case of boys between 14 and 17 years of age working on steel base plugs, the hourly output was increased 16 per cent after the Christmas holidays, and later, when the hours of labor were reduced from 70.3 to 57 per week, the output was increased 19 per cent.

GRADUATING GEAR SHAPER DIALS ON THE GEAR SHAPER

BY JOHN G. BRUEGGEMAN [1]

The extreme accuracy of the indexing mechanism of the Fellows gear shaper in connection with the cutting of gears is well known. It is perhaps not generally appreciated, however, that this feature of the machine adapts it to the accurate graduating of dials, etc. The writer of "Graduating on the Gear Shaper," in the October number of MACHINERY, has shown that the Cleveland Machine Tool Co. is using this machine for graduating circles. This practice is also in use in the shops of the Fellows Gear Shaper Co. where two of its own dials are graduated on the gear shaper. These are the dial for setting for depth of tooth and the small micrometer dial on the lead-screw.

Graduating the pitch depth dial is a particularly interesting example of what can be done on the gear shaper in the way of indexing. It also illustrates the adaptability of the gear shaper cutter and the gear shaper molding-generating principle. The dial, instead of being graduated in thousandths of an inch, reads directly for the gear pitch desired. This makes the graduations irregular, and in consequence, when indexing in the usual way with the milling-machine dividing head, errors are likely to creep in.

Fig. 1 shows the depth dial (integral with the dial gear) and the graduating cutter mounted in position on the machine. At M is shown, also, the micrometer dial. Fig. 2 is a view of the top face of the cutter and shows the spacing of the teeth. This cutter is made the same diameter as the dial and the two roll together like two friction rolls—the same as the cutter and the gear in gear cutting. Consequently, the spacing of the graduations on the rim of the dial corresponds to the spacing of the teeth on the cutter. Fig. 2 shows also how the graduations are marked in terms of gear pitches (diametral) instead of in thousandths of an inch. With this marking, the operator has only to set the dial to the pitch number, and the machine automatically feeds the cutter in to the correct depth for a tooth of that pitch. It will be seen that the cutter and dial are set up on the machine in the same way as are the cutter and work when cutting gears. They are aligned by means of the block B and the slot in the rim of the dial; this alignment is necessary to prevent a graduation from falling in the space occupied by the slot. One revolution of the cutter and work completes the operation. The time for graduating the dial by this method is three minutes; using the milling-machine dividing head, the job took fifteen minutes. In making the cutter, the blank was slotted on the milling machine with the arrangement formerly used for indexing the dials. The proper spacing of the teeth was determined by means of very simple calculations.

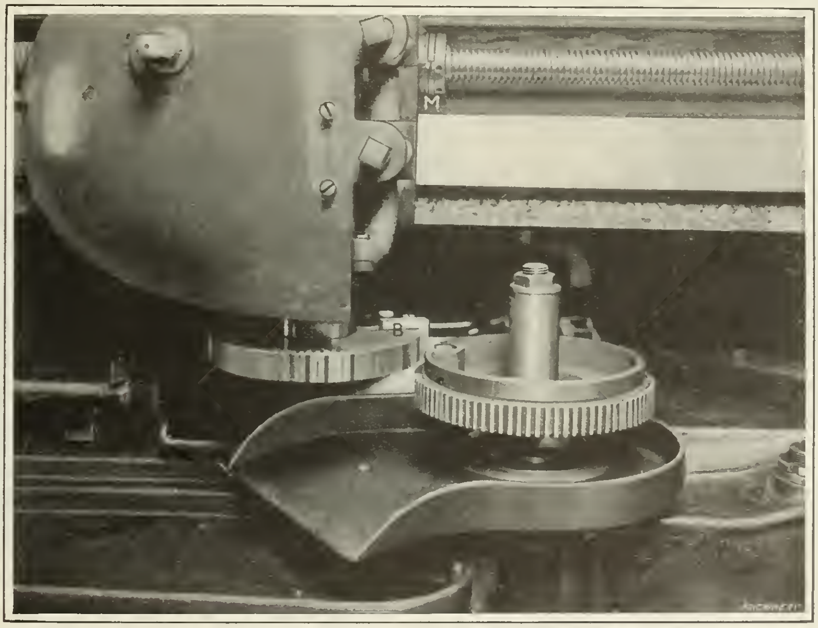


Fig. 1. Depth Dial and Cutter used for graduating

In use, the dial is mounted on the lead-screw, the lead of

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Fig. 2. Top of Cutter showing Spacing of Cutter Teeth

which is 1 1/3 turn per inch. One revolution then means 0.750 inch travel of the saddle; or, 0.001 inch travel of the saddle corresponds to 1/750 revolution of the dial. With forty teeth on the worm-wheel in the index-head, 1/750 revolution of the work means 40/750 revolution of the crank-pin in the index-head. Then using a seventy-five-hole row in the index-plate, indexing four holes will give a motion of the dial which would correspond to 0.001 inch travel of the gear-shaper saddle. Knowing the depth of tooth, in thousandths of an inch for the first gear pitch, say twenty, the number of holes to index is found by multiplying the four holes by the depth of a twenty-pitch gear tooth; for the second pitch, say eighteen, by multiplying by the difference between the depth of tooth for the eighteen-pitch and the twenty-pitch and so on. Graduating for metric cutters is done by the same method. This requires, of course, a differently spaced graduating cutter. In special cases, where both the English and the metric graduations are put on the same dial, the graduating is done in two operations, using the English and then the metric cutter, with one setting of the work.

Fig. 3 shows the micrometer dial, and the cutter with which this graduating is done. This job differs but little from the one described in the article previously referred to, except in the construction of the cutter. To get the different lengths of graduations, instead of making the cutter solid and grinding the teeth to different lengths, the cutter was constructed with each different length of tooth on a separate piece. The three pieces were then assembled and aligned with a pin driven through them. The method of mounting the cutter and work, and of cutting the graduations is similar to the method described in the preceding and in the article on graduating with the gear shaper referred to. The time for this job is four minutes.

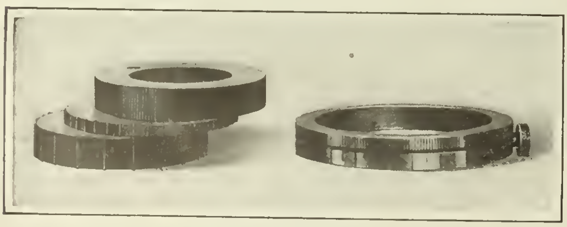


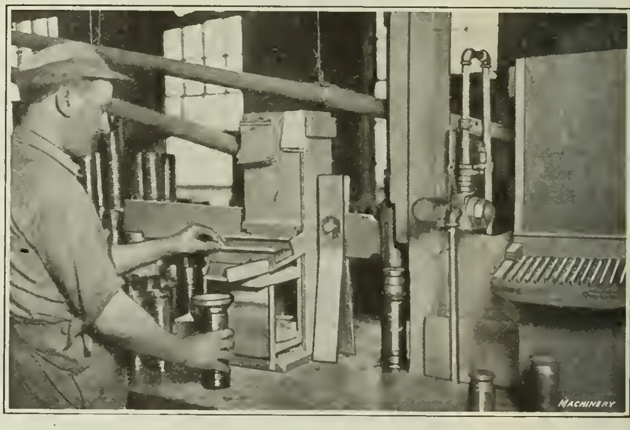
Fig. 3. Micrometer Dial and Cutter used for graduating

SHRAPNEL BALL COUNTER

At the Vermont Farm Machine Co.'s plant, Bellows Falls, Vt., the loading of 3-inch Russian shrapnel with ½-inch balls is done in two operations. In the first operation, ninety of the balls are dropped into the shrapnel case, and are then submitted to a three-ton pressure to pack them down. The second operation consists of dropping 150 additional balls into the shrapnel case, sprinkling in a charge of smoke making powder, weighing and adding enough balls to attain the exact weight required and then pressing with a three-ton pressure.

The improvised counting machine shown herewith has worked out very satisfactorily at this plant for inserting the correct number of balls in the shrapnel case with two pressings, which seems to be the advisable practice. The counting machine to the left which the operator is using consists principally of a storage chamber fed by an inclined pipe from a large tank near the ceiling. Opening from the bottom of the small retaining tank is an inclined raceway which is divided into ten channels. There are two gates which are spaced approximately nine ball diameters apart.

In operation, the workman lifts the upper gate, nearest the tank, which causes ninety balls to roll forward, stopping against the front gate. He then replaces the rear gate and lifts the forward gate, as shown in the illustration, releasing the ninety balls which drop into the shrapnel case. During the process the shrapnel case is being shaken up and down by a jogging device on which it rests. The partially filled case then passes to the hydraulic press at the right of the operator, where the three-ton pressure is applied. It then goes to the counting machine shown at the extreme right of the illustration, where 150 balls are added. This machine has fifteen raceways and is constructed to space off ten balls between the gates. These counting machines might have been made to count out 100 balls for the first pressing and 140 for the



Shrapnel Ball Counting Machines and Hydraulic Press

second or any other combination, but the one used was considered advisable and worked out satisfactorily. Though these devices were more or less makeshift, they have proved very effective in getting out a large quantity of work, and the principles involved are simple but ingenious. V. B.

* * *

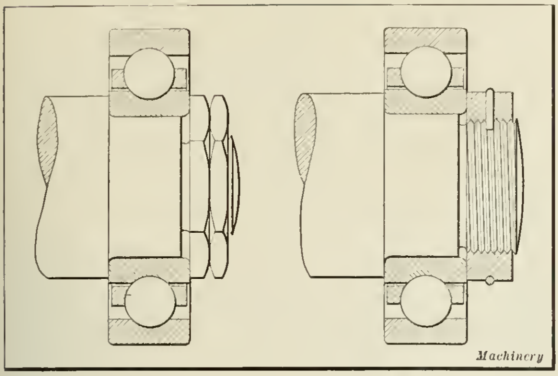
S. A. E. SCREW THREAD STANDARDS CHANGE

The Society of Automobile Engineers has issued a revision of the S. A. E. standard screws and nuts in respect to the threaded portion of the bolt. The length of effective thread now specified is $D \times 1.5 + \frac{1}{4}$ inch, in which D is the diameter of bolt in inches. The length of the thread previously specified was $D \times 1.5$, but it was found that the bolt makers were prone to make the effective threaded portion too short, measuring the thread to the extreme point that had been marked by the die; hence the length of the threaded portion was increased by ¼ inch on all sizes.

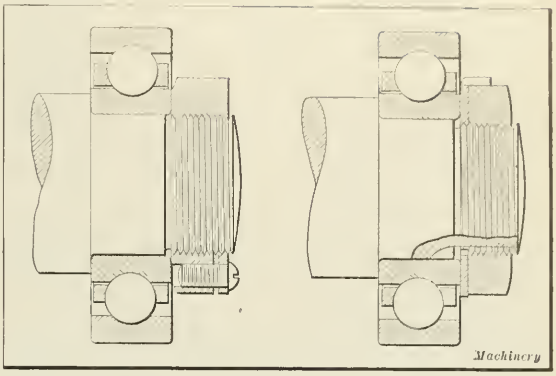
USING BALL BEARINGS[1]

CARE, STORING, HANDLING AND MOUNTING

BY OTTO BRUENAUER[2]



Figs. 1 and 2. Simple Mountings of Straight-bore Bearings on Straight Shafts, showing Means of locking Nut



Figs. 3 and 4. Alternative Methods of locking Nut to clamp Ball Bearings on Straight Shafts

A BALL bearing is a piece of mechanism of extraordinary precision and accuracy. The balls and races are truly spherical and circular, respectively, within a fraction of a thousandth of an inch, and the balls are fitted between the races with equal accuracy. A speck of dirt in the raceways will give a sensation when the hand spins the bearing as if the balls were rolling over a big lump. Dirt and grit in a bearing or rough and careless treatment affect its running qualities and ultimate wear in the same way as they would the works of a watch. No man would ever think of letting his watch with the case open lie around on dirty work benches or on the floor of the shop. Yet he will do this with a ball bearing, giving it every possible opportunity to become filled with foreign matter, and otherwise abuse it to the detriment of its life and usefulness.

Because of ignorance of conditions and lack of proper methods in handling ball bearings before and during the process of mounting many ball bearing installations have been failures. They were rendered useless before they were put into operation. No matter how carefully and correctly the design has been worked out by the engineer his best efforts are likely to be defeated by careless or improper methods of handling the bearings in the shop. The one must supplement the other, and it is with this correlation in mind that the handling, mounting and lubrication of ball bearings are dealt with in the following. Many of the directions are intended particularly for large quantities of bearings. However, the general principles of cleanliness and carefulness apply whereever ball bearings are used, regardless of the quantity or the size of the shop. The details of the method alone may be varied to suit conditions, and of course will be less elaborate in a factory which uses but few ball bearings.

STORING AND HANDLING

When taking the bearings out of the shipping cases the individual boxes in which they are packed must not be opened. The unpacking should be done on tables rather than on the floor of the receiving room, and the shipment after being checked should be sent to the store-room immediately. If trucks are used for this purpose other material should not be piled on top of the bearing boxes, as this is likely to damage the bearings. If the individual boxes and wrappers in which the bearings are packed by the manufacturer remain intact, the bearings may be stored and kept almost indefinitely. They are slushed and well protected from danger of rusting and should not be unwrapped or handled in any way until ready for use. Each box is distinctly marked with the number and type of bearing it contains. Thus, it is an easy matter to store them neatly on shelves, arranged by numbers and types.

Used bearings should not be stored without careful inspection. Frequently bearings are delivered to the store-room that have been used in some way or other in the assembling department or that have been taken out of dismantled machines. It should be made a strict rule that no such bearings may be stored without having been washed, inspected, slushed and

[1] The following articles relating to the care, use, design, construction, manufacture and application of ball bearings have previously been published in MACHINERY: "Lubrication of Ball Bearings," July, 1915; Ball Bearings," June, 1915; "Pitch Diameters of Ball Bearings," January, 1915; "Load Capacity of Ball Bearings," May, 1914; "Sliding Action in Ball Bearings," April, 1914; "Formula for Determining the Ball Circle Diameter for Ball Bearings," September, 1913; "Ball Bearings—Their Construction and Application," July, 1913; "Making Annular Bearings," December, 1912; "Making New Departure Ball Bearings," November, 1912; "Ball and Roller Journal Bearings," September, 1912; "Ball and Roller Thrust Bearings," August, 1912; "Some Tools used in the Manufacture of Small Steel Balls," August, 1912; "The Mounting of Ball Bearings," July, 1912; "The Manufacture of Steel Balls," February, March and April, 1912; "Use of Ball or Roller Bearings in Machine Tool Construction," November, 1910; "Some Notes on Ball Bearings," May, 1909; "Ball Bearings," December, 1907, and January, 1908; "A New System for Manufacture of Steel Balls," November, 1900; "Ball Bearings," July, 1900.

[2] General Sales Manager, Gurney Ball Bearing Co., Jamestown, N. Y.

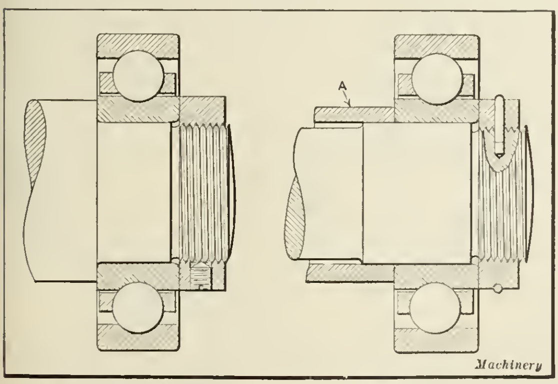
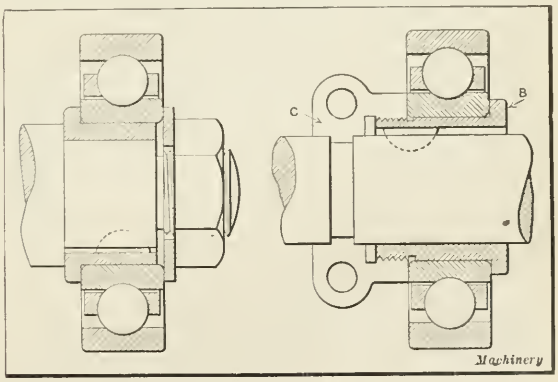


Fig. 5. Another Ball Bearing Mounting held by Nut

Fig. 6. Ball Bearing Mounting utilizing Spacer Ring



Figs. 7 and 8. Methods of mounting Bearing with Bore Same as or Larger than Diameter of Shaft

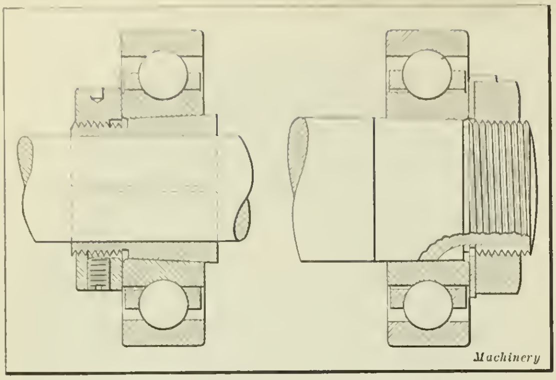


Fig. 9. Use of Adapter for mounting Bearings on Shafts that must remain Cylindrical

Fig. 10. Unsatisfactory Method of mounting Bearing on Tapered Shaft

repacked. In other words, they should be put in the same condition as a new bearing. To accomplish this, wash them in fresh gasoline, making sure that the pan is perfectly clean. The work bench or table on which this is done should be covered with paper or preferably lined with sheet metal, which must be kept clean. The best way of washing the bearing is to stick the fingers of one hand into the bore of the inner ring, and with the other hand spin the outer ring, and then quickly submerge the bearing in the gasoline. Bearings that are full of old or gummy grease should soak in the gasoline until the grease is dissolved. Dirt or grit will make the bearing run rough. In most cases repeated washing and spinning are necessary to remove these foreign matters. If they cannot be entirely washed out the bearings should be rejected.

If compressed air is available it may be used to advantage in cleaning bearings that have become full of dirt. After the bearing has been dipped in gasoline its inner ring should be driven by a tapered mandrel rotating at fair speed. One hand holds the outer ring stationary, the other applies the air blast. Repeated blowing of this kind will clean almost any bearing. Care should be taken, however, to have the compressed air clean and free from water.

Immediately after washing dip the bearing in kerosene to prevent rusting. Inspect it carefully. Make sure that the inner ring has not been cracked by driving it onto an over-size shaft, and that the ball separator has not been damaged by carelessly hitting it with a tool in driving the bearing on or off the shaft. If it is in good condition dip in a vaseline slush which will not gum up. Wrap in paraffine paper and place the bearing in its box. If a box is not available a heavy paper can be used. The bearing may now be stored again.

Bearings rejected by the inspector should be lubricated and repacked at once. If the inspector for any reason rejects part of a shipment of bearings they should not be allowed to lie around on benches, on the floor, or any place where they may rust or become dirty or wet. It is not fair to expect the manufacturer to accept a return shipment of new bearings which have been allowed to become dirty or covered with rust. The same cleanliness and care should be applied in such case as if the bearings were to be kept and paid for.

Before the bearing is mounted it must be washed in gasoline to remove the slush. If this is done in the assembling department a sufficiently large part of the work bench or a table should be used which is lined with galvanized or tinned sheet metal. A table with a metal lined basin sunk into its platform which may be covered up flush is a very good arrangement. The basin should have a drain however. When the mounting of bearings on shafts or spindles is done in one department and when the quantity of bearings warrants it, the washing should be done in a separate room and away from the work bench, preferably in the store-room or inspection department. Immediately after washing, the bearings should be dipped in kerosene. If this is not done they will dry quickly and have no protection against rusting. Dry bearings, if handled by perspiring hands, will soon rust, regardless of the amount of oil or grease with which they are lubricated afterward. It is difficult and often impossible to remove a bearing which has become rusted onto a shaft or into a housing. For this reason, as well as to keep the bearings clean, the assemblers should wash their hands freely in kerosene. Otherwise chips or filings sticking on their hands can easily enter into the bearing at the last minute and ruin it in a short time.

Under no conditions should a man be permitted to throw bearings around on a work bench full of tools, chips, sawdust, etc., or to throw them or let them lie around on the floor of the shop. Provide suitable equipment such as described and strictly enforce its use. A bearing with a chip or dirt in it will prove a very expensive thing to put into a machine, and any such neglect on the part of the workmen should be considered just as inexcusable as the dropping of a monkey wrench into a gear-box.

The washed and dipped bearings are best handed out to the assemblers in metal boxes. These may be provided with upright pins on which the bearings are stacked. A sufficient number of the various sizes required for a certain number of jobs may thus be handed out. The boxes can be kept close to the work when assembling and are a good protection for the bearings. If such boxes are used, it is well to leave a spare pin for each stack. Thus, when a man tries a number of bearings for the best fit, he can replace them on this pin instead of having to lay them temporarily on the bench or floor. The assembling department for reasons outlined above should be removed from the grinding department and located in a room which is unlikely to become filled with dust of any kind. Cleanliness should be the watchword.

When assembling transmission cases it is frequently customary to "run in" noisy gears with a grease which is mixed with some kind of abrasive. If this is done a special set of bearings must be used for this purpose only. Remove them afterward, wash case, gears and shafts thoroughly, blow them out, and remount the shafts on new bearings. Grease loaded with fillers such as sawdust, ground cork, etc., for the purpose of deadening the sound of gears is extremely injurious to ball bearings and must not be used.

Don't try to save by using grease or oil which has been used before. When the bearings are assembled in their places and ready for lubrication, fresh lubricant should be available. Aside from the reduced lubricating qualities of used oil or grease there is danger of their containing dirt or foreign matter.

Don't pack bearings between sawdust, excelsior, straw, etc. When bearings are to be shipped from one plant to another they should be carefully packed in strong cases. Under no circumstances should excelsior, sawdust, or similar material be used as a filler. The paper boxes in which the individual bearings are packed may break or open up because of rough treatment in transit and in consequence the bearings will become full of sawdust, etc.

MOUNTING BALL BEARINGS ON SHAFTS

The inner ring of a ball bearing must have a firm seat on the shaft. A press or force fit is often considered sufficient to

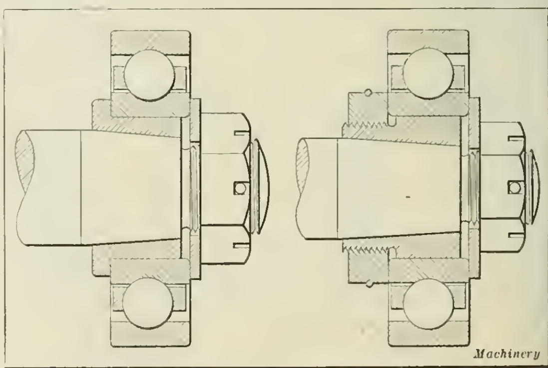


Fig. 11. Preferable Method of mounting Bearing on Tapered Shaft

Fig. 12. Method of mounting Bearing that gives Accurate Sidewise Location

mount a ball bearing properly on a shaft. However, if this bearing is once pulled off its seat and driven on again, there will be enough metal rubbed off the shaft to materially reduce its diameter. The bearing, when replaced, will have a more or less loose fit and will at once begin to peen down the shaft under the vibration of the varying loads, and thus gradually bring about abrasion of the shaft. A press fit is further objectionable for the reason that if not applied judiciously a stretching of the inner ring of the bearing, particularly of the light series, and a consequent tightening of the bearing, may result. Sometimes the inner ring will be stretched to such an extent that it will crack.

The proper fit, therefore, for an inner ball bearing ring on a shaft is what is commonly called a light drive fit. Slight tapping of the inner ring should be sufficient to make it slide along the shaft onto its seat and against the shoulder of the shaft. The practice of locking the ring against this shoulder by means of a nut or its equivalent (except in the case of taper-bore bearings) is recommended under all circumstances.

Limits of Bearing Variations and Allowances for Shafts

The standard accuracy applied to the manufacture of ball bearings is for obvious reasons extraordinarily high. For the limits of variations for various sizes of bearings a standard maximum and minimum has been adopted by all ball bearing manufacturers. These variations have been regulated with a view to insuring proper fits on shafts turned within such limits as will permit of this operation being done commercially by the users of ball bearings.

The accompanying table gives limits of variations in the bores of ball bearings and the appropriate limits on the shafts to secure desirable fits. This table will be useful to the engineer or superintendent in specifying the plus and minus allowances on the working drawings.

For the benefit of those who have had little experience with ball bearings, it may be said that they are made to metric dimensions, the bores increasing by five millimeters, or 0.1969 inch—less than 13/64 inch. For each size of bore three different series of bearings are made, namely, light, medium, and heavy series. For the medium series larger balls are used than for the light series. Hence, the medium series bearing of the same bore as that of the corresponding light series will have a larger outside diameter and thickness. The same condition exists for the heavy series with reference to the corresponding size of the medium and light series, respectively. The purpose of this is obvious. It permits of a more economical selection of the proper bearing for a given shaft to support light, medium or heavy loads, as the case may be. Different manufacturers number their bearing sizes differently, and in most cases so as to identify the type of bearing, namely, whether it is a plain radial single-row bearing, a double-row bearing or a combination radial and thrust bearing. Since in all cases, however, the bores increase by five millimeters it will serve our purpose if we list the bearings in the accompanying table merely by their bores, and not by numbers and types.

BORE AND SHAFT TOLERANCES FOR MOUNTING BALL BEARINGS

Bore of Bearings, Millimeters			Limits of Variations of Bore, Inches		Limits on Shafts if Race is Clamped between Shoulders	Limits on Shafts if Race is not Clamped between Shoulders
Light Series	Medium Series	Heavy Series	Plus	Minus		
10 to 20			0.0002	0.0004	+0.0000 −0.0005	+0.0002 −0.0003
25 to 80	20 to 65	20 to 55	0.0002	0.0006	+0.0000 −0.0008	+0.0003 −0.0004
85 to 110	70 to 110	60 to 110	0.0002	0.0007	+0.0000 −0.0010	+0.0003 −0.0005
115 and up	115 and up	115 and up	0.0002	0.0007	+0.0000 −0.0010	+0.0003 −0.0005

Machinery

Methods of Securing Inner Ring on Straight Shaft

Shoulder on Shaft.—Leaving a shoulder on the shaft against which one face of the inner ring may be clamped by a nut is the most satisfactory and economical method of mounting a straight-bore ball bearing on a straight shaft. In the majority of cases the design can be made so as to permit this method. Figs. 1 to 5 show simple and effective means of locking the nut.

No Shoulder on Shaft.—If the shaft cannot be designed so as to leave a shoulder on it, a spacer sleeve *A*, Fig. 6, between the inner ring of the bearing and some other rotating and laterally fixed member on the shaft will serve the purpose: The hub of a gear, worm, pulley, sprocket, or drum may be conveniently utilized. If nothing of the sort is available, Figs. 7 and 8 show a satisfactory solution of the problem. Fig. 7 shows the mounting of a bearing having a bore the same as or larger than the diameter of the shaft, and it is assumed that the size of the bearing cannot be reduced. By cutting down the shaft and driving on a bushing with a shoulder on one end, the bearing will be satisfactorily mounted, provided the bushing has a firm seat on the shaft and its outside runs true with the shaft. When a bearing must be mounted under such conditions away from the ends of the shaft, a good method is to use a bushing *B*, as shown in Fig. 8, which is held in position laterally by the split bushing *C*. The split bushing also serves the purpose of locking the inner ring between two shoulders. The same conditions for true running of bushing *C* with the shaft must obtain as in the case illustrated in Fig. 7.

The form of bearing mounting for vertical shafts shown in Fig. 13 will often be found very satisfactory. The illustration shows the mounting of the inner ring of both the

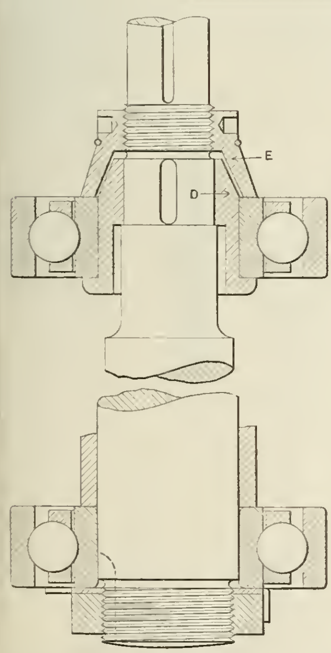


Fig. 13. Satisfactory Method of mounting Bearings on Vertical Shaft

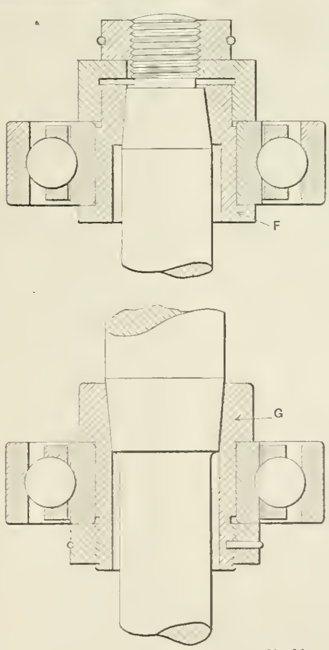


Fig. 14. Method of mounting Bearings on Tapered Vertical Shaft

Machinery

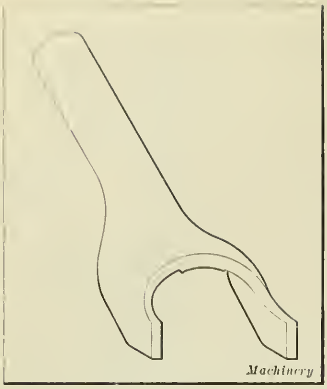


Fig. 15. Tool for removing Ball Bearings from Shafts

upper and lower bearings on the same shaft. The member *D* supporting the upper bearing is held against the shoulder on the shaft by means of the collar *E*, which, at the same time, serves to clamp the inner ring between shoulders. The inner ring of the lower bearing is locked in any of the ways previously given.

Adapters for Taper-bore Bearings.—Shafts that must remain perfectly cylindrical, particularly lineshafts and countershafts, permit but one method of mounting a ball bearing, namely, by the use of a so-called adapter, Fig. 9. This is a split bushing which can be clamped tight onto the shaft by driving over its tapered periphery a bearing with a taper bore. The bearing is held in position by a nut on the adapter. A 4-degree included angle is the accepted standard for taper-bore bearings.

Methods of Securing Inner Ring on Tapered Shaft

The mounting of bearings on a tapered shaft, as shown in Fig. 10, should be avoided as much as possible. There is great danger of stretching and cracking the inner ring, unless more judgment is used than the average working man possesses. A decidedly preferable method is shown in Fig. 11, which illustrates an adapter with a taper bore and straight outside, enabling the use of a straight-bore bearing. Since it is difficult to locate either the bearing or the adapter accurately, recourse may have to be had to the method shown in Fig. 12, if this accurate sidewise location is really essential.

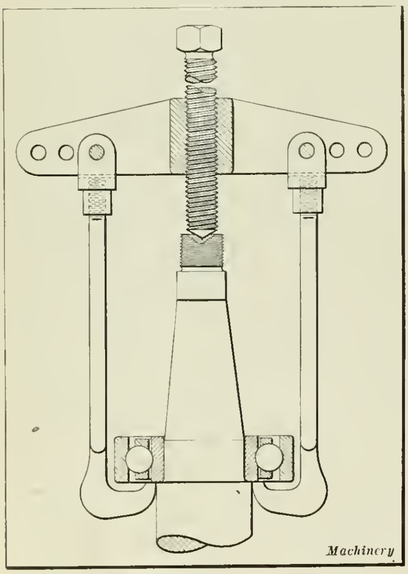


Fig. 16. "Bearing Puller" for removing Ball Bearings from Shaft

Fig. 14 illustrates the mounting of bearings on a tapered vertical shaft. The upper bearing is carried on a member *F* having a straight seat for a straight-bore inner ring which is clamped between shoulders by means of the nut on the end of the shaft. This nut, at the same time, drives the member *F* up on the taper of the shaft. For the lower bearing the weight of the shaft and the parts mounted on it is depended upon to establish a firm seat between the shaft and the member *G* on which is mounted a straight-bore bearing in any of the ways previously given.

In all cases the shoulder against which the bearing rests with one face of its inner ring should be at least 1/8 inch smaller in diameter than the outside diameter of the inner ring of the bearing. This is for the purpose of leaving enough of the inner ring exposed to pull off the bearing if necessary. Where the exigencies of the case may make it desirable, two notches diametrically opposite may be cut into the shoulder to enable a special tool called a "bearing puller" to be used, as illustrated in Figs. 16 and 18.

Machining Shaft for Mounting Ball Bearings

The seat of a ball bearing on a shaft should best be ground. When the finishing operation must be done in a lathe great care should be taken to make the seat very smooth. It is important that the seat be perfectly round. If it is not on a true circle the inner ring of the bearing will contact with the shaft only on high spots and soon will peen down, causing a looseness and often ultimate destruction of the shaft or bearing, or both. Working drawings should give plus and minus limits according to the table given in the foregoing, and they must be strictly adhered to. The operators and inspectors should be furnished with "Go" and "Not Go" gages. Micrometer reading should be discouraged. The fillets on the shafts should not exceed the blueprint dimensions. The latter, of course, must be slightly smaller than the chamfers of the bearings for which every bearing manufacturer furnishes specifications in his catalogue. If the fillet on the shaft were larger than the chamfer of the bearing, the bearing would contact only on the fillet instead of with the shoulder on the shaft. If side thrust were transmitted onto a bearing so mounted, the small area of contact between fillet and chamfer would soon wear, causing lateral play of the bearing in its seat with all the consequent destructive results.

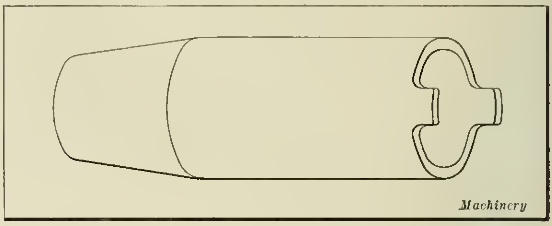


Fig. 17. Tool for removing Bearing mounted on End of Shaft

Driving Bearings on Their Seat on Shaft

Under all circumstances the force required to drive the bearing on its seat, should be exerted against the inner ring and not against the outer ring. This rule should be thoroughly understood and strictly enforced. A little oil should always be put on the seat before driving on the bearing. The driving should not be done by hammering directly against the inner ring. This is very hard, and such hammering is likely to chip or crack the ring or to damage the separator in the bearing. A tool like that illustrated in Fig. 15 should be used, which of course must not be hardened. If the bearing is mounted on the end of the shaft, the tool shown in Fig. 17 will serve well. In any event, the ring should be driven simultaneously at two diametrically opposed points of its outside surface. Tap gently, and

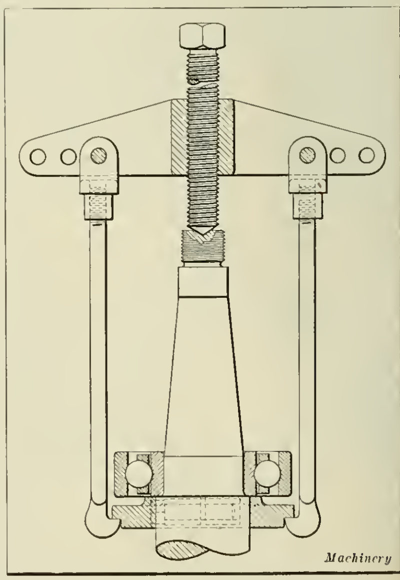


Fig. 18. Another Form of "Bearing Puller"

only with soft metals. If the bearing drives on too hard, take it off and use another one, or have the shaft ground or turned down. Never attempt to grind out the bore of the bearing to make it fit.

When mounting taper-bore bearings on adapters, Fig. 9, the same method of tapping the inner ring on its seat should be used as in the case of straight-bore bearings. The adapter, of course, should be backed up on its other end. It will not do to draw the bearing up on its seat by turning the nut. The adapters are made as thin as is consistently possible to keep down the size of the bearing. The threads on the adapter are consequently fine and only expected to hold the bearing in its place, and not to withstand the strain of driving it on its seat.

Pulling Bearings off Their Seats

The same fundamental rule applies in the case of pulling bearings off their seats as in driving bearings on their seats, namely: Don't exert force against the outer ring. Wherever possible the tool shown in Fig. 15 should be used and the bearing pushed off its seat. If the rules suggested in the foregoing for rust prevention have been followed and if the shaft was oiled before the bearing was driven on, it will come off very easily. If the bearing rests against the hub of a gear, etc., the bearing may best be driven off through the latter. There is no objection to driving the shaft out of the bearing, where this is more convenient, as long as the outer ring of the bearing is not used for support. Where the conditions require a tool of the type shown in Figs. 16 and 18, this must be used for pulling the inner ring off its seat. If notches are provided on the shoulder such a tool will work very well.

* * *

DR. IRA N. HOLLIS

Dr. Ira N. Hollis, the newly elected president of the American Society of Mechanical Engineers and president of the Worcester Polytechnic Institute, was born in Mooresville, Md., in 1856. He graduated from the Louisville, Ky., high school in 1872, and went as an apprentice in a machine shop for building and repairing all kinds of engines, principally those used on the Ohio River steamboats. His health failing, he changed his occupation, and finally entered the Naval Academy at Annapolis in 1874, from which he graduated in 1878. Two years later he was commissioned assistant engineer in the United States Navy, and in 1888 passed assistant engineer. He resigned from the Navy in 1893 to become professor of engineering at Harvard University, and in 1913 was called to his present position.

During the fifteen years after graduation from the Naval Academy he had a varied experience and was chief engineer of two ships. In 1884 he served with the advisory board that built the four ships of the White Squadron and spent some months in the inspection of machinery at Chester, Pa., New York City, and Nashua, N. H. He spent three years at the Union Iron Works in the inspection of machinery for the *Charleston* and on the naval board for fitting up the merchant ships as auxiliaries. In 1892 he was ordered to the Bureau of Steam Engineering under George W. Melville, then engineering chief, and his first service was a series of lectures at the War College on the new ships of the navy. His last work in the navy was drawing specifications for the machinery of the gunboat *Nashville* and designing machinery for new torpedo boats.

Dr. Hollis was twenty years with the Harvard University during the rejuvenation of its engineering work. He was active in the development of the university's facilities for sports, including a boat house, ball cage and stadium. The stadium was his idea and the use of concrete for its construction was novel. The stadium was the first of its type in the country, and it was probably the first large structure above ground, inasmuch as up to that time concrete had been used for only underground structures. He planned and built Pierce Hall, which was used for engineering for many years.

Dr. Hollis received the honorary degree of Master of Arts from Harvard University in 1899, the degree of L.H.D. from Union College in the same year, and the degree of Doctor of Science from the University of Pittsburg in 1912. He was elected to membership in the A. S. M. E. in 1884 and was its vice-president from 1911 to 1913. He is a member of the Society of United States Naval Engineers, the American Society of American Architects and American Engineers, the Boston Society of Civil Engineers and the Society for the Promotion of Engineering Education. He is the author of the History of the Frigate *Constitution* and War College Lectures on Naval Ships. He presented a paper before the A. S. M. E. in 1909, "Cast-iron Fittings for Superheated Steam," and has presented other papers dealing with naval, educational and engineering subjects.

Dr. Ira N. Hollis

* * *

ANNUAL MEETING OF A. S. M. E.

The thirty-seventh annual meeting of the American Society of Mechanical Engineers was held in New York City December 5 to 8, inclusive. The program followed the usual lines, the president's reception being held on Tuesday evening, following the president's address. President D. S. Jacobus delivered an address on "Education in Engineering". The officers chosen at the annual election are as follows: Ira N. Hollis, president; Charles H. Benjamin, Arthur M. Greene, Jr., and Charles T. Plunkett, vice-presidents; Robert H. Fernald, William B. Gregory, C. R. Weymouth, managers; and William H. Wiley, treasurer.

On Wednesday the following papers were presented:

"The Proportioning of Surface Condensers," by George A. Orrok.

"The Testing of House Heating Boilers," by L. P. Breckenridge and D. B. Prentice.

"Water for Steam Boilers—Its Significance and Treatment," by Arthur C. Scott and J. R. Bailey.

"Proposed Code of Safety Standards for Cranes."

"Steam Safety Valves," by George H. Clark.

"Efficiency of Propulsive Machinery and Late Developments in Naval Engineering," by H. C. Dinger.

"Standardization of Power Plant Operating Costs," by Walter N. Polakov.

"Report of Efficiency Tests of a 30,000-kilowatt Cross-compound Steam Turbine," by H. G. Stott and W. S. Finlay, Jr.

"The Design and Test of a Large Reclamation Pumping Plant," by G. C. Noble.

Following the presentation of these papers, memorial exercises were held in the auditorium for John E. Sweet, past-president, honorary member and founder of the society. After these exercises in the afternoon there was a conference of the local sections. The following papers were presented:

"The Utilization of Waste Heat for Steam-generating Purposes," by Arthur D. Pratt.

"Graphic Methods of Analysis in the Design and Operation of Steam Power Plants," by R. J. S. Pigott.

"Power-plant Efficiency," by Victor J. Azbe.

"The Impact Tube," by Sanford A. Moss.

"The Flow of Air and Steam through Orifices," by Herbert B. Reynolds.

"Topical Discussion on Industrial Management."

"Heat Transmission through Various Types of Sash," by Arthur N. Sheldon.

"Spontaneous Ignition Studied by Means of Photographic Plates," by Frederick J. Hoxie.

Vibration in Textile Mill Buildings," by G. H. Perkins.

"Standardization of Machine Tools," by Carl G. Barth.

"A Proposed Plan for the Activities of the Machine Shop Practice Sub-committee of the A. S. M. E.," by H. K. Hathaway.

The capacity of the rooms on the fifth floor of the Engineering Societies Bldg. was taxed Wednesday evening by those attending the smoker and vaudeville entertainment. Frank B. Gilbreth, the well-known efficiency expert, gave an illustrated talk on his experiences traveling to Europe, following which was a varied entertainment provided by hired talent.

The papers presented on Thursday included the following:

"Accurate Appraisals by Short Methods," by J. G. Morse.

"How Does Industrial Valuation Differ from Public Utility Valuation?" by John H. Gray.

"Relation between Perpetual-inventory Value and Appraisal Value," by Charles Piez.

"Valuation of Industrial Properties vs. Valuation of Industrial Methods," by Walter N. Polakov.

"Productive Capacity a Measure of Value of an Industrial Property," by H. L. Gantt.

Five papers were presented at the gas power session held under the auspices of the sub-committee on gas power as follows:

"A Gas Producer for Bituminous Fuel," by O. C. Berry.

"The Commercial Sampling and Analysis of Producer Gas," by P. W. Swain.

"The Ratio of the Specific Heats and the Coefficient of Viscosity of Natural Gas from Typical Fields," by Robert F. Earhart.

"An Investigation of the Internal-combustion Engine as Applied to Traction Engines," by A. A. Potter and W. A. Buck.

"Illustrated Review of the Development of the Werkspoor Marine Diesel Engine," by Thomas O. Lisle.

The evening was devoted to a symposium on aviation in the auditorium, and the annual reunion. Illustrated addresses included moving pictures of recent flights of the original Langley machine.

On Friday simultaneous sessions were held at which the following papers were presented:

"Illustrated Review of the Development of Our Fleet and Naval Stations," by W. L. Cathcart.

"Heat-treatment of Wrought-iron Chain Cable," by F. G. Coburn, W. W. Webster and E. L. Patch.

"An Analysis of Marine Safety Valves, with Suggestions for Repairs and Improvements," by E. F. Maas.

"The Talbot Boiler," by Paul A. Talbot.

"The Downflow Type of Steam Boiler," by John C. Parker.

"Clasp Brakes for Heavy-passenger-equipment Cars," by T. L. Burton.

"Mechanical Design of Electric Locomotives," by A. F. Batchelder.

"Pulverized Fuel for Locomotives," by J. E. Muhlfeld.

Public hearings by the boiler code committee were held on Friday and Saturday.

As usual, excursions were made to nearby points of interest among which were the new Telephone Bldg., new Equitable Bldg., works of the Otis Elevator Co. in Yonkers, New York Steam Co.'s plant, and the Navy Yard in Brooklyn.

* * *

WARTIME WAGES

A young man from an Ohio farm got work in a munitions factory and made $6 a day. Suddenly the factory reduced its force and he returned home with a lot of fancy clothes and a new outfit of expensive tastes. The money had come easily and had gone quickly. His case is typical of many thousands within the past year. One munitions plant laid off more than two thousand men in a week. A hundred miles away a plant that had been paying big wages and large bonuses closed and turned out its men without warning. Most of them had been spending as they went along. Their big pay had done them little good. In leading them to extravagance it was an evil. We all know that the labor situation has been critical. The sudden rise in wages demoralized the supply. Farms were especially hard hit. Their labor was the kind the factories wanted, and the factories bid the limit and threw ethics out of the window. They raided conservative concerns and cared not how the men came, so long as they got them. In its effect upon employment the war has been a curse, because it has encouraged bad practices. When the young man on the Ohio farm looks at his fancy clothes and thinks about what became of his money he may get a useful angle on the wage question. We hope so, and we hope others will think of it from the same angle. But to be honest, we doubt that it will do much good—more's the pity.—*Country Gentleman.*

OCCUPATIONAL DISEASES

BY CHESLA C. SHERLOCK [1]

Under the workmen's compensation acts there is no recovery from an employer for occupational or industrial diseases. When the courts were first presented with this question, they found that the only recovery provided for, under those statutes, was for accidental injury or for injury arising in the course of employment by accidental means. It will be seen, then, that the only theory on which recovery for such a disease could be supported would be on the theory that such an infirmity was the result of an accident.

The courts of this country have followed the lead of the English courts and are practically united on the proposition that there is no recovery for a purely occupational or industrial disease. However, they have quite uniformly held that where the disease sued upon results from a *bona fide* injury there will be recovery against the employer. Indeed, most of our compensation acts expressly provide that there can be no recovery in such cases; and those that make no mention of the subject have been construed to bar a recovery.

Certain occupations, if followed for any length of time, are exceedingly dangerous to the health of the employe. This is quite generally known to the employe as well as to the employer. If the employe, having the right to choose his own work, engages in a dangerous occupation and in due course of time contracts an occupational disease, there should be no recovery under the compensation acts. The purpose of those statutes was not to act as insurance for the employe against the reasonable risks of his employment, but rather to safeguard his interests in case of sudden injury or loss of his faculties so as to impair his earning capacity.

The courts have handed down some specific decisions that will tend to illustrate the line of reasoning followed. For instance, they have said that a skin disease caused by the workman's hand coming in direct contact with poisonous substances, in the course of his employment, is not an accident. Likewise, they have held rash, dermatitis and eczema are not accidents. Ptomaine poisoning, typhoid fever, enteritis, lead poisoning, and copper poisoning have all been held not to be accidents. However, in Massachusetts, lead poisoning was held to be a recoverable injury, as the statute in that state provided for recovery on personal injury, and the court said that lead poisoning was within the technical meaning of the law in that state. Likewise, a recovery was allowed in the same state for blindness caused by optic neuritis, produced by poisonous gases.

Where the disease is the result of some unusual condition of work, as where a workman, unduly exposed to the elements, contracts a severe cold which runs into pneumonia and death results, recovery will generally be allowed. Following this line of reasoning, the New York courts have said that where a person was employed to cut weeds along a railroad right-of-way and died as a result of infection from poison ivy, the disease was accidental and recovery was allowed. Sunstroke and heat prostration have both been held accidental, but this question is largely one of fact and depends upon the circumstances of each case. Recovery has been allowed for blood poisoning when it was clearly demonstrated that it was contracted in the course of the employment. And the courts have gone so far as to say that the mere fact that an employe is suffering from disease at the time of the injury complained of does not bar a recovery. It may be shown that, although the workman was in a diseased condition at the time of the injury, such injury aggravated the disease to the extent that death resulted and recovery will be allowed.

In regard to general breakdowns and nervous disorders due to overwork, the courts seem to be of the opinion that they correspond too closely to occupational diseases for recovery to be allowed on them. Such disorders are not accidents within the meaning of the compensation acts. It will be seen that diseases are divided into two classes by the courts: occupational or industrial, for which there is no recovery; and those resulting from injury or aggravated by injury sustained in the course of employment, for which recovery is allowed.

[1] Address: 408 S. & L. Bldg., Des Moines, Iowa.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

MICROMETER MEASUREMENTS

The article in the October number of MACHINERY, showing a large snap gage with micrometer adjustment and giving tables of figures in ten-thousandths of an inch for running, driving and shrinking fits, makes me think of an experience I had when a kid in a machine shop in the early 70's, where the "instruments of precision" were a pair of long-legged calipers and a two-foot rule graduated to 16ths. A near-by rolling mill was frequently breaking their squeezer pinion, and it was a part of our job to have on hand a duplicate ready for immediate use. This pinion was a cast-iron bevel gear about 24 inches in diameter with a 9-inch hole, which had to be a good driving fit. I used to face up the gear hubs and rough-bore them, but a down-east machinist called "Williams"—a thin, medium-sized man with red whiskers—was always sent over to the lathe to take the finishing cut. One day, after he had set the tool and had it cutting to his satisfaction, he was asked: "What rule have you for setting your calipers for the allowance for the different kinds of fits—such as running, driving and shrinking?" He didn't reply for a moment, but stood there running his fingers through his long red whiskers; then he said: "Cox, I ain't got no rule; I jist guess at it—but I'm a d—— good guesser."

Cleveland, Ohio. J. D. COX

BABBITTED MACHINERY CONSTRUCTION

The article entitled "Babbitted Machinery Construction" that appeared in the November number of MACHINERY is both interesting and timely, and graphically illustrates a common mistake made by many engineers and designers, either through prejudice or a desire to follow the trend of the times. That a good babbitted bearing is to be preferred to a poor bronze one goes without saying. The experience of many years has proved that a babbitted bearing, properly lubricated, gives a low coefficient of friction and long life as well.

It is common practice to babbitt the main bearings of marine engines, and this material gives entire satisfaction, notwithstanding the enormous weight of the crankshaft and other parts, connecting-rods, crossheads, pistons and piston-rods, to say nothing of the extra weight brought to bear by the steam pressure. Yet a marine engine must run continuously from the time the ship leaves the port until she docks again, for it is exceedingly dangerous to stop a ship for repairs when there is a heavy sea running. Marine-engine main bearings that are babbitted often run for many years without attention, aside from a little scraping and adjustment of liners, and when they are worn to a point that demands renewal, they are replaced at a comparatively trifling cost.

In the past, many machine-tool builders employed babbitted bearings in lathes, screw machines, small milling machines, etc., with very satisfactory results. In such cases, the babbitt is poured over a mandrel somewhat smaller than the desired finished size and later is thoroughly peened. The bearings are then bored and line-reamed. This method gives excellent results, as any mechanic of the older school can testify. Yet the purchaser of machinery at the present day looks askance at a good, honest babbitted bearing, thinking that it is a sure sign of cheap construction. One concern that obtained excellent results with babbitted bearings made semi-automatic machines for folding collar blanks, preparatory to stitching, that had several shafts connected by gearing. These shafts were carefully lined up by means of templets and then babbitt was poured in the journals. As the spacing of the shafts had to be fairly close, because the gears had to mesh properly, considerable money was saved by this method; for otherwise it would have been necessary to bore the frames very carefully, or make expensive jigs.

The babbitted bearing has earned for itself an established place in the mechanical world, and engineers, designers and those who contemplate the purchase of machinery should investigate its merits before hastily condemning it as little better than a makeshift, or, at best, a short-cut toward a desired end.

Indianapolis, Ind. F. B. JACOBS

DEVICES FOR TWISTING AND BENDING ECCENTRIC RODS, LINK HANGERS, ETC.

Fig. 1 shows an excellent device for twisting eccentric rods, link hangers, and parts of a similar nature. In repair work, when links and their parts are being assembled on an engine, the jaws of the eccentric rod in nearly all cases are out of alignment with the link; as a result, the rod must be twisted a little to make the parts fit as they should. The illustration shows plainly how the device is used. The hooked ends of the

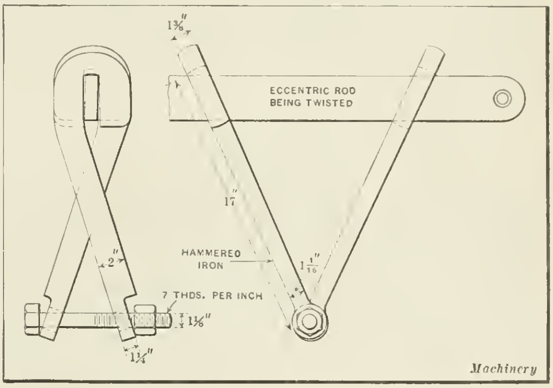


Fig. 1. Device for twisting Eccentric Rods, Link Hangers, etc.

straps are put on the eccentric rods, from 12 to 18 or 20 inches apart and then the other ends are brought together by screwing up the bolt.

In Fig. 2 is shown a handy and, in most shops, a badly needed device for bending eccentric rods and link hangers or similar objects. After part *A* is put on an eccentric rod *B* the key *C* is driven in. Tightening the set-screw *D* will bend the rod. Sometimes it is necessary to make two bends because the rod *B* and the link *E* are so far out of alignment. To bend the rod at *F*, would throw it over nearly in line but would twist it so much that the pin would not go in even if the jaw would go over the link. So it is necessary to give it a big bend at *F* and a reverse bend at *G* to get the parts properly aligned.

M. K.

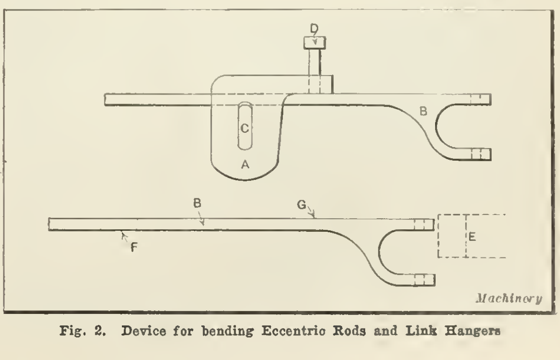


Fig. 2. Device for bending Eccentric Rods and Link Hangers

THAT T-SQUARE PROTRACTOR

The "Handy T-square Protractor" shown on page 246 of the November number of MACHINERY has at least one disadvantage—that of rapidly becoming inaccurate. The least wear or batter of the corner *A* of the head will throw it badly out of true. This error will be multiplied many time at the blade, and the shorter the head the greater will be the error thus caused. Further, when one has to work on a small sheet, it is not usual to employ a long-bladed square; and the system there shown would require graduating both a long- and a short-bladed square, if not the squares used. The writer uses glass-bladed squares; and graduating their blades with a diamond or wax and acid will not lessen the liability of the blade's breaking near the head.

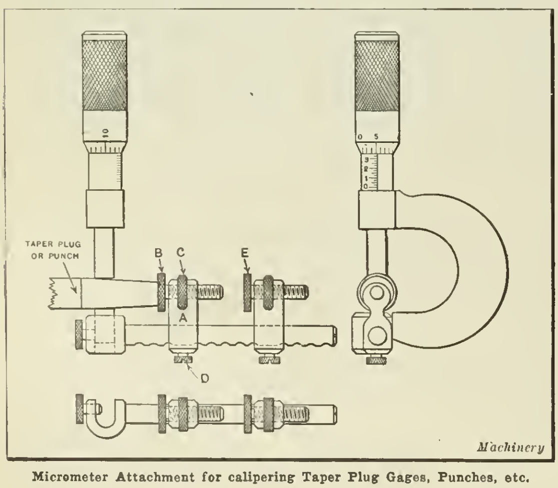
Another way of being sure to get tapers right is to graduate the end cleats of the drawing board with a knife point or other scribing device. When a short-bladed square is used, one that does not reach to the right-hand cleat, this way is as accurate as the one previously described; and where the blade reaches to or beyond the right-hand end of the board, it is even more accurate. When the blade is set to the required taper, a light line is drawn across the paper and the tapered lines on the drawing are made parallel to this by the usual method with triangle and square. (The average double-slotted parallel rule, being an invention of the devil and inaccurate, is barred from draftsmen's work, and the roller type is inapplicable to vertical boards.) If the drawing is small in proportion to the board, no setting line in the paper is necessary, as the guide lines on the board suffice. Where the T-square has a swivel head, the graduated board is as handy as the proverbial pocket in a shirt.

New York City. ROBERT GRIMSHAW

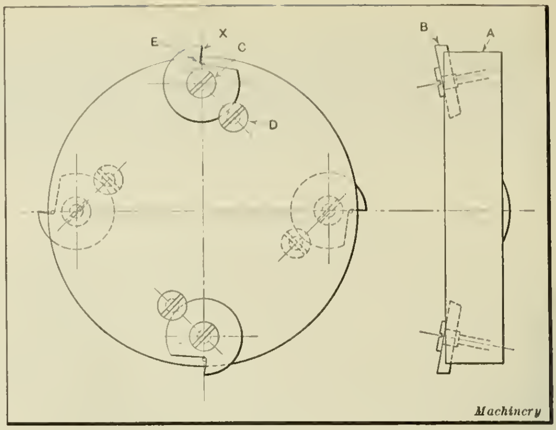
MICROMETER TAPER CALIPER ATTACHMENT

Where taper plug gages, punches, arbors, etc., are made in quantity, the attachment shown in the accompanying illustration will be found very convenient for calipering, and will give accurate results. Its construction and the manner of attaching it to the micrometer are clearly shown. The standards *A* are placed in approximately the correct position, and the stop *B* can then be set in the exact position after the clamp ring *C* is loosened. Should it be desired to caliper a second taper, the screw *D* at the bottom of standard *A* may be loosened so that the standard will fall into an inverted position. Then the second stop *E* may be used. If it is desired to again caliper the first taper, standard *A* may be placed in its former position and screw *D* again tightened in the former position. Should the work have a tip at the end that is to be removed after grinding, a screw with a hole in it is used in the standards instead of stops *B* and *E*.

Bridgeport, Conn. L. E. HARRISON



Micrometer Attachment for calipering Taper Plug Gages, Punches, etc.



Side Milling Cutter of Cheap Design

SIDE MILLING CUTTER

The side milling cutter shown in the accompanying illustration is one of those odd arrangements that are recommended chiefly because of cheapness but cannot be used as manufacturing tools. It consists of a body *A*, cutting disk *B*, stud *C* that holds the cutting disk in place, and a screw *D* that locks the cutting disk in place when edge *X* is against pin *E*. The body is made of machine steel. The cutting disks are easily ground and may be replaced readily when worn out, or thicker cutting disks may be used for milling wider grooves, resulting in a saving where the first cost of the tool is limited. In the cutter shown, two cutting disks are placed on each side of the body. This cutter was the middle one of a gang of three, the end cutters having cutting disks only on one side.

F. SEVER

COLD-ROLLED STEEL

Machinists commonly call all bright steel "cold-rolled," whether rounds, squares, flats, or shapes, but this is not a correct designation. Shafting, rounds, key-stock, etc., are given their finish and accuracy by cold-drawing, which is quite different from rolling. The quality of the steel also differs; broadly speaking, cold-rolled steel is soft and easily bent or punched, while that which is cold-drawn is harder and stiffer. Cold-rolled steel is obtainable only in flats, so there is not much danger of getting the two kinds mixed in everyday practice; it is well, however, to remember that there is a distinction, and there are cases where the failure to order correctly has been costly.

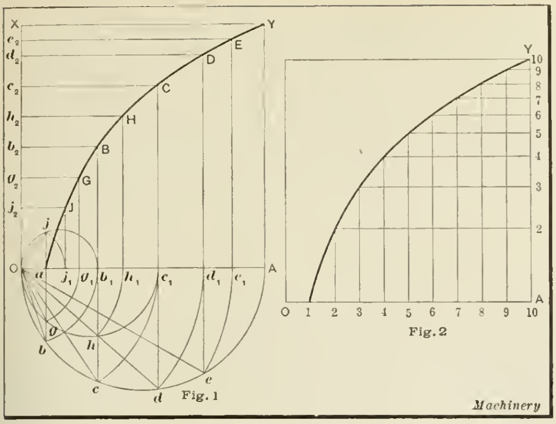
D. A. H.

"Cold-rolled" is, in general, a misnomer, but the foregoing statement is not altogether correct. The Jones & Laughlin Steel Co. of Pittsburg, is still making round shafting by the cold-rolling process.—EDITOR.

CONSTRUCTION FOR LOGARITHMIC GRADUATION

The following construction, which deserves to be more widely known among draftsmen and students of graphics, may be used for dividing a line for logarithmic graduation, when the line is of an odd length.

Draw a square *AOXY*, Fig. 1, on the line *AY*, which it is desired to divide logarithmically, and take on *OA* a point *a*, such that $Oa = 1/10OA$. On *OA* draw a semicircle and draw *ab* at right angles to *OA*, cutting the semicircle at *b*; then with *O* as a center inscribe the arc bb_1, making $Ob_1 = Ob$, and draw a vertical line through b_1 (assuming that *OA* is horizontal) to meet in *B* a horizontal line through b_2, which is such that $Ob_2 = 1/2OX$. Draw b_1c vertically to meet the semicircle in *c*, and inscribe arc cc_1 from *O* as a center; bisect b_2X in c_2 and draw horizontal and vertical lines through c_2 and c_1 to meet in *C*. The point *D* is next found by finding d_1 similarly, and bisecting c_2X in d_2 and projecting horizontal and



Construction for Logarithmic Graduation

vertical lines as shown. We thus get points *BCDE* upon a curve; to obtain intermediate points, draw a semicircle on Oc_1, and draw the arcs gg_1 and hh_1 from the center O. We then bisect Oc_2 in g_2 and draw horizontal and vertical lines through g_2 and g_1, respectively, to meet in G; and repeat the construction for H by bisecting b_2c_2 in h_2. The point J is obtained by drawing a semicircle upon Ob_1. In this way any desired number of points may be obtained, the resulting curve being a curve of logarithms. To save confusion with the construction lines, this curve is redrawn in Fig. 2, and the manner in which it is employed to divide AY into logarithmic graduations is shown. The base OA is divided into ten equal parts, and the resulting points are projected vertically to the curve, the points of intersection being then transferred to the vertical line AY by horizontal projections as shown. E. S. A.

MECHANICS' SOAP PASTE

The demand for soap or hand paste, or sand soap as it is more generally called, has increased to such an extent in the last few years that many companies have been organized for the purpose of manufacturing it. Each department store, drug store and corner grocery store has on its shelves a dozen different brands, together with the usual "superior article made by itself." Also, the spare time of many mechanics is spent in boiling fats and filling cans for their local clientele. About two hundred trade-marks are registered, by Massachusetts men, with the Secretary of State in Boston. The number registered in Washington from all the states must be enormous.

Inasmuch as an increasing number of people are beginning to do the mechanical work on automobiles and motorcycles, the field for the paste is continually growing. But to add even one brand to the already long list would seem senseless from a financial point of view. Some manufacturers will furnish the paste in bulk or put it up under any trade name desired. Most of these pastes are sold for 10 cents a can, or 25 cents at retail, but there are many brands that retail for 5 cents a can. The profit to the retailer is so much greater in the case of the inferior pastes that good paste can be had only from the most reliable dealers.

A soap paste can be made at home at a trifle less than the cost of the best hand soap. But a paste as good as the best on the market cannot be made and sold at a profit, either wholesale or retail, without the use of expensive facilities for its manufacture. In addition, the cost of raw materials has of late increased from 100 to 300 per cent. The lithographed cans alone cost two cents each, in lots of 25,000, and hardly any firm today will consider a smaller order. Firms, like Colgates and Armours, that have an extensive business in this line have special departments for making the cans, as the difference of a mill in the cost of each can may mean a profit or a loss for their product.

The making of soap paste at home is not altogether a difficult process. The body of a good paste is composed mostly of fatty acids. In the best sand soaps talc is sometimes added, while the cheaper grades are often adulterated with gypsum, lime, pipe clay, or sodium silicate to make a larger quantity of soap out of the same amount of the more expensive body. In the poorer grades, an equal part of rosin is often boiled with the more costly tallow to lessen the cost of production. Tallow and rosin boiled together absorb a great amount of water, and the more water that a soap can contain the greater will be the profit. All these adulterants are of no use and simply act as fillers. In fact, if sodium silicate is introduced into the soap at any except the right stage, it will spoil the compound. The usual test for detecting the presence of adulterants in the ordinary soap is to dissolve some of it in distilled water or alcohol and then note if there is a precipitant. The detection of these adulterants is more difficult with sand soap, however, because of its more solid ingredients.

The process of separating the fatty acid and glycerine from the tallow or lard probably requires the only technical skill needed in this work. As there is an element of danger in this, especially when sulphuric acid is used as a decomposing agent, it might be well for a person desiring to make soap paste for his own use to purchase the fatty acids from the nearest rendering works. As a further guarantee of the purity of the acids he should add some antiseptic. Cuts and scratches have often been made worse by the introduction into the sensitive tissues of a piece of contaminated grit and the lack of a healing antiseptic. An antiseptic is found in all good pastes, seldom in the poor ones. It is usually present in the form of antiseptic cocoanut oil. The use of sassafras as a perfume had almost become extinct until it was revived by hand paste. Where, why, or when the odor of sassafras was declared to be the national perfume for these pastes I do not know; it seems to be generally adopted, however.

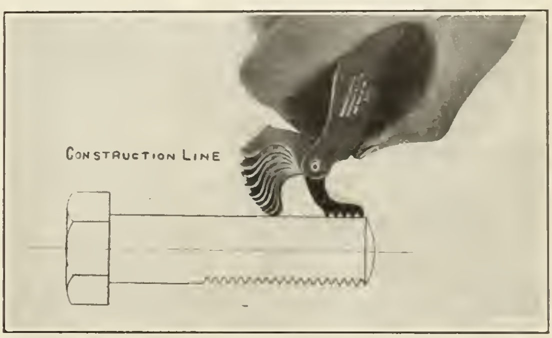
Finely ground pumice is a necessity in all good soap pastes; some of the best pastes are made up almost entirely of fine pumice stone and just enough pure neutral soap to make it lather well. These pastes remove the stains and leave the skin soft, white, and smooth. Coarse pumice stone will scratch the skin. Cheap soap pastes contain sea sand or glass sand, or both. Although glass sand is finer than sea sand, it scratches and irritates the skin more. There is not much choice, however, between the two, and any soap that contains either should be avoided. An excess of alkali in soap paste will cause the hand to chap, and is, therefore, avoided by the best manufacturers.

Worcester, Mass. ROBERT J. SPENCE

LAYING OUT SCREW THREADS

The draftsman and designer will find that screw threads can be more easily and quickly laid out by means of the screw pitch gage than by the old method of using a pair of dividers. The accompanying illustration shows the gage used for laying out a 7/8-inch cap-screw having nine threads to the inch. Two light construction lines are laid off for the outside diameter of the screw, then the gage marked nine threads to the inch is found and its teeth are pressed into the paper along the light construction lines. From the indentations thus formed, the threads can be easily and accurately laid out.

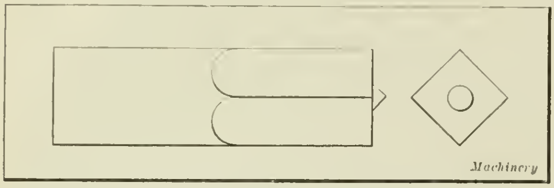
Prince Bay, N. Y. WARREN H. BARTON



Method of using Screw-pitch Gage

HEAVY-DUTY PUNCH

To make a heavy-duty punch that will stand up and hold a good cutting edge for from ten to twenty times as many pieces as the ordinary flat-pointed punch, turn up a 90-degree teat on the end, 3/32 to 1/8 inch long, according to the size of the punch. This teat will carry the stock ahead of the punch and relieve the pressure at the cutting edge. It gives a long life to the cutting edge of punches, especially those with sharp corners. A good lubricating compound is essential to assist in stripping the work from the punch.



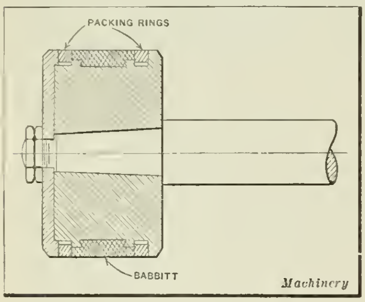
Heavy-duty Punch with Central Teat to relieve Pressure on Cutting Edge

Ypsilanti, Mich. A. E. Sanford

The use of a central teat on boiler plate punches was long ago found to greatly improve their action and durability. The teat centers the punch on the plate directly over the die, and holds it steady and in line, thus preventing deflection, broken punches and chipped dies. Of course the same improvement may be realized with punches used for other metal punching when so made.—Editor.

BABBITTED PISTON CONSTRUCTION

We recently had occasion to overhaul our seventy-two-horsepower steam engine, and after the engineer had removed the cylinder head and piston I was surprised to find that calipering showed the cylinder to be only a scant 1/32 inch out of round. The engineer said that it had not been bored for six years, which seemed incredible until I examined the piston and found that the metal had been turned away between the rings to make a space in which had been cast a good grade of babbitt metal, which took all the wear between the piston and cylinder. During the course of my experience I have frequently seen locomotive cylinders worn as much as 1/16 inch out of round after being in service for about eighteen months, while our engine had been running continuously for six years without showing a serious amount of wear. All that was necessary to put this engine in good running order was to renew the piston rings, face the valve seat and true up the valve stem and piston-rod.



Piston with Babbitt cast in between Rings to avoid Wear of Cylinder

Toledo, Ohio. R. B. Spencer

EXTRACTING ROOTS OF NUMBERS

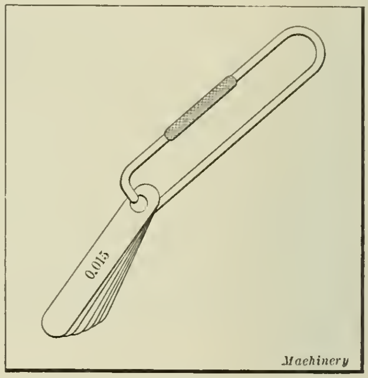
In the October number of Machinery, there was an inquiry for a method of extracting the roots of a number. It seems to the writer that for all practical purposes any method of actually extracting these roots is too tedious and laborious, and that, as stated in Machinery not long ago, use should be made of what has already been worked out.

By using tables of squares and cubes that may be found in almost any handbook, the fifth root of any given number may be accurately found to several places by interpolation, as the fifth power of a number is equal to the product of its square by its cube. For instance, suppose that the fifth root of 7214 is required, accurately, to five places. A moment's inspection of the tables will show that the product of the square and the cube of 6, or $6^2 \times 6^3 = 7776$, is a little too large. Looking into the fifties and inserting the decimal point in the proper place to get the powers of 5.9, it will be found that the fifth power of 5.9, or $5.9^5 = 5.9^2 \times 5.9^3 = 7149.3$, is too small. But by interpolation $100 \times \dfrac{7214 - 7149.3}{7776 - 7149.3} = 10$; therefore, 5.910 is part of the root. In the same way, $5.91^5 = 5.91^2 \times 5.91^3 = 7210.03$, and $5.92^5 = 5.92^2 \times 5.92^3 = 7271.25$. Then by interpolation $100 \times \dfrac{7214 - 7210.03}{7271.25 - 7210.03} = 6$; therefore, 5.9106 is the required root.

A result closer than four or five places is seldom of special value, and the foregoing method is not very tedious. Fourth and sixth roots may also be found by means of the tables in two operations, interpolation usually being necessary.

However, by using a five-place table of logarithms, the same result may be obtained in a minute's time. To obtain greater accuracy a more extensive table should be used. In the present case, the number is between 1000 and 10,000; therefore, the integer of the logarithm is 3. From the table the decimal part of the logarithm of 7214 is 0.85818. The logarithm of the required root then is $3.85818 \div 5 = 0.77164$. From the table, the corresponding number is found to be 5.9106.

A. H. Kirker
Homestead, Pa.



Convenient Arrangement of Feelers on Key Ring

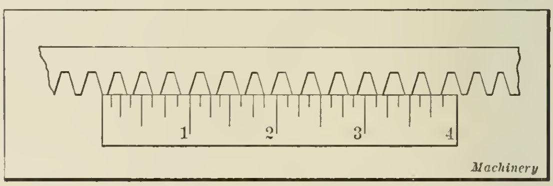
KEY RING FOR HOLDING FEELERS

The writer finds a key ring, of the type here shown, very useful when he has to use different sizes of feelers a great number of times. The feelers are removed from the regulation holder and slipped on the key ring by pushing back the knurled plunger that slides on the ring proper.

Bridgeport, Conn. James McIntyre

TO FIND THE PITCH OF A RACK

When it is required to know the pitch of a rack, many mechanics resort to such roundabout ways as trying a cutter to fit the teeth, matching a gear and computing from that, trying to count the teeth in one inch and converting from circular to diametral pitch, etc. The simplest way is to read the pitch directly from a steel rule. The number of teeth in 3 1/8 inches is the diametral pitch of the rack. To be exact, it should be read to 3 9/64 inches, but the racks in common use have teeth sufficiently coarse to be counted without mistake to the 1/8-inch line. If this length of rack could be bent into a circle without deforming, it would make a gear with a pitch diameter of 1 inch; hence its pitch equals the number of teeth.

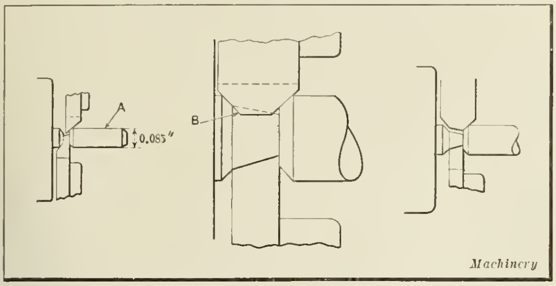


Measuring the Pitch of a Rack

Middletown, N. Y. Donald A. Hampson

CHAMFERING PINS IN THE AUTOMATIC SCREW MACHINE

Pins and rivets similar to that shown at *A* are made in large quantities in the manufacture of typewriters, guns, etc. The end is chamfered to facilitate assembling and also to remove the burr thrown up by the cut-off tool when it first comes in contact with the stock. In the following the writer describes an improved method of machining similar parts in the automatic screw machine. This method will greatly lessen the liability of pins under 1/8 inch diameter breaking off next to the chuck, a condition which quite often makes it necessary to cut down the feed and production.



Arrangements of Chamfering and Cutting-off Tools

In the left-hand view is shown a much used method of making pins. But this requires a number of cutting-off tools, to suit the various diameters of wire from which the pins are made. A more recent method is to use a standard cutting-off tool for all pins and the double chamfering tool shown in the center view. The fault of this method is that part *B* of the chamfering tool will come in contact with the conical shaped part of the pin formed by the cutting-off tool, and reduce it sufficiently to cause this part of the work to break off. In the case of pins 3/32 inch in diameter, or less, the large amount of cutting surface of the chamfering tool in contact with the wire will cause sufficient torsion and pressure to break off the wire close to the chuck. On small work, the cause is not apparent so that very often the feed of the cutters is reduced in an effort to overcome the difficulty; this, of course, means reduced production.

In the right-hand view is shown a solution of the difficulty without loss of production, providing the cams are made correctly. With this method the chamfering tool follows the cutting-off tool into the stock just far enough to chamfer the rear end of the work and then either dwells or withdraws until the pin has been cut off, when it again moves forward and chamfers the front end of the wire for the next pin. The order of operations for making the pin in a No. 00 Brown & Sharpe automatic screw machine is as follows:

Operation	Number of Revolutions of Stock	Hundredths
Feed stock to stop (lead and front cross-slide cam)	20	13
Cut off, 0.062 inch travel at 0.00045 inch feed (lead and front cross-slide cam)	37	85½
Chamfer, 0.022 inch travel at 0.0004 inch feed (rear cross-slide cam)	55	(34)
Chamfer tool clear stock (rear cross-slide cam)	40	(24½)
Chamfer end of bar, 0.025 inch travel at 0.0005 inch feed (rear cross-slide cam)	46	(29)
Clearance (lead and front cross-slide cam)	3	1½
Total	160	100

The fastest speed of the machine is used; this is 2400 revolutions per minute, or a surface speed of 54 feet per minute. The feed per revolution for the chamfering tool is less than that for the cut-off tool so that it will follow the latter into the stock. The net production resulting from the lay-out is 8100 a day, and the time for one piece, four seconds.

The adoption of this method of making pins allows the front end of the bar to be chamfered after the pin has been separated, thus eliminating the breaking of a large percentage of the work.

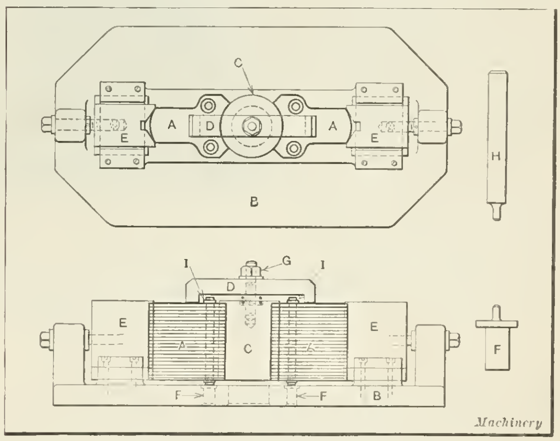
Philadelphia, Pa. HARRY BOYNE

THE "PUSHING STROKE"

I was taught at college, in connection with my drafting course, that one should never push on a drawing pen; that the drawing strokes should always be pulls. And later, when teaching mechanical drawing, I taught the same doctrine. After having had more practical experience, however, I have found that in some cases pushing strokes are better than pulling strokes. This is particularly true where a curve must be accurately traced. On a pushing stroke, it is always possible to see what is being done and the curve can be followed with surprising accuracy, no matter how irregular it may be. If attempted with a pulling stroke, the pen covers the line so that the work cannot be seen. Irregular curves usually follow most curves approximately, but not accurately. So, with the aid of an irregular curve and the pushing stroke, it is a simple matter to follow the curve to be inked with an accuracy that cannot be criticized. N. G. NEAR

FIXTURE FOR RIVETING THIN PLATES

While it is seldom necessary, in shop practice, to use a fixture for riveting, the arrangement shown in the accompanying illustration gave much better results than could have been obtained by the usual method of holding the work while riveting. In this case, a number of thin plates *A* were to be held together by two rivets *I*. They were, therefore, arranged in stacks of the required number, the rivets with their washers were inserted, and then the stacks were placed on the fixture two at a time. The fixture consists of a base *B*, stud *C*, clamp *D*, two sliding jaws *E* with the necessary binding screws, and plugs *F* for supporting the rivets. In use, a stack of plates was placed on each side of the stud *C*, as shown, and the clamp *D* was tightened just enough to hold the plates *A* in place while the sliding jaws *E* were brought up to force all the plates against the stud. The plates were then securely clamped in place by tightening the nut *G*, and the rivets were headed by using the upsetting tool *H* and a hammer in the usual manner.



Fixture for supporting Thin Plates while riveting

F. SERVER

GRINDING NARROW PARALLEL STRIPS

The writer agrees with "A Grinder," in the October number of MACHINERY, that the best grade of wheel is the Norton 38-46 G, 7- by ½-inch face, for he has successfully ground work only 0.008 inch thick with it. But even with this wheel very thin pieces will become heated and warp, because the wheel becomes glazed and polishes, instead of cutting, before one cut is taken over the job. To prevent this glazing, slots ¼ inch deep, 1/8 inch wide, and about 1½ inch apart should

be cut along the cutting edge of the wheel. These slots break up the continuity of the cutting edge and it does not glaze so rapidly. They also act as a fan and keep the work cool while grinding.

Another cause of warping is the attempt to grind a piece that is not flat. A thin piece that is not flat will be pulled down on the magnetic chuck and the wheel pressure will straighten it out. But thicker pieces, when the power is turned off, spring back again into their original form. A piece that is not flat should be peened with a hammer on the low spots; this will draw it down and flatten it. The piece must not be hammered on the high spots, as that is likely to break it. Hammer dents must not be deeper than the amount of stock to be removed. A parallel smaller than the one being ground should be placed on the left-hand side of the piece. This prevents the wheel pressure from pushing the piece off the chuck. Another good stunt is to place the job either diagonally or endwise, so that the wheel will have as short a traverse cut as possible.

The writer has also used slotted wheels, with great success, on internal work. In these days of war orders, labor troubles, and shortage of materials, most manufacturers are experiencing difficulty in obtaining enough wheels of the correct grade and grain. Anyone who has had to use a hard-grade, fine-grain wheel for grinding a high-speed bushing has realized how quickly a wheel will glaze, polish and heat the job, instead of cutting free and fast. This tendency to glaze may be prevented by taking an old hacksaw (one that is of no more use for cutting steel) and cutting about six zigzag shallow slots in the wheel. One of the writer's regular jobs is to grind piston gages, 3.790 inches in diameter, on a No. 22 B. & S. internal grinder. He uses a two-inch spindle fitted with a bushing, so that he can use up the old H and G wheels from the surface grinders. These gages are roughed, then left standing to shrink, and finished on a surface plate. An H or G wheel is used until the job is within 0.0015 inch of finished size, and then a hard fine-grade slotted wheel is put on and the work is finished. The wheel will not glaze and polish the job out of round, but will cut free and at the same time give that "mirror" finish so much desired in gages.

Detroit, Mich. R. Drew, Jr.

EPICYCLIC GEAR PROBLEM—CORRECTION

Permit me to call your attention to an error in the solution of the problem in epicyclic gearing given in the December number. The correct analysis in chart form is as follows:

	M	*N*	*P*	*A*
Wheels locked......	+ 50	+ 50	+ 50	+ 50
Arm stationary and *M* returned to original position..	— 50	$+\frac{120}{90}\times 50$	$-\frac{120}{40}\times 50$	0
Arm stationary and *M* turned thirty-six times, as shown by arrow *C*..........	— 36	$+\frac{120}{90}\times 36$	$-\frac{120}{40}\times 36$	0
	— 36	+ 164 2/3	— 208	+ 50

The arm *A* and gear *M* are moving in opposite directions with velocities of 50 and 36 R. P. M., respectively. This gives 86 R. P. M. as the rate of the gear *M* relative to arm *A*, while the statement published gives it as 36 R. P. M. only. The gear *M* makes 164 2/3 R. P. M. in the direction of the arrow *B*, while *P* makes 208 R. P. M. in the direction of arrow *C* in the illustration appearing in the December number.

Fitchburg, Mass. V. Charushin

A POINT IN GUARD DESIGN

One of the strongest arguments used against the guarding of belts and pulleys is the inconvenience caused by the guard, which has a tendency to curtail production. This point is especially noticeable when the guards are so arranged as to protect cone pulleys and shifting belts. It is possible, however, to arrange guards for cone pulleys so that the belt may be shifted as easily as if the guards were not present, and yet the opening and closing can be made so convenient that the operator can perform the movements almost without thinking and with practically no loss of time. Fig. 1 shows the application of a guard to the standard column shaper in which the cone pulley is on the side rather low down in a somewhat dangerous position for anyone who may be obliged to pass the moving belt. The guard shown is made of ½-inch pipe and fittings, and the two flanges screwed to the column are the only means of support. Two tees with the threads drilled out are hung from the flanges, and by this means it is possible to swing the entire guard toward the rear out of the way.

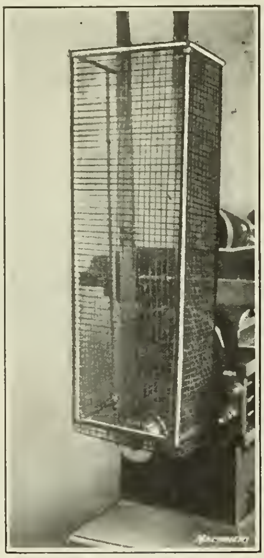


Fig. 1. Guard for Belt on Column Shaper

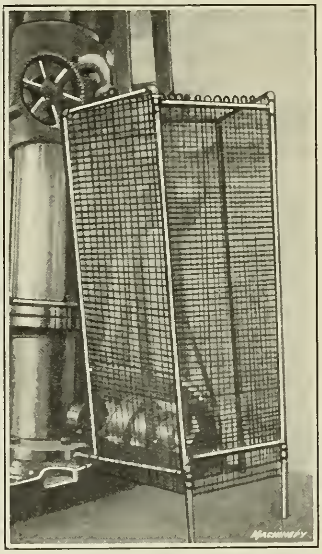


Fig. 2. Guard for Belt on Radial Drilling Machine

Fig. 2 shows a guard for the 4-inch belt of a radial drilling machine which is constructed in much the same manner. The panel to the left is the only stationary one, and the other two swing on the drilled out tees. Support is given by one flange on the base of the machine and the extension of one pipe which is set into the concrete floor. The guard is shown partly open and two legs may be seen resting on the floor, which provision is made on account of the extra size and weight. These two guards are typical of what might be done toward combining protection and convenience at a minimum cost. They pass the rigid New York state requirements and, furthermore, offer no obstruction in the way of keeping the floor clean about the machine.

Middletown, N. Y. Donald A. Hampson

WORKING GERMAN SILVER

In the How and Why section of the November number of Machinery, a correspondent says that he has had trouble annealing German silver, and the matter was referred to readers who have had experience with this metal. The best grade of German silver consists of four parts copper, two parts nickel, and two parts zinc, and is the best alloy for table silverware. In late years, many alloys bearing the name German silver have been placed on the market; and while many stand the test of common manufacturing operations, now and then trouble like that mentioned is experienced. While the trouble may be in the annealing, the writer would suggest that first of all the die used in the first drawing operation be examined. The edge of this die should be kept just as smooth as possible by polishing it at least every two or three thousand pieces with the finest emery or crocus cloth; the die should then be washed with gasoline or blown out with compressed air, so that not the slightest bit of stone will be left in it.

The gage of the metal being worked is not given, but any German silver under 0.045 inch should draw and anneal without much trouble if worked under good conditions. When the edge of the drawing die becomes rough from long use, or insufficient drawing solution is used, or there are dirt, steel chips, etc., in the solution, tiny scratches will appear on the side of the shell as it is drawn over the edge of the die. These scratches will become deeper until the edge is stoned off and polished. When this work goes to the annealing oven and the heat expands the metal, these scratches slit or crack open. Unless the shell is very deep or of peculiar shape, a shell of this size can and should be drawn in one operation. The writer has drawn German silver shells four inches deep and three inches in diameter, with flaring sides and bulging bottom, in one draw.

If a shell drawn under ideal conditions, with perfectly smooth sides, is brought red hot from the oven and immersed in cold or running water, the sides may crack, as the cold water chills the metal too quickly. The shells should be cooled in warm water or in the air. In annealing work of this kind, the following method has been used with success. Bring the furnace to about 1500 degrees F., then shut off all fuel and the blower, and fill the furnace with the work, which has been placed in pans or trays made for the purpose. As the furnace cannot become hotter, there is no chance whatever of the work burning; and as it is slowly cooling, the shells will heat and cool with the furnace, and thus anneal perfectly.

Cracks may also be caused by drawing the shells too dry or by the use of a poor lubricant; try good, clean lard oil and use plenty of it—if there is virtue in lard oil, get it. A solution of soap, warm water and lard oil may also be tried. This solution is formed by dissolving common hard washing soap in warm water and then adding an equal quantity of lard oil. If the cracking continues, the shell should be nickel-plated before it is annealed, just a slight nickel wash; brass plating is just as good. The writer sees no reason why this trouble should not be stopped at once, and thinks that if a good grade of alloy, say Coe brass branch German silver, is used under these conditions, there will be no more trouble with the cracks.

There is a hydraulic process of shell drawing in which any shell can be drawn in one operation. As the principle is so different from power-press shell drawing, the required stretch of the metal being distributed evenly over the entire area of the blank, a metal of very low tensile strength can successfully be drawn by this process.

Pittsfield, Mass. G. R. Smith

SOLVING EQUATION FOR SPIRAL GEARING

On page 346 of Machinery for December, the following equation was given:

$$R \sec \alpha + \operatorname{cosec} \alpha = k,$$

in which $R = 3$ and $k = 5.714$, and in which α is known to be in the neighborhood of 45 degrees. The equation was solved by the method of repeated trials, and it was found that α was equal to 46 degrees, 6 minutes. The above equation can also be solved in a simpler and somewhat more elegant way. Let:

$$\alpha = 45 \text{ degrees} + \delta$$

or, in radians:

$$\alpha = \frac{\pi}{4} + \delta$$

Then,

$$\sin \alpha = \sin \frac{\pi}{4} \cos \delta + \cos \frac{\pi}{4} \sin \delta$$

and

$$\cos \alpha = \cos \frac{\pi}{4} \cos \delta + \sin \frac{\pi}{4} \sin \delta$$

Now δ is a small angle. Consequently, we can write, without introducing an appreciable error:

$$\sin \delta = \delta, \text{ and } \cos \delta = 1,$$

and, furthermore,

$$\sin \frac{\pi}{4} = \cos \frac{\pi}{4} = \frac{1}{\sqrt{2}}$$

Then,

$$\sin \alpha = \frac{1+\delta}{\sqrt{2}}, \text{ and } \cos \alpha = \frac{1-\delta}{\sqrt{2}},$$

or, using the reciprocals:

$$\operatorname{cosec} \alpha = \frac{\sqrt{2}}{1+\delta}, \text{ and } \sec \alpha = \frac{\sqrt{2}}{1-\delta}$$

Substituting for α in the original equation:

$$\frac{R\sqrt{2}}{1-\delta} + \frac{\sqrt{2}}{1+\delta} = k$$

and, simplifying,

$$\sqrt{2}\,(R + R\delta + 1 - \delta) = k\,(1 - \delta^2)$$

By substituting the given values and simplifying:

$$\delta = 0.0201 - 2.0201\,\delta^2$$

But δ is small and, hence, δ^2 is still smaller, so that $\delta' = 0.0201$ must be very near the value of δ. By substituting δ' for δ in the second member of the right-hand side, we have:

$$\delta = 0.0201 - 2.0201 \times 0.0201^2 = 0.0192 \text{ radian},$$

from which $\delta =$ 1 degree, 6 minutes, and $\alpha = 46$ degrees, 6 minutes, which is the same value as obtained by the other method.

Chicago, Ill. Nikola Trbojevich

The above solution is unquestionably more mathematical and interesting from the mathematician's point of view than the trial-and-error method, but it is doubtful if it is to be recommended for practical purposes, for two reasons: In the first place, the method is not as easily applied by a man who is not well versed in mathematics as is the more simple trial-and-error method; and, in the second place, as far as the trained mathematician is concerned, it is doubtful if he can save any time by the proposed method, because the arithmetical work of solving the equation, as outlined above, is probably greater than the arithmetical work involved in making about three or, at most, four trial solutions, which is all that a mathematically trained man would need. Nevertheless, the above method should prove interesting to all students of mathematics, showing how, by means of mathematical formulas, a simple expression can be obtained for solving an equation which, on the face of it, appears impossible of a simple mathematical solution.—Editor.

BORING STRAIGHT HOLES ON A WORN LATHE

When the writer was passing through a repair shop recently, he saw a good lathe man boring a hole that tapered because the ways or vees of the lathe were not in line with the head. Had the man turned his boring tool upside down and bored from the other side, with the machine running the same, he would have obtained a straight hole. This is due to the fact that in boring the tool approaches the center line as it feeds into the hole; therefore, when the tool is turned over and used at the back of the hole, it will recede from the center as it feeds along. Consequently, if, because of a worn spindle, ways or vees, or for some other cause, a tool approaches the center when a hole is being bored, it will move a corresponding distance from the center when it is turned, and the hole is rebored and will thus produce a straight hole. Should the holes bored be larger at the back, however, the problem is more difficult. While the same result will be obtained by turning the tool, care must be exercised and stock should be left for cleaning up.

Lancaster, N. Y. Edward Bingemann

"LAPPING" THREADS WITH ACID

It often happens that after an important screw has been cut, hardened, and lapped to size, it will still fit too tight in places. This may be caused by unequal expansion and contraction during the hardening process, or it may be through some inaccuracy in lapping; whatever the cause, the fact remains that in hardened screws this trouble is the rule rather than the exception. In some cases it will be of small consequence, and a wrench may be used to force the screw; but in gage screws, jig screws, adjusting screws, and in all high-grade work it becomes a troublesome matter. This evil may be remedied, however, by cleaning the screw in hot soda water, then dipping it for about a minute in a bath of nitric acid, and on its removal immersing it in water. After it is dried, it should be tried in the tapped hole. If the screw is still too large, the process should be repeated until the desired fit is obtained. This method provides a very good "acid lap" that will be found convenient for many purposes in and about the shop.

Plainfield, N. J. J. B. Murphy

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

STRAIGHTENING PIPE

W. H. J.—I am working in the oil field and often need a pipe-straightening machine to straighten pipe of all sizes up to 10 and 12 inches diameter. One of our chief troubles is bent pipe. Can you offer any help?

A.—We know of no means for straightening bent pipe other than pipe bending machines, which may, of course, be employed for taking the kinks out of bent pipes. The pipe bending machine, however, cannot be used for field work on such large sizes as 10 or 12 inches. The only means we can suggest for straightening large pipe is the lathe, lever or screw and test method commonly employed in straightening shafting. The question is referred to readers for suggestions.

LETTERING ON DRAWINGS

D. W. B.—The question of conventions and lettering to be used on drawings has come up, and I would like to know if there is some definite form and style adopted as a standard of practice. One of the mooted questions is the use of small letters in italic lower case, or all caps. Some argue that the small letter is more rapidly made and is easier to form, while others claim that legends in all caps are used more commonly in mechanical drawing and in architectural and furniture designs.

A.—It is generally conceded that legends on drawings can be made neatly and rapidly in italic lower case. The practice, however, is by no means uniform, and small caps are often used by draftsmen. Simplicity should be the keynote in all mechanical drawings, and the use of ornate headings and lettering generally should be tabooed. Whether or not small caps or italic lower case are to be preferred for legends is a question that has not been decided by general use.

PLANED AND BORED CROSSHEAD GUIDES

R. T. R.—Will you please explain the advantages and disadvantages of the two types of crosshead guides shown in Figs. 1 and 2, and tell why the style shown in Fig. 1 is the general type of guide used on locomotives, and why that shown in Fig. 2 is generally used on stationary engines? Is the type shown in Fig. 2 a cheaper guide for the reason that it may be machined when the cylinder is bored?

A.—The type of crosshead and guide shown in Fig. 2 is cheaper than that shown in Fig. 1 for the reason that the guides may be bored when the cylinder is bored and the crosshead may be turned in a lathe instead of being planed. The bored type of crosshead guide is not, however, suitable for locomotive use. In the first place, the guide and frame cannot be cast integral as is common practice in stationary steam engine construction. In the second place, the crossheads of a locomotive need to be restrained in a vertical plane because

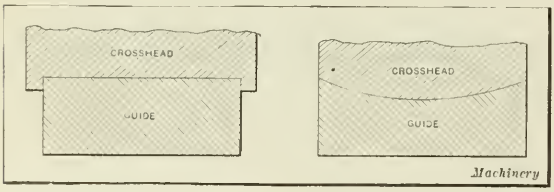


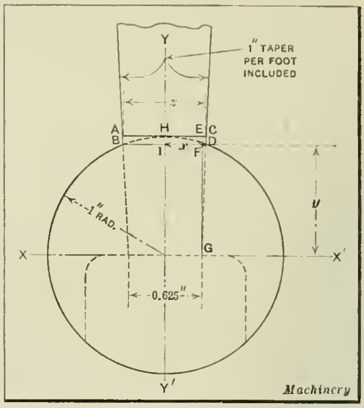
Fig. 1. Planed Crosshead Guide   Fig. 2. Bored Crosshead Guide

of the turning moments set up in the piston, crosshead and connecting-rod due to uneven track, curves and loose connections. These turning moments are negligible in a stationary engine and are restrained by the connecting-rod and crank-pin.

A GEOMETRICAL PROBLEM

W. A. W.—Referring to the illustration, please show process of solution in finding the values of z and y.

A.—Draw AC parallel to BD and tangent to the circle; draw GE parallel to the center line, and consequently perpendicular to AC and BD. Since GE = the radius = 1 inch, and since a taper of 1 inch per foot = 1/12 inch per inch, $EC = 1/2 \times 1/12 = 1/24$ inch, and $HC = 1/2 \times 5/8 + 1/24 = 17/48$ inch. We now know (or can find) all the parts of the triangle EGC, and we know, therefore, the angles of the similar triangle FGD, but we know nothing in regard to its sides. Hence, neither FD nor FG can be found by trigonometry or geometry; but these sides can be found by applying certain principles of analytical geometry. The equation of a straight line through a point is



A Geometrical Problem

$y = mx + b$, where y = ordinate, x = abcissa of point; m = tangent of the angle which the line makes with the X axis, and b = y intercept. Thus, the equation of the line GC through point D whose coordinates are x and y with reference to the axes X-X[1] and Y-Y[1] is $y = 24x - 7.5$, and the equation of the circle is $x^2 + y^2 = 1$. Making these two equations simultaneous and substituting the value of y from the first equation in the second equation, we have $2308x^2 - 1440x + 221 = 0$, from which $x = id = 0.351508$ inch. Substituting this value of x in the first equation, $y = 24 \times 0.351508 - 7.5 = 0.93619$ inch $= GF$. Therefore, $z = BD = 2x = 2 \times 0.351508 = 0.70302$ inch. J. J.

INTERPOLATING TO SECONDS

H. J. L.—Suppose the natural tangent is 0.63154; how can I find the angle in degrees, minutes and seconds, using the table in MACHINERY'S HANDBOOK? Also, in using a sine bar and getting a dimension, how can I get the exact angle carried out into seconds?

A.—Referring to page 188 of MACHINERY'S HANDBOOK, the angle whose tangent is 0.63154 is seen to lie between 32 degrees, 16 minutes (the tangent of which is 0.63136) and 32 degrees, 17 minutes (the tangent of which is 0.63177). The difference between these two values is 0.00041; the difference between the tangent of the smaller angle and the given tangent is 0.00018; and the difference between the two angles in the table is 1 minute = 60 seconds. Assume that the following proportion is true, as it will be for practical purposes,

$$x : 60 = 0.00018 : 0.00041, \text{ from which } x = \frac{60 \times 0.00018}{0.00041} = 26$$

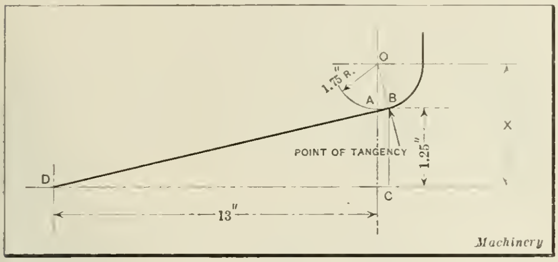
inches. Therefore, the rule is: Find two consecutive functions in the table, one of which is greater and the other less than the given function, and take their difference. Find the difference between the given function and the function corresponding to the smaller of the two angles; multiply this difference by 60 and divide the product by the difference previously found. The quotient will be the number of seconds sought.

It is not possible to find an angle correct to seconds by using the sine bar, and such extreme accuracy is entirely unnecessary in practical work. If the sine bar and the measurements are sufficiently accurate to determine the angle to a single minute, the result may be considered refined enough for practical purposes. J. J.

PROBLEM IN DESIGNING DIES

F. A. R.—The illustration shows a problem in connection with the designing of dies for forming a sheet-metal piece. Please show how to find the distance X.

A.—Since the right triangles BOA and BDC are similar, $\frac{AB}{OB} = \frac{BC}{DB}$. Let $AB = y$; then $DC = 13 + y$, and $DB = \sqrt{(13 + y)^2 + \left(\frac{5}{4}\right)^2}$, since $1.25 = \frac{5}{4}$. $OB = 1.75 = \frac{7}{4}$. Sub-



Problem in designing Dies

stituting these values in the above proportion, $\frac{y}{\frac{7}{4}} = \frac{4y}{7} = \frac{\frac{5}{4}}{\sqrt{(13 + y)^2 + \left(\frac{5}{4}\right)^2}}$. Squaring both sides of this equation and clearing of fractions, $256y^4 + 6656y^3 + 43664y^2 - 1225 = 0$. Solving this equation by Horner's method, $y = 0.165411$. $OA = \sqrt{1.75^2 - 0.16541^2} = 1.74217$. Therefore, $X = 1.25 + 1.74217 = 2.99217$ inches. To prove that the value of y is correct, compute DB, obtaining $\sqrt{13.16541^2 + 1.25^2} = 13.2246$. Then, in the above proportion, $\frac{AB}{OB} = \frac{0.16541}{1.75} = 0.09452$, and $\frac{BC}{DB} = \frac{1.25}{13.2246} = 0.09452$. J. J.

WHY A SAFETY VALVE IS IN EQUILIBRIUM

C. M. G.—My text-book on mechanics states that a couple produces or tends to produce rotation only, and that it can be balanced only by another couple that tends to rotate the body in the opposite direction. How can this statement be reconciled with the forces acting on a safety-valve lever? Here the steam pressure acts upward and the weight acts downward, thus forming a couple; where is the other couple?

A.—You have not taken into account all the forces acting on the lever. Referring to the illustration, the force P acting upward represents the steam pressure, and the force W acting downward represents the weight. The lever would turn under the action of these two forces if it were not for the pin O. As the bar presses against the under side of this, the pin reacts downward an equal amount; this force is represented by R. We may imagine that the pin O is removed and that equilibrium is maintained by means of a force R acting on top of the lever in a vertical line through the center of the pin. Then, force P must equal $R + W$, since it supports both W and R, both acting downward. P may, therefore, be considered as made up of two forces, one equal to R and the other equal to W, and both acting upward. This force R combined with the downward force R forms a couple, the arm of which is OA, and which tends to turn the bar counter-clockwise; W combined with the force (weight) W forms another and equal couple, the arm of which is AB, and which tends to turn the bar clockwise; the two couples thus neutralize each other. Taking an actual case, suppose $W = 28$ pounds, $OA = 4$ inches, and $AB = 38$ inches. Then, taking the center of moments at A, $R \times 4 = 28 \times 38$, or $R = 266$ pounds. Taking the center of moments at O, $P \times 4 = 28 \times (38 + 4)$, or $P = 294$ pounds $= 266 + 28 = R + W$, as it should. Your assumption of a couple formed by P and W is wrong, because a couple consists of two equal parallel and opposite forces, and P is greater than W. Note that the weight of the bar (lever) has been neglected. J. J.

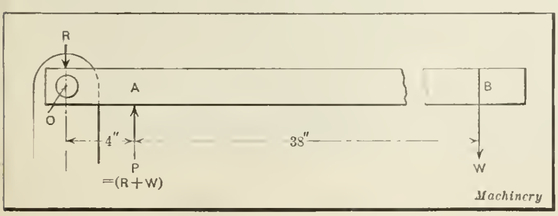
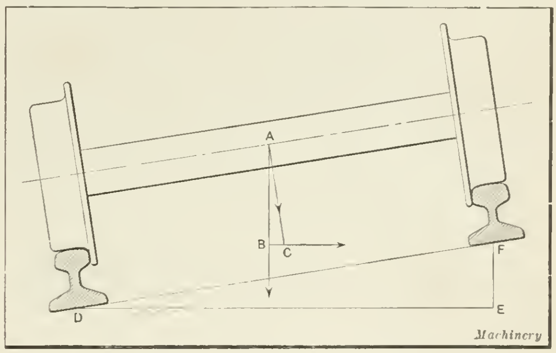


Diagram showing Principle of Safety Valve

ELEVATION OF OUTER RAIL ON A RAILWAY CURVE

B. H. H.—I notice that on all railway curves the outer rail is higher than the inner rail, and I am told that this counteracts the centrifugal force. Will you please explain? Also, what effect does the weight of the train have in determining the amount of elevation?

A.—In the September number of MACHINERY, page 63, it was shown that when a body moves in a circle, the centrifugal force is expressed by the formula $F = \frac{Wv^2}{gR}$, in which $F =$ centrifugal force, in pounds; $W =$ weight of moving body, in pounds; v = velocity of moving body, in feet per second; $g = 32.16$; and $R =$ radius of circle or curve, in feet. Now, when a train goes around a curve, it is deflected from the straight line in which it would ordinarily move and is kept to the rails by reason of the flanges of the outer wheels pressing against the outer rail; this pressure is the centripetal force, and acts in the direction BC (see illustration). The weight on a pair of wheels acts vertically downward in the direction AB; the resultant of these two forces is represented by AC. When one of the rails is elevated until the line DF, which is parallel to a line touching the tops of the rails, becomes perpendicular to the line of action of the resultant AC, the centripetal force BC will be exactly balanced by the tendency of the wheels and their load to slide in the direction FD, and there will be no pressure between the flange and



Elevation of Outer Rail on Curve

the rail. Since the triangles ABC and DEF are similar, $AB:BC = DE:EF$, or $W:F = b:h$, when $b = DE$ and $h = EF$; whence, $h = \frac{Fb}{W}$. Substituting the value of F given above, $h = \frac{Wv^2}{gR} \times \frac{b}{W} = \frac{bv^2}{gR}$. If b is in inches, h is also in inches. Note that the weight of the train has no effect on the elevation of the rail. Suppose the train is running fifty miles per hour around an eight-degree curve, and that b, or the distance from center to center of rails, is 4 feet, 8.5 inches, or 56.5 inches.

The elevation is then $h = \frac{56.5\left(\frac{50 \times 5280}{60 \times 60}\right)^2}{32.16 \times 716.2} = 13.2$ inches.

The radius of an eight-degree curve is 716.2 feet. J. J.

LOCATING AND BORING HOLES IN A SINE BAR

C. W. H.—I read with interest the article in the October number by Donald Baker on sine bars. I know comparatively little about precise tool work, but venture to ask the question why, instead of boring the soft steel plugs in the lathe, the bar was not set up in the milling machine vise and the holes bored with a vertical milling attachment, using the lead-screw to set off the distance of 5 inches. Would not this method be accurate in locating the holes within limits of 0.0001 inch?

Answered by Donald Baker, Montreal, Canada

A.—It is possible to locate and bore the holes in the sine bar on a milling machine by clamping the bar in a vise and using the vertical attachment and the feed-screws; or it might be clamped to the table or on an angle-plate. But in the case of holding in a vise, for instance, extreme care must be taken to insure that the vise is set up perfectly square in all directions with the spindle. The lead-screw of the ordinary milling machine cannot be depended upon for precision work, and to secure accurate spacing with one would be more or less of a cut-and-try method. At best I would not expect to get results much closer than $\pm$ 0.0003 inch. On the other hand, if we button up a soft plug, as described, we have fewer difficulties to contend with. The flat sides of the bar having been ground accurate and the two edges rough-ground, the buttons are put in place and located, using Johanssen gages, if at hand. Micrometers may be depended upon if they are correctly and carefully used. No special pains need be taken to set the buttons closer than 0.001 or 0.002 inch of parallel with the edges of the bar. The next step is to true up a lathe faceplate and strap the sine bar in place and indicate one of the buttons carefully. The final indicating is done after the bar has been securely clamped and the lathe is running at the correct boring speed. This precaution is essential, for if the lathe is out of balance, the truth of the boring operation will be affected. After both holes have been bored, the buttons are inserted and finally inspected for the distance apart. If the distance apart is found correct, the grinding of the edges follows, which is done on the surface grinder, setting up the bar on an accurate angle-plate and using an indicator or parallels to set the buttons level. No matter what method is employed, however, the human element is an important factor in bringing work of this kind to a successful conclusion.

THE RECOIL OF A GUN

E. F. R.—I enclose a clipping regarding the "kick" of a gun. Will you please show me how the recoil energy is calculated from the formula? Please note that the author states that the recoil energy of a 12-bore shotgun is nearly twice that of the army rifle, and that a trapshooter will take the kick without a murmur, while a soldier is sensitive to the kick of a rifle and the limit is 300 rounds a day. Is his explanation of why this is so reasonable?

A.—The formula mentioned is $vW = Vw + 4700W'$, in which v is the recoil velocity of the gun, and V is the muzzle velocity of the bullet, both in foot-seconds; W is the weight of the gun, w is the weight of the bullet, and W' is the weight of the charge, all in grains. The formula applies only to the U. S. army rifle; for other weapons and ammunition, the constant, 4700, would need to be changed. According to the Encyclopedia Britannica, for the present U. S. army rifle, $W = 8\frac{1}{2}$ pounds, $V = 2600$ foot-seconds, $w = 150$ grains, and $W' = 50$ grains. Substituting these values in the above formula,

$$v = \frac{2600 \times 150 + 4700 \times 50}{8.5 \times 7000} = 10.5 \text{ foot-seconds.}$$

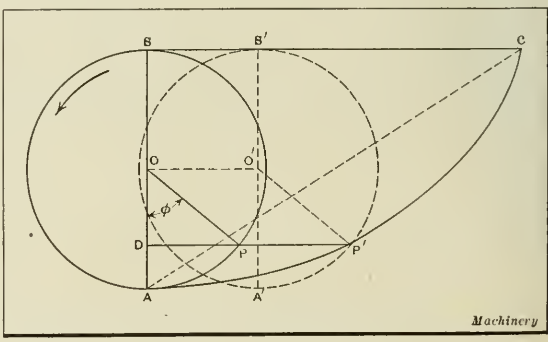
The recoil energy is found by substituting the values of v and W in the expression for kinetic energy, $\frac{Wv^2}{2g} = \frac{8.5 \times 10.5^2}{2 \times 32.16} = 14.6$ foot-pounds.

Regarding the explanation as to why the kick of a shotgun is not felt so much as the kick of a rifle, it must be remembered that the force of a blow depends largely on the distance through which the moving body passes in coming to rest; the shorter the distance, the greater the blow. According to the author: "The shotgun is fired with the muscles tense and the body moving—in other words, the shot is taken by a set of tense springs; the rifle is fired with the muscles relaxed, fired deliberately. The shotgun has also a straighter stock, thus bringing the line of direction nearer to the direction of recoil." Suppose that the gun were placed in a vertical position with the stock resting on a block of wood that, in turn, rested on the platform of a scale; the force of the recoil could then be measured. Suppose, further, that a set of springs (or some yielding substance) were placed between the block of wood and the scale platform; the force of the recoil would then be found to be considerably less. Assuming that the author's statements regarding the manner of firing are right, the stock of the rifle rests more firmly against the bones of the shoulder than is the case when the shotgun is fired; consequently, even though the recoil energy of the shotgun may be greater, the gun moves through a greater distance and the resulting kick may be less than with a rifle. The writer is inclined to doubt that a trapshooter will ever fire 300 rounds in a day. J. J.

LINE OF QUICKEST DESCENT

S. I. N.—Suppose that a ball is to roll without friction from a point C to a point A; what must be its path in order to get to A in the shortest time? I claim that the path will be a straight line from C to A, because the velocity of the ball when it gets to A will be the same, whatever path it takes, and a straight line is the shortest distance between two points; but a friend tells me that if the ball follows a certain curved path, it will reach A more quickly. If this is so, what is the curve?

A.—If the ball rolls from C to A along the straight inclined plane CA, the acceleration will be uniform throughout the entire distance. If, however, the ball takes a curved path, such as $CP'A$, the acceleration will be variable, and a velocity that nearly approaches the final velocity at A will be attained for some time before the ball reaches A. It will thus be apparent that there must be some curve that will take the ball from C to A in a shorter time than if it follows some other path. The curve is called the brachistochrone, a word derived from the Greek and meaning shortest time. It is commonly called the cycloid, and is the curve that would be traced by a point on the circumference of a circle rolling on a straight line without slipping. Thus, suppose that a circle having the diameter BA rolls from B toward C, turning in the direction indicated by the arrow; the path (locus) of the point A will be the half cycloid $AP'C$, and BC will be equal in length to half the circumference of the circle. For any position of the circle, as B', the center will be at O'; the point A will be at P'; and $BB' =$ arc $AP = OO'$. To construct the cycloid, divide the semicircle APB into any convenient number of parts; suppose that one of these parts is AP. Through P draw DP' parallel to BC; draw OO', and make it equal in length to the arc AP. With O' as a center and OB as a radius, describe a circle cutting DP' in P'. Note that angle $A'O'P' = AOP$ and that $POO'P'$ is a parallelogram; hence, $PP' = OO' =$ arc AP; $DP = r \times \sin\phi$; and $DA = r\,(1 - \cos\phi)$. Also, $DP' = r\,(\sin\phi + \phi)$, in which ϕ is the angle AOP, in radians. Therefore, by using a table of trigonometric functions, the values of DA and DP' may be readily calculated for any angle desired. J. J.



Curve of Quickest Descent

AJAX SCRAP RECLAIMING ROLLS

The waste represented by the scrap heap may be an important item especially at the present time owing to the relatively high cost of materials. When it is realized that practically all of the large railroads dismantle from a few hundred to several thousand cars annually and that there are many companies in other lines of business that accumulate thousands of tons of scrap yearly, the importance of reclaiming at least a certain percentage of this material is evident. In most cases it would not be considered practicable to install and operate a regular rolling mill but a considerable saving could be effected by the use of reclaiming rolls such as are illustrated in Figs. 1 and 2 which show two views of a recent design that has been brought out by the Ajax Mfg. Co., Cleveland, Ohio. This machine is designed for reclaiming such scrap as arch bars, brake staffs, brake levers, tension rods, scrap ends from forging operations, etc., by heating the scrap and re-rolling it into bars of stock from which bolts, car fittings, or similar parts may be made.

In general design the reclaiming rolls resemble very closely a modern rolling mill. The working parts are mounted on a massive cast-iron base which is cast in one piece. There are two sets of rolls which are "three-high," where the rolling is done. A detailed view of the rolls and housings is shown in Fig. 3. The cylindical surface of the rolls containing the grooves is 12 inches in diameter and 40 inches long. By using the two sets of three rolls each, it is possible to roll all standard sizes of round bar stock up to 1¾ inch in diameter. Round or square scrap measuring 2½ inches in diameter or width, or scrap of an equivalent section, represents the largest size that may be used. The widest flat stock that can be rolled is 4 inches, provided the thickness is ¾ inch or more; 3¼ inches is the maximum width for stock ½ inch thick, and 2½ inches the maximum width for stock ¼ inch thick. Two sets of rolls, or a total of six rolls, are furnished with each standard equipment; these rolls will be grooved to suit the requirements of the user. Additional rolls can be obtained at any time for any size stock.

The rolls are made of special rolled steel castings. The bearings are of liberal proportions and bronze bushed; they are split to provide adjustment for wear. The roll shafts have independent adjustment horizontally and vertically except the middle shaft which does not require vertical adjustment. The vertical adjustment of the upper roll is obtained by means of studs and set-screws on top of the housing. For the bottom roll the vertical adjustment is obtained by means of taper wedges on which the bearings rest; these wedges are operated by set-screws that project from each side of the housing. Horizontal adjustment of the rolls to align the grooves is obtained by means of bronze taper wedges located between the housings and the shoulders of the rolls at the bearings. These wedges may be seen at the extreme left in Fig. 3. The adjustments referred to do not interfere in any way with the driving of the rolls, because the "crabs" connecting the various units of the shaft do not need to be in accurate alignment.

The main driving pinions are of forged steel and have herringbone teeth cut from the solid. These pinions are mounted in separate housings as illustrated to the right in Fig. 3. The grooves in the rolls are shaped according to the best rolling mill practice. The "break-down" grooves for round stock

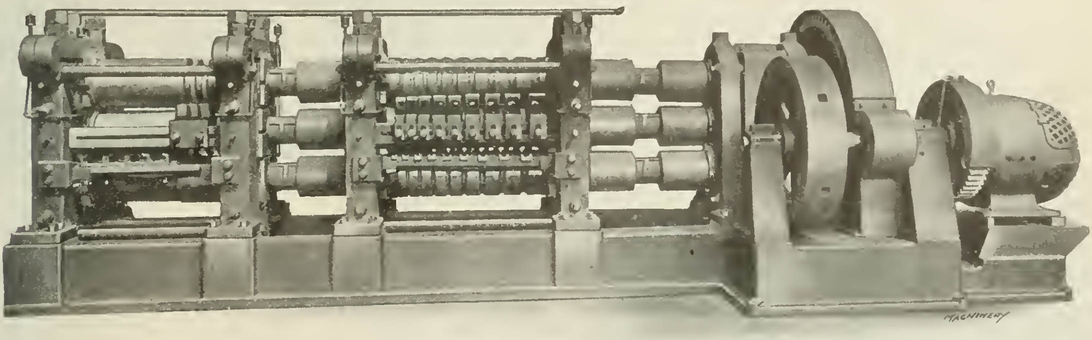


Fig. 1. Reclaiming Rolls set up to roll Round Stock in One Set of Housings and Flat Stock in Other Set

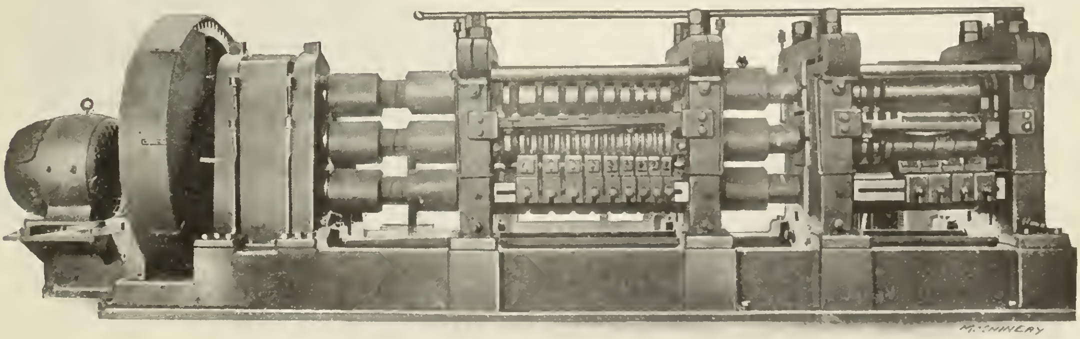


Fig. 2. Opposite Side of Ajax Scrap Reclaiming Rolls shown in Fig. 1

are oval or of "gothic" design. The number of grooves in a set of rolls is varied according to the size of the stock. The best results have been obtained by having the heavy break-down grooves in one set of rolls and the smaller and finishing grooves in the other set. By doing the heavy break-down work in one set of rolls and the lighter finishing work in the other set, the fine adjustment necessary for the finished product can be maintained.

Both the entering and receiving guides (see Fig. 4) are individual units for each groove and can be adjusted to suit any spacing of the grooves. The bracket which holds the receiving guides is also adjustable. The lower guides shown in Fig. 4 are entering guides for oval stock and lead into the round grooves in the rolls. The entering guides for stock entering the oval or gothic grooves, are similar to the entering guides for the round grooves except that they are cast in one piece and have square holes for the bar to pass through so that they do not guide the stock as closely. These reclaiming rolls are equipped either with motor or belt drive. Special care has been taken to cover all gears, and projecting screws at the shaft connections have been avoided.

The machine described in the foregoing is the smaller of two sizes that have been placed on the market. The larger size is similar in design and differs only in regard to capacity. The roll shafts of the larger machine are 14 inches in diameter and 44 inches long on the working surface. These larger rolls will reduce material having a diameter or width of 3½ inches, or scrap of equal section. The maximum widths of flat stock that can be rolled are as follows: for a thickness of ¾ inch,

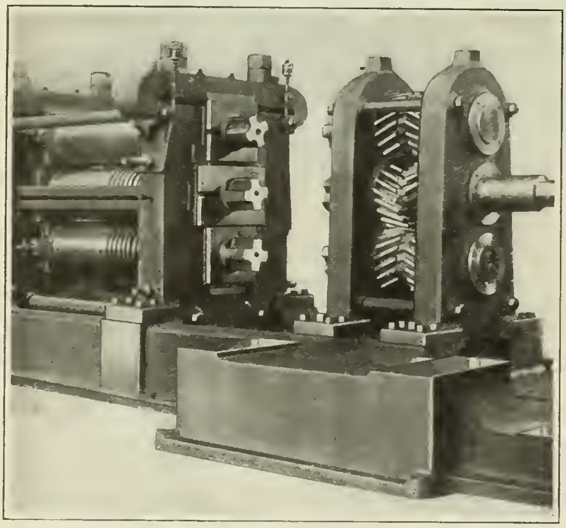


Fig. 3. Close View of Herringbone Driving Pinions, Housings, Bearings and Rolls

5 inches wide; for a thickness of ½ inch, 4 inches wide; for a thickness of ¼ inch, 3 inches wide. Round scrap to be passed through these rolls should be reasonably straight and should be cut to lengths which will roll to the required length. When scrap has holes drilled through it a very good product has been obtained by rolling it at a welding heat. Scrap such as arch bars, brake levers, and other wide flat stock must be split before rolling. This may be done either hot or cold in a splitting shear or splitting blades may be made for two of the rolls on the reclaiming rolls.

The saving that may be effected by the use of these reclaiming rolls is indicated by the following figures. These figures, however, apply to rolls of an earlier design than those described in the foregoing and which lack several advantages of the latest design. These figures are also based on the prices of scrap, stock bar, labor, etc., which prevailed before the war. In one case the average output per day was 5 tons, which was valued at $150. The value of the scrap iron was $75, making the gross earning per day, $75. Deducting a total operating cost per day of $35.70 leaves a net earning of $39.30. The average output includes slack times when the rolls were idle.

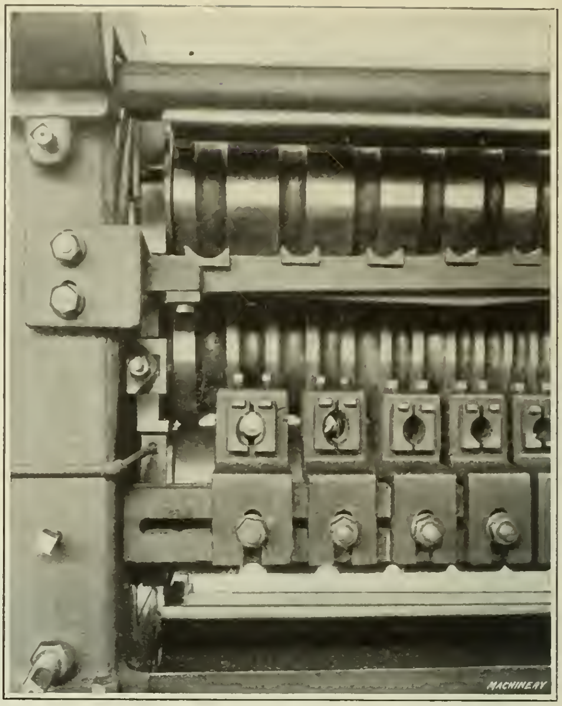


Fig. 4. Close View of Rolls for Round Stock, Guides and Guide-holders

On one of the eastern railroads re-rolled stock is produced at a cost of $3.75 per ton. Reports from various users of these reclaiming rolls representing different periods of time within three years, indicate that the average output of these rolls is about one ton per hour, working time. The product is claimed to equal hot-rolled bar stock.

BICKETT AUTOMATIC GEAR AND RACK PLANER

The automatic gear and rack planer illustrated herewith is a recent product of the Bickett Machine & Mfg. Co., Cincinnati, Ohio. The operation of this machine is somewhat similar in principle to that of a crank shaper in that it has a ram operated by a crank which carries the cutting tools back and forth across the work, but its most distinctive feature is that two tools are used. One of these tools operates on the forward stroke and the other on the return stroke of the ram. The cutter operating on the forward stroke is the roughing cutter. It has corrugated sides and may be forced into the metal at the maximum speed and depth of cut that is practicable with

Bickett No. 3 Automatic Gear and Rack Planer

the best high-speed steel; cuts of 1/32 inch on cast iron are not unusual. The other cutter, which operates on the return stroke, is ground accurately to the exact contour of the gear tooth and takes light finishing cuts.

In order to insure accuracy and prevent chatter when working at high speeds, the work spindle is mounted directly upon a massive bed. This spindle is 4 inches in diameter, 16 inches long, and has a No. 12 B. & S. taper hole. The ram carriage is also mounted directly upon the bed and the ram has a metal-to-metal contact throughout the entire length of its working surface. The in-feed mechanism for the cutter is so designed that the rate of feed gradually diminishes as the cutter approaches the total depth for the tooth space. The cut is heavy at first and then is gradually reduced until the proper depth has been reached, when there is a dwell of the ram carriage for the finishing cut. This diminishing feed prevents uneven strains and gives a fine finish to the tooth surfaces. The cutter ram has a variety of speed changes controlled by a quick-change gear-box and a regulating lever.

The time required to index the work and return the ram carriage to the cutting position is only 1½ second for any width of gear. The clearance required for the cutting tool at the beginning of the cut is only 1/64 inch. A general idea of the performance of this machine will be obtained from the accompanying table, which gives the time required to cut a

TIME REQUIRED FOR CUTTING GEARS OF DIFFERENT PITCHES

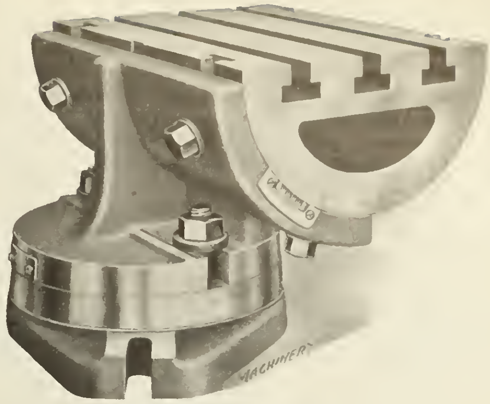
Diametral Pitch	Number of Teeth	Width of Face, Inches	Strokes of Ram Required to Cut Tooth	Speed of Ram, Feet per Minute	Total Time Required to Cut Gear, Minutes
4	40	8	46	90	28
6	48	6	37	90	22
9	54	2	30	90	9
12	60	3	26	90	10
14	84	4	25	90	20
16	112	7	22	90	37

Machinery

series of gears ranging from 16 to 4 diametral pitch. The capacity of the machine is as follows: maximum outside diameter of gear, 28 inches; maximum length of rack, 30 inches for one setting, 60 inches for two settings; maximum face width, 8 inches; maximum size of teeth, 4 diametral pitch. A pump and piping for supplying cooling lubricant forms part of the regular equipment. The machine may be driven by means of a regular countershaft, a motor drive with long connection for a leather belt, or a motor drive with a short connection close to the machine for a silent chain drive.

UNIVERSAL ANGLE-PLATE

In connection with work on planers, milling machines, shapers, drill presses, grinders, etc., it is frequently necessary to hold parts at an angle, and in some cases one or more adjustments have to be made in order to perform successive operations. For work of this class an adjustable plate provided with suitable graduations not only saves time but insures accuracy, especially when two or more surfaces or holes must be located at different angles. The universal angle-plate brought out by the Boston Scale & Machine Co., 381-389 Congress St., Boston, Mass., is intended for use in machine shops and tool-rooms whenever angular adjustments are required in connection with machining operations. This fixture



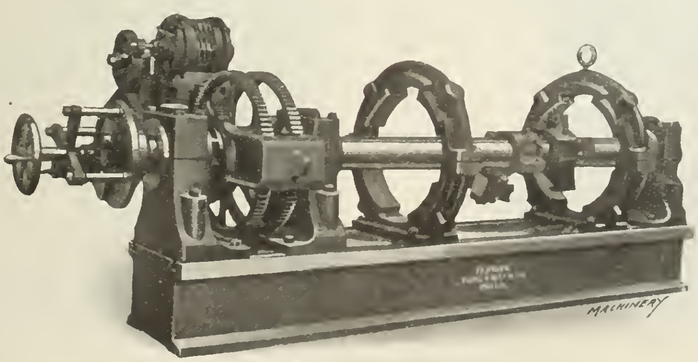
Angle-plate having Universal Adjustment

has an angular adjustment of 360 degrees in a horizontal plane and 90 degrees in a vertical plane. The graduated scales for both vertical and horizontal angular adjustments are provided with verniers which make it possible to set the fixture accurately to a given angle. This angle-plate is especially adapted to jig and fixture work as it is capable of rapid adjustment, and after the work is clamped in position it is not necessary to reset it in order to drill or machine two or more holes or surfaces located at different angles. The various ways in which this angle-plate may be applied will be apparent to those familiar with machine shop and tool-room practice. It is made in three different sizes, with working surfaces measuring 4 by 6, 6 by 8, and 8 by 10 inches.

PEDRICK TUBE BORING AND FACING MACHINE

The tube boring and facing machine described in the following is a recent development of the Pedrick Tool & Machine Co., 3639 Lawrence St., Philadelphia, Pa. This machine was designed for boring torpedo tubes, which is work requiring considerable accuracy. Obviously the machine is also applicable to the boring of various other parts such as cylinders, linings, bushings, or other work which can be held readily in saddles. The machine may also be used for boring pillow blocks, pedestals, and similar parts. The boring-bar is supported in three pedestals at a fixed height above the bed. These pedestals are so designed, however, that spacing blocks may be used to raise them if this is necessary, without interfering with the alignment of the boring-bar or the other mechanism. Large bushings in the pedestals provide bearings for the boring-bar. The latter is revolved from an electric motor through compound gearing, so arranged as to permit speed variations to be obtained. A belt drive may be employed if desirable.

The cutter-head travels along the boring-bar, the same as in the regular portable machine made by this company, and it is controlled by an automatic reversible feed having three changes. The saddles for holding parts to be bored may be plain, as shown in the illustration, or equipped with four adjusting screws when a miscellaneous line of work is to be handled. These saddles may be adjusted along the bed and are held in position by stud bolts engag-



Pedrick Tube Boring and Facing Machine

ing two T-slots, which extend the full length of the bed on both sides. The cutter-head has four arms for carrying a like number of tools. The facing arm seen on the bar in the illustration is for facing the flanges or ends of tubes or cylinders. This machine is intended for use in railway shops, repair shops, in shipyards where the boring of sleeves and tubes is done constantly, and in many other kinds of industrial plants. The machine has a long boring travel for its size and is self-contained, so that it can be placed in any part of a shop or yard.

HARRIS AUTOMATIC HOB SHARPENING MACHINE

The grinding machine to be described is one of the special types built by the H. E. Harris Engineering Co., 1041 Broad St., Bridgeport, Conn. This machine operates automatically after the hob is in position, which insures sharpening hobs accurately, uniformly, and at a certain fixed speed. When hobs are ground by hand operation, the teeth are sometimes burned by attempts to grind too rapidly and one series of teeth may be ground below another, thus causing an uneven distribution of the work of cutting. This machine has been designed to avoid defects of this kind.

The wheel spindle is mounted in ball bearings carefully adjusted to eliminate end thrust and insure steady operation. The spindle bearings are on a horizontal slide, which is adjusted with a micrometer screw. This horizontal slide is carried by a vertical slide, which also has a micrometer screw to insure accurate adjustment. With this arrangement the wheel may be set both horizontally and vertically with considerable accuracy, and the machine may be adjusted for any size or shape of wheel within its range and for grinding the faces of the teeth to any degree of rake required. By applying an extra attachment of simple design, this machine is adapted for grinding either right- or left-hand spirally fluted hobs, as well as those having straight flutes. The machine is also adapted for grinding taps as well as for various other tool grinding operations.

The work-table is moved back and forth with a uniform motion by a cam in the body of the machine. This cam receives its motion through worm-gearings and a belt connecting with a countershaft. The work-table may also be operated by a handwheel, as when setting up or adjusting the machine; then the automatic driving clutch is thrown out of mesh by a lever. The indexing of the work is entirely automatic, the motion being obtained from the same cam-shaft that operates the table. When a hob is being ground it is flooded with the cooling lubricant. The lower part of the machine contains a tank from which the lubricant is pumped into a close fitting wheel guard over the wheel. The work-table is pan-shaped and has a drain emptying into the reservoir. The indexing mechanism is covered by a guard which protects it from the lubricant.

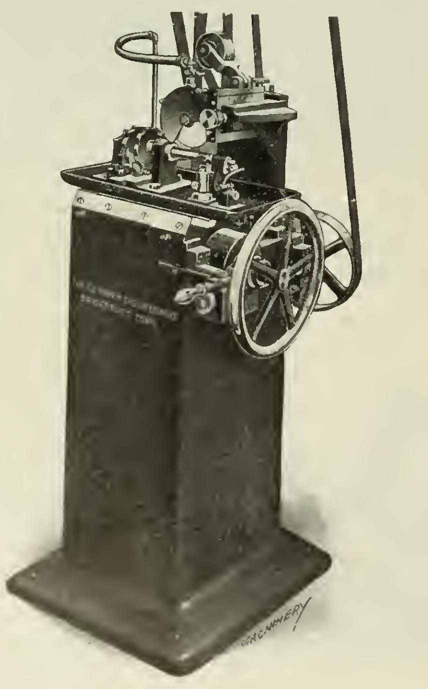


Fig. 1. Front View of Harris Automatic Hob Grinding Machine

Fig. 2. Rear View of Harris Hob Grinding Machine

The tension of the belt is controlled by the idler pulley shown, which operates against the slack side. A setting block is provided for locating the hob to be ground in the proper position. This block may be lowered out of the way after using it. The work is supported at its outer end by a center carried by a swinging arm, which can be clamped rigidly. Surfaces of the machine liable to wear are adjustable and carefully protected from abrasive. The machine also has ample facilities for lubricating the moving parts.

METALWOOD HYDRO-MECHANICAL RIM SHRINKER

The Metalwood Mfg. Co., Leib and Wight Sts., Detroit, Mich., is now manufacturing a hydro-mechanical rim shrinker or banding press for automobile wheel rims. This press is operated by hydraulic pressure. The motion is transmitted to the dies, which force the rim inward, by means of a powerful toggle mechanism. The front view, Fig. 1, shows the arrangement of the eight dies, and the side view, Fig. 2, illustrates the general construction of the press. The closing of the dies is regulated by the handwheel shown in the illustration, which, through worm-gearing, controls the position of a nut and a screw bolt, which bears against the stop-plate or main casting of the frame. The variation of sizes is taken care of by adjusting this screw bolt forward, which increases the diameter of the ram. A receding movement of the screw bolt allows the cylinder ram a longer travel and a greater movement of the toggles which operate the dies.

Any lost motion in the toggles is compensated for by compression springs. The toggles are adjustable for angularity by means of outside adjusting screws, which may be seen in

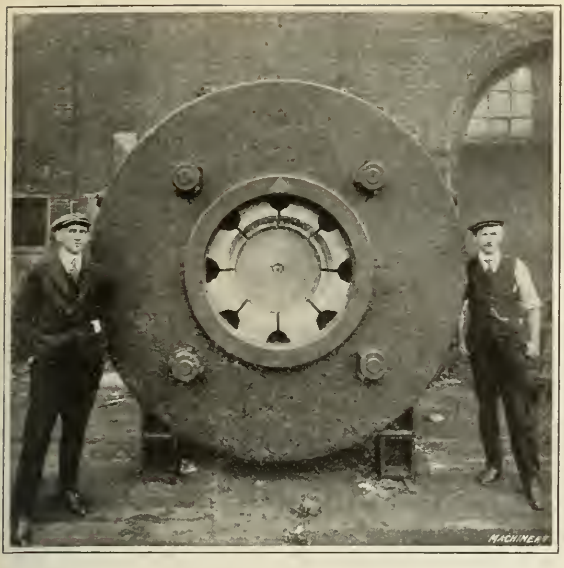


Fig. 1. Front View of Metalwood Hydro-mechanical Rim Shrinker

Fig. 2. All parts of the toggles are of carbon steel and the entire press is made of steel, no cast iron being used, except for the press legs. The ram is of hard semi-steel, finished and polished. The ram shoe or part carrying the pivots or connections to the toggles has babbitted bearings on the columns. The press has a hydraulic pull-back subjected to a constant pressure from an accumulator line. U-type chrome leather packing is used for the ram and also in the pull-back cylinder. The construction is such that the gland may readily be removed from the ram cylinder when new packing is to be inserted.

The machine is designed to operate under a hydraulic pressure varying from 1000 to 2000 pounds per square inch, and at a pressure of 1000 pounds it develops about 675 tons on the toggles or rims to be pressed. An increase of pressure causes the pressure on the toggles or dies used in forming the rims to increase at the same ratio. The dies are of carbon steel and are fitted with angular tongues and grooves, and held in place by screws in the die-block. The press has a maximum closure of 3 inches, and under test has made from eight to nine strokes per minute. The weight of the press is 26,000 pounds.

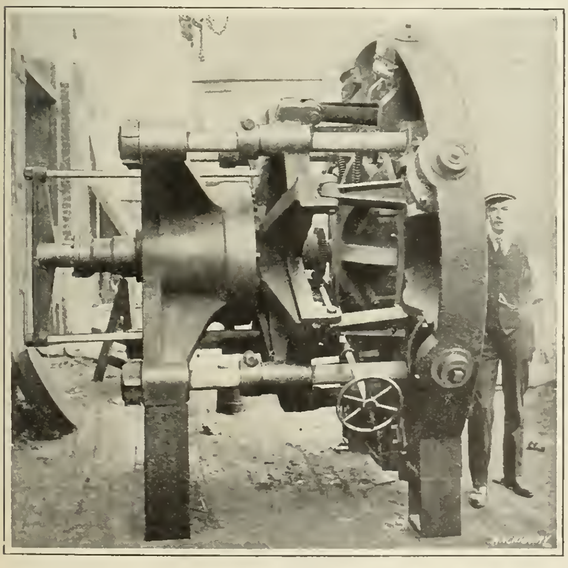
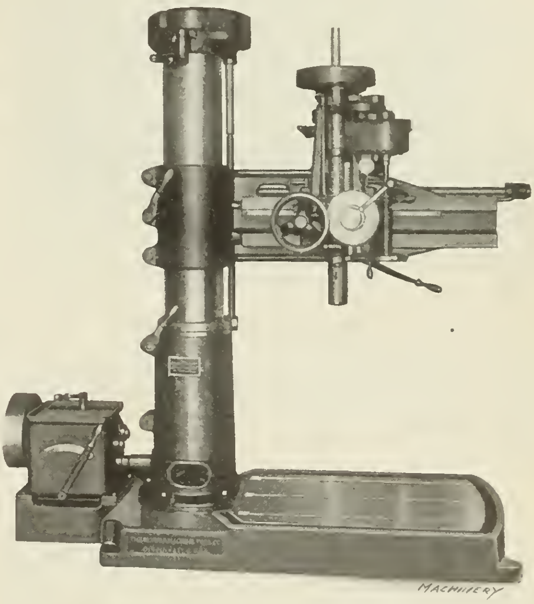


Fig. 2. Side View of Rim Shrinker

MORRIS MACHINE TOOL CO.'S RADIAL DRILLING MACHINE

The Morris Machine Tool Co., Cincinnati, Ohio, is now manufacturing the radial drilling machine shown in the accompanying illustration. This machine has incorporated in its design the various features essential to a modern tool of this type. It is adapted for tapping, facing, counterboring, etc. as well as for high-speed drilling operations. These drilling machines are made in 2½-, 3-, and 3½-foot sizes, capable of drilling to the centers of circles 5 feet, 6 feet, and 7 feet in diameter, respectively. The columns of these machines swivel on roller bearings in a heavily designed stump which is securely bolted and doweled to the base. The column projects deeply enough into the stump to insure alignment under heavy strain, and the stump is arranged to take up any wear in the column bearings.



Morris Radial Drilling Machine

The deep well ribbed base has large T-slots and an oil channel extending around it provided with a screen through which the lubricant passes into the large reservoir. This reservoir has an overflow partition to prevent chips and dirt from entering the pump. The arm is raised and lowered on the column by means of a screw operated by tumbler gears on the cap. These gears are engaged by a handle within convenient reach of the operator, and are so arranged that the tendency is to disengage, thus making it necessary for the operator to hold the elevating handle while the arm is in motion. If the operator should forget to unclamp the arm, or if the latter should reach the extreme position, the gears would disengage, as the operator could not hold them in mesh.

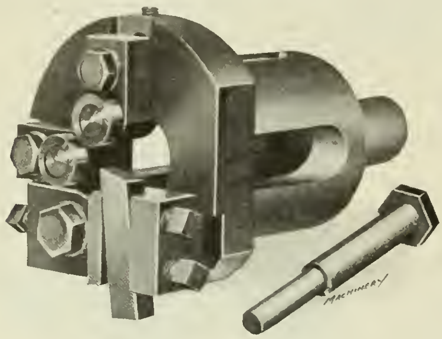
The head is adjusted along the arm by means of a rack and pinion and a handwheel located at the left-hand side. The back-gears may be engaged or disengaged while the machine is running by the lever seen to the left of the spindle. The reversing lever is located on the right-hand side of the spindle below the arm. The reversing frictions are adjustable for wear and the clutches are heat-treated and hardened. All of the gears are covered to protect the operator.

The thrust of the spindle is taken by a ball bearing. The spindle sleeve is graduated and a direct-reading depth gage and automatic feed trip are provided. Ten spindle speeds are available with the cone drive and twelve with the speed-box drive. The feed-box is a unit mounted on the head and gives four changes; each feed change is marked in thousandths of an inch advance per revolution of the spindle. Motor drives

may be arranged either with a four to one variable-speed motor or a constant-speed motor used in connection with a geared speed-box.

WATSON TANGENT-CUT BOX-TOOL

The Biggs-Watterson Co., 722 Guardian Bldg., Cleveland, Ohio, has placed on the market an all-steel tangent-cut box-tool for use on screw machines and turret lathes. This tool is designed to take heavy cuts and still produce accurate work. The tool body is a one-piece steel forging heat-treated to prevent it from becoming battered as the result of careless handling. The rollers and stops are of tool steel hardened and ground. The position of the cutter insures the correct clearance and pressure angle of cut regardless of the diameter. The grinding and replacing of the tool or cutter does not change the cutting diameter appreciably. Standard sizes of cutters are used so that they may be replaced readily when necessary. The tool can be furnished in either right- or left-hand models to fit various makes of hand-operated and automatic machines.



Watson Tangent-cut Box-tool

DRAKE LOCK-NUT

The Western Screw & Lock-nut Co., 342 Mills Bldg., San Francisco, Cal., has placed on the market a lock-nut which is claimed to be efficient in load-carrying strength, correct in mechanical principle and able to withstand the most severe vibrations without jarring loose. Fig. 1 shows the two parts which compose the nut and their relative position when placed together. The arrangement of this lock-nut is further illustrated by the sectional view, Fig. 2, which shows it applied to a bolt.

The lower or main part of the nut is slotted, as clearly shown in the middle view in Fig. 1, to provide a slight amount of elasticity or compressibility. The beveled edges of these fingers engage a beveled seat on the locking part of the nut, as indicated by the sectional views. When the locking member is screwed on, it is claimed that the nut is locked so effectively that no vibrations yet tried in a test have been able to loosen it. In one test, the lock-nut withstood the vibrations from an air hammer delivering a 25-pound blow at 500 blows a minute for nine hours, which was sufficient to jar off an ordinary nut in a comparative test. In another test a ⅜-inch nut withstood the constant jarring from a small electrical apparatus for seventy-two hours without becoming loose.

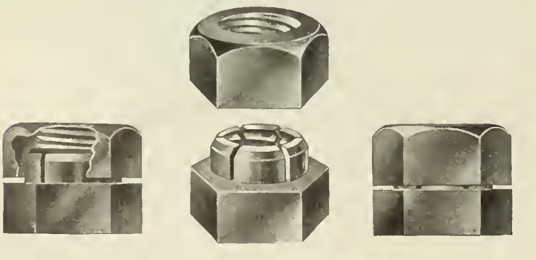


Fig. 1. Drake Lock-nut

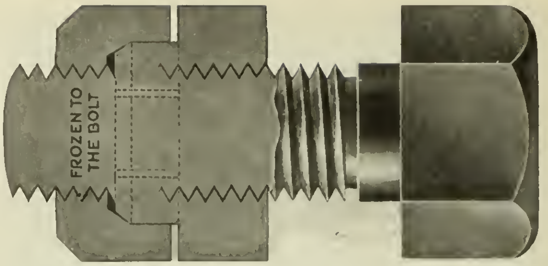


Fig. 2. Drake Lock-nut applied to a Bolt

The complete nut when locked together as shown to the right in Fig. 1, presents a finished appearance and is of standard hexagonal form so that ordinary wrenches may be used. One of the important points claimed for this nut is the fact that the "dead member" is locked and not the moving member. This dead member which bears against the work is designed to have sufficient strength to carry the load and the strength is considerably increased when the locking member is placed in position.

"NAMCO" COLLAPSING TAP

A collapsing tap having several improvements in design which adapt it for an exceptionally wide range of work is shown in Fig. 1 and also in the sectional view Fig. 2. This tap is made by the National-Acme Mfg. Co., Cleveland, Ohio. The tap body and shank are no larger than the cutting diameter of the chasers. As the maximum diameter represents the extreme cutting size of the tap, there is practically no limit to the depth to which work can be tapped, since it is only necessary to increase the length of the shank according to the depth required; therefore, it is possible to use the design of tap here illustrated for cutting threads to depths which exceed the length of the chasers many times, and on classes of work for which taps having a relatively large body or shank could not be used.

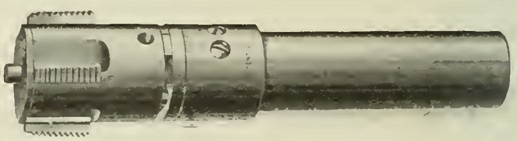


Fig. 1. "Namco" Collapsing Tap

These collapsing taps are designed for use on all turret head machines, screw machines, bolt threaders, finishing lathes, or wherever threads one inch or larger in diameter need to be tapped. They may also be used for either straight threads or pipe threads. The chasers are supported throughout practically the entire length when cutting, and either right- or left-hand threads can be cut by using the proper chasers.

The operation of the tap is as follows: When the travel of the turret is stopped at a predetermined point, the tap continues to cut until, at the required depth, the forward move-

SIZES AND CAPACITIES OF "NAMCO" COLLAPSING TAPS

No. of Tap	Outside Diameter, Inches	Capacity, Min. — Max.	No. of Tap	Outside Diameter, Inches	Capacity, Min. — Max.
118	¾	1 — 1⅛	334	2½	3 — 3¾
138	⅞	1¼ — 1⅜	414	3	3½ — 4¼
158	1	1⅜ — 1⅝	434	3½	4 — 4¾
178	1¼	1⅝ — 1⅞	514	4	4½ — 5¼
214	1½	1⅞ — 2¼	534	4½	5 — 5¾
234	1¾	2¼ — 2¾	614	5	5½ — 6¼
314	2	2½ — 3¼	...	...	....

Machinery

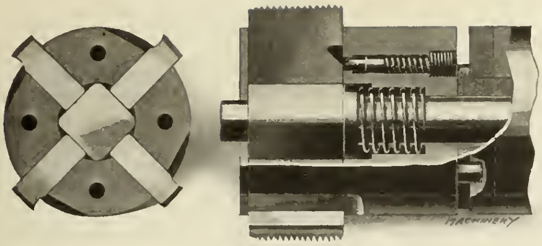


Fig. 2. Sectional View of Collapsing Tap

ment due to the action of the chasers in the tapped hole causes the driving pins to disengage; the chasers then revolve with the work until the tripping point is reached, when they collapse and are automatically released from the tapped hole. The end views, Fig. 3, illustrate the positions of the chasers for cutting right- and left-hand threads and also the change which takes place when the chasers move inward and the tap is in the collapsed position. The view in the lower right-hand corner shows the tap set for the smallest adjustment. When a tap is used on a drilling or chucking machine and the depth of the hole is measured from the outer face or surface, what is known as an outside trip is provided. The use of this trip insures collapsing the tap at a given depth from the surface, thus insuring uniformity and protecting the tool itself. When this collapsing tap is used on the Acme and Gridley single- and multiple-spindle automatics and 2-A bolt threaders, a spool

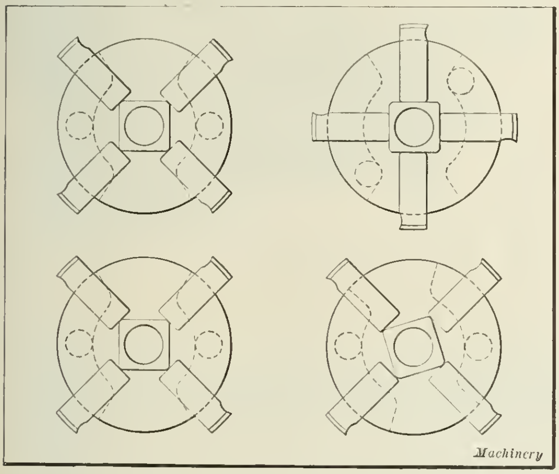


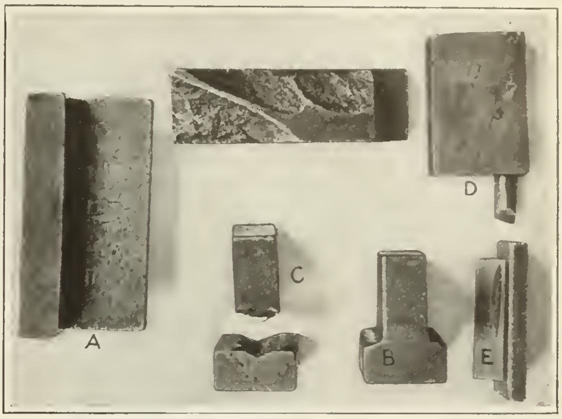
Fig. 3. End Views of Collapsing Tap

and tap operating mechanism is applied. The sizes, with the minimum and maximum capacities of these collapsing taps, are given in the accompanying table.

FERRO BRAZING PASTE

The Ferro Brazing Paste Co., 1423 Farragut Ave., Chicago, Ill., is now manufacturing a paste which makes it possible to braze all metals except soft brass and aluminum. An idea of the range of work that may be handled can be obtained from the fact that it is possible to braze copper onto malleable iron, cast iron, steel, etc. Stellite may be brazed onto cold-rolled steel bars; and high-speed and carbon tool steels may be brazed onto cold-rolled steel bars. These applications are of particular value in making tools, as it is possible to effect a considerable saving in the cost of high-priced steels. In addition to the uses already mentioned, cast iron may be brazed onto cast iron, and there are a number of other metal combinations that may be handled with equally satisfactory results.

Ferro brazing paste is a chemical that comes in the form of a grease and is rubbed on those surfaces of the work that are to be jointed together. The work is then heated in a gas furnace, and it is believed that the chemical has a tendency to open the pores of the metal, thus making it possible to secure a partial weld in addition to brazing the joint through the use of ordinary brazing spelter consisting of one-third zinc and two-thirds brass. This method of brazing may be used to advantage in making repairs or in the manufacture of tools and many other metal products. In the accompanying illustration, the piece shown at *A* consists of copper brazed onto cast iron. At *B* and *C* are shown two pieces of cast iron brazed together, and in this case the joint was so perfect that a test showed that the metal broke before the brazed joint could be torn apart. The possibility of brazing high-speed



(A) Copper brazed to Cast Iron; (B) and (C) Cast Iron brazed to Cast Iron; (D) and (E) High-speed Steel brazed to Cast Iron

or carbon tool steel to cast iron is illustrated at *D* and *E*, where it will be seen that a perfectly smooth and uniform junction is secured, and this is of sufficient strength to enable tools to stand up under severe conditions of service.

HOLMES MACHINE VISE

The Holmes Mfg. Co., Shelton, Conn., has placed on the market the vise shown in Figs. 1 and 2. This vise is the result of a study of the requirements of large munitions plants where production milling and other operations requiring a good machine vise have been in progress. It is of heavy construction, and there is no tendency for the movable jaw to lift and throw the work out of true. The cutting strains are taken on the solid jaw, while the movable jaw has a floating movement, as described later.

The solid or fixed jaw *A* is bolted to the main body of the vise base. The main casting is centrally slotted to receive the sliding jaw *B*. It will be noticed that jaw *B* has a base that extends the full length of the vise, and has the clamping section at one end and the portion that receives the operating screw at the other end. Jaw *B* is prevented from lifting by its close fit in the slotted base and is held down by the application of jaw *A* at one end and of guide strip *C* at the opposite end. If wear should develop at any time, it is only necessary to remove the solid jaw *A* and the guide strip *C*, take a light planer cut over the base of the casting, and reset the jaw and guide strip to make the sliding strip of jaw *B* more accurate. Both jaw castings are made of semi-steel.

The floating feature of the movable jaw is secured by pivot-

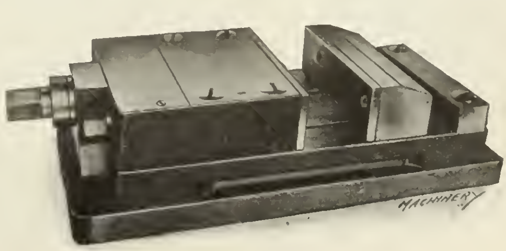


Fig. 1. Holmes Machine Vise

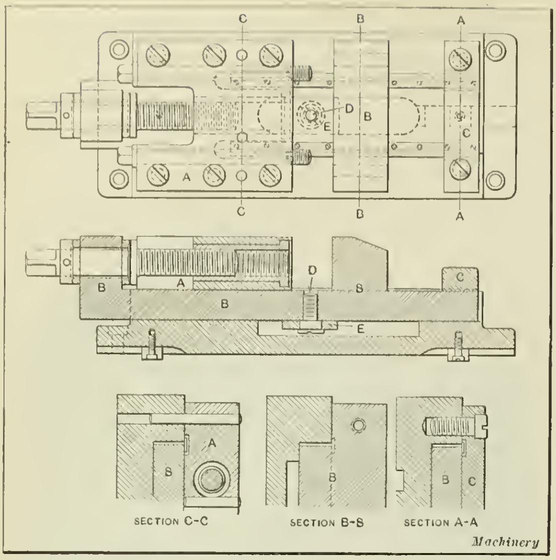


Fig. 2. Sectional Views and Plan of Holmes Machine Vise

ing this member upon stud *D* that is supported by sliding block *E* operating in a milled slot in the base casting. The hole in the left-hand end of the sliding jaw *B* that is bored to receive the operating screw is made large enough to allow the necessary movement at this point. The operating screw is 8 pitch and the buttress type of thread is employed. The steel screw works in a brass bushing, and a protecting cap at the end keeps dirt and chips from the threaded hole. The movable jaw has a travel of three inches. The slot in the main casting in which block *E* operates is filled with oil, and thus provides permanent lubrication for this feature.

Vise jaw faces or "false jaws," as required, are attached to the faces of the jaw castings by screws. The vise itself may be clamped to the table of the milling machine or other machine tool by four screws at the corners, or, if desired, it may be strapped on, the clamps or straps engaging slots, one of which may be seen at the side. The weight of the vise is 48 pounds.

BROWN & SHARPE MICROMETER INDEX

An attachment for the spiral head and universal index centers known as a micrometer index has recently been perfected by the Brown & Sharpe Mfg. Co., Providence, R. I. This attachment is intended for indexing, with greater facility, irregular spacings in degrees and minutes, and it gives results much finer than are ordinarily obtained with the regular equipment. Heretofore, such indexing was obtainable only by a rather complicated process, involving the careful consideration of index plates and calculations of differences by which errors were easily possible. With the micrometer index these calculations are eliminated and a direct reading is secured. The relatively finer divisions that can be indexed are apparent from the fact that by the usual method of using one hole in the forty-nine-hole circle (that being the largest plate regularly furnished for B. & S. heads) the smallest division obtainable is 11.02 minutes, whereas the micrometer index readily gives readings to ½ minute.

The attachment, as shown in Fig. 1 and also in the diagram Fig. 2, consists of a compact housing containing a worm on a vertical shaft, at the upper end of which a dial, graduated to half minutes, is located. This worm meshes with a wheel mounted free on the spiral head worm-shaft. The regular index plates are fastened directly to this worm-wheel, and connection with the spiral head worm-shaft is obtained by the regular index crank and pin engaging with holes in the index plate. One revolution of the index crank rotates the spindle 9 degrees, by means of the 40 to 1 reduction. By giving the vertical shaft of the attachment one revolution, this 9-degree movement is divided into quarter degrees by a 36 to 1 reduc-

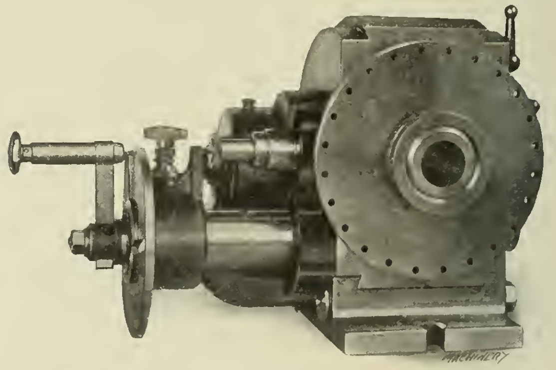


Fig. 1. Brown & Sharpe Micrometer Index for spacing in Degrees and Minutes

tion. The graduated dial on the worm-shaft has thirty divisions; consequently, a movement of one graduation turns the spindle of the spiral head ½ minute, and indexing to this reading is therefore obtained directly.

The micrometer index is easily attached, and it does not hinder the spiral head in the regular performance of its work. When in use the index-plate stop-pin engages a hole in the attachment casting and prevents it from rotating. When it is not desired to use the micrometer index, as when cutting

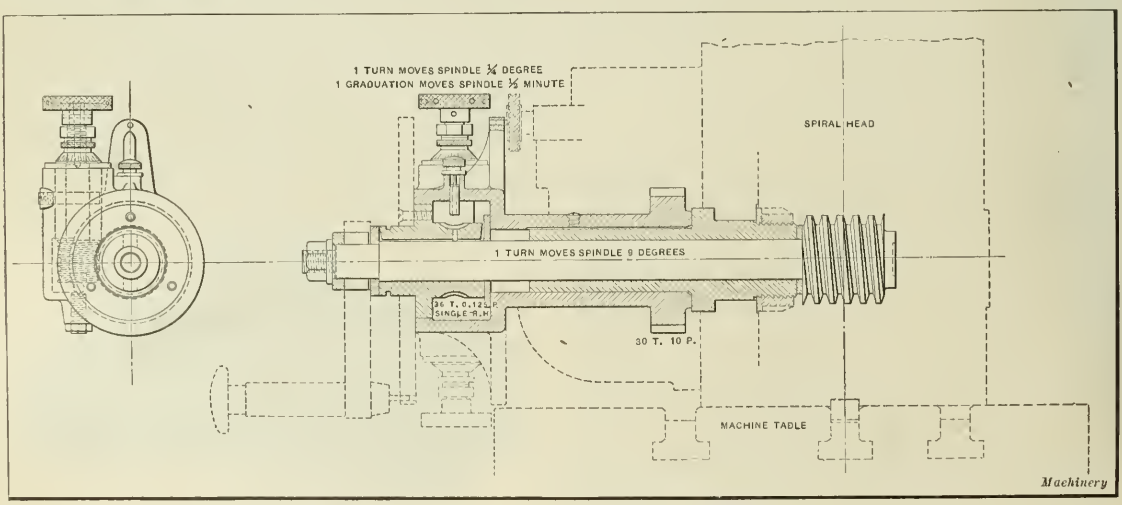


Fig. 2. Sectional View of Micrometer Index which gives Direct Readings to One-half Minute

spirals or for differential indexing, the stop-pin is withdrawn and the operation carried on in the usual manner. In applying the attachment, the regular worm-shaft, eccentric sleeve and gear are removed and replaced with a new worm-shaft and sleeve furnished with the attachment. The remainder of the mechanism is then slipped in place over the worm-shaft eccentric sleeve, the regular plates, sectors and crank being used, and held in place in the usual way.

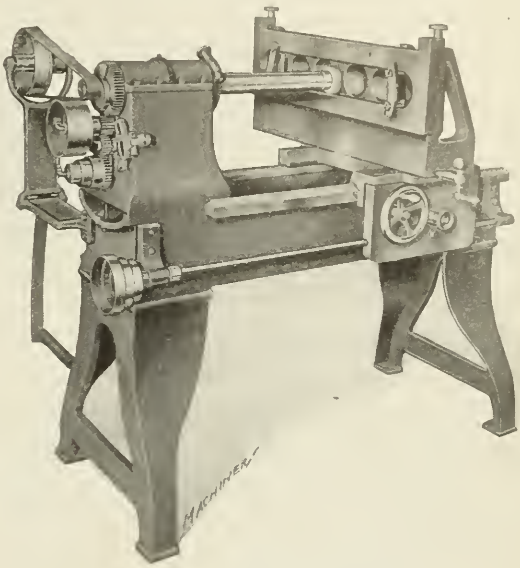
NEWTON FOUR-SPINDLE BORING MACHINE

A new design of four-spindle street railway and mine locomotive boring machine has been developed by the Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa. Earlier types of this machine have been extensively used for boring the axle, armature shaft and field bearings of motors for street railway equipment and mine locomotives. The machine illustrated was originally designed for boring the axle and end bearings, as well as the field pads of steel railway motor castings. Various other machines have been built according to the same general plan, but with slight modifications, such as the inclusion or omission of back-gears in the drive of the main end-bearing boring spindles, a rapid traverse for the spindle saddles, geared feed-boxes, hollow or solid spindle noses, auxiliary boring spindles inside the sleeves, and changes in the location of operating levers according to individual requirements.

Machines of this type have spindles or sleeves with exterior threads on the nose for carrying cutter-heads or boring-bars, and each spindle has an independent worm and worm-wheel drive controlled by a clutch. The main spindles remain in fixed positions in their saddles, and their alignment coincides, although in special cases spindles have been equipped with a large sleeve having a threaded nose for carrying the boring heads and arranged with drift key slots for locating the spindles at different distances or positions, as determined by the location of the field pads to be bored. In such cases, boring-bars are screwed onto the nose of one spindle and the other one is bored hollow and bushed to serve as a support for the outer end of the boring-bar. The spindles used for boring the axle bearings are in the same vertical plane, but their saddles and rear driving gear brackets are adjustable crosswise to give the various center-to-center distances required within the range of the machine. These machines are preferably arranged for one driving motor on each end of the two adjacent spindles, but they can be equipped for a belt drive or with a separate motor for each spindle. Provision is made for the use of spacing blocks to facilitate the accurate duplication of center distances.

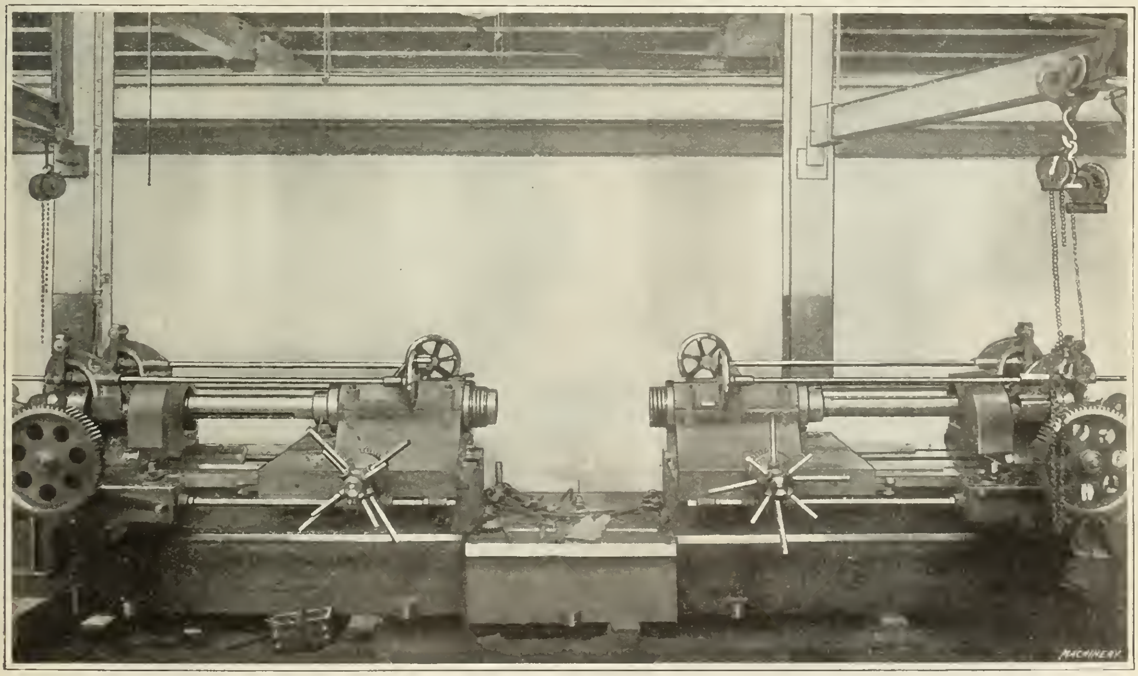
SCHMIDT CYLINDER GRINDING MACHINE

The B. L. Schmidt Co. of Davenport, Iowa, has brought out a cylinder grinding machine designed especially for use



Schmidt Cylinder Grinding Machine

in repair shops, garages, etc., for regrinding cylinder bores. This machine may be used for various classes of heavy grinding operations within its range. The bed is of box section, and it has a large V-shaped bearing at the front and a flat bearing at the rear. The headstock has been made strong and rigid and has large spindle bearings for avoiding vibration



Newton Four-spindle Boring Machine

and producing smooth surfaces such as are required in automobile cylinders. The carriage is gibbed front and back and has a bearing on the bed throughout its entire length. The cross-slide of the carriage has a bearing surface 22 inches long by 8 inches wide, giving the angle-plate a rigid support. The carriage is reversed by a pair of tumbler gears working from the gear on the driving pulley. The feed-rod has a three-step cone, thus providing three changes of feed to the carriage.

The angle-plate has a separate front plate equipped with two knurled knobs for raising and lowering it. This adjustment facilitates centering the cylinder on the angle-plate. This angle-plate will hold all cylinders from the smallest of the motorcycle type up to a solid block of six cylinders 31½ inches long. Separate plates can be furnished having smaller or larger openings. The angle-plate has a long slot in the slide for clamping the cross-feed screw nut. This nut can be loosened and the angle-plate pulled to any position on the carriage and then clamped; the finer adjustments are made with the cross-feed screw. The countershaft attached to the machine bed, and also the grinding wheel arbor, are equipped with ball bearings. The length of the bed is 55 inches, and the width, 15½ inches. The machine will grind cylinders from 2½ to 8 inches in diameter and 15 inches long. The height from the bed to the center of the spindle is 12 inches, and the floor space required, 5 by 3 feet.

BAKER HIGH-DUTY MANUFACTURING DRILLING MACHINE

Baker Bros., Toledo, Ohio, have recently added to their line of heavy vertical drilling machines a machine known as a No. 216 single-purpose high-speed drilling machine. This machine, which is shown in Fig. 1, has capacity to drive 1½-inch high-speed drills to the limit of their efficiency in steel. It is designed especially for quantity production, but is adapted for a wide range of work.

Speeds are secured by change-gears. In this manner practically any speed between 76 R. P. M. and 614 R. P. M. may be secured. By changing top driving gears, a speed range from 25 R. P. M. to 614 R. P. M. may be obtained, with a possibility of securing 105 speed changes. The speed gears can be readily and quickly changed. The change-gears are well guarded by a neatly designed box cover which can be readily removed.

The feeds are also secured by change-gears. A quick change from a drilling feed to a reaming feed is available, thus securing feeds 3 1/3 times the drilling feeds. This change is made by a push-rod at the left of the spindle. On the standard machine a drilling feed range of from 0.005 to 0.024 inch and a reaming feed range of from 0.020 to 0.089 inch can be secured. Change-gears for securing six feeds are furnished as standard equipment with the machine. Gearing for additional feeds can be furnished as special equipment. The feed changes are made at the left-hand side of the machine within easy reach of the operator.

All operating levers are conveniently located. The machine is started and stopped by shifting a belt on tight and loose pulleys. A spring device holds the belt securely on or off. In the off position a brake is applied in such a manner as to stop the spindle quickly and hold it effectually.

The spindle is of forged high-carbon steel and is fitted with special chrome thrust races. The spindle nose is bored for a No. 5 Morse taper, and is slotted across the end for driving heavy boring and facing tools. The spindle sleeve has a bearing in the head for its entire length. This is a novel feature and adds greatly to the durability and rigidity. The feed pinion and rack are hardened nickel steel. The worm-gear is provided with a safety shear pin to protect the feeding mechanism and provide for uniform wear.

Fig. 2 shows how these machines can be arranged in gangs. This particular view illustrates the compact arrangement of a four-spindle unit and the small floor space required. Machines are furnished as one-, two-, three- or four-spindle units. Each machine in a gang is a single, belt-driven, self-contained unit, complete in itself. Gang machines can be furnished with one continuous table or with independent tables for each spindle. The table is raised and lowered by means of elevating screws and is designed with ample pockets for cutting lubricants. It is so constructed that it can be bushed readily for supporting the boring-bars.

The distance from center of spindle to face of column is 10 inches; maximum distance from end of spindle to table, 32 inches; length of feed, 12 inches; vertical adjustment of table, 18 inches. The driving pulleys are 15 inches in diameter and 2½ inches wide. A four-spindle gang drilling machine takes up a floor space of 8 feet, 5 inches by 3 feet, 10 inches, and weighs about 10,250 pounds. A single-spindle machine requires a floor space of 2 feet, 5 inches by 3 feet, 10 inches, and weighs about 2550 pounds.

Fig. 1. Baker High-duty Drilling Machine

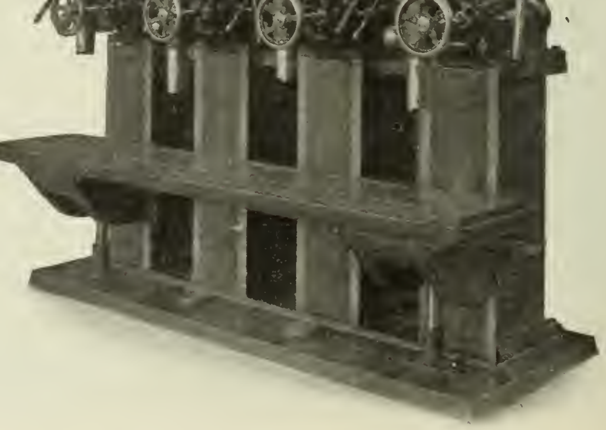


Fig. 2. Four Machines of Design shown in Fig. 1 arranged in a Compact Gang

NEW MACHINERY AND TOOLS NOTES

Return Mechanism: B. Menkin, 2141 Honeywell Ave., New York City. A return mechanism for the knockout of a die, consisting of a helical spring which is wound about the exterior of the die and engages a cross-bar and fixed pins in such a manner as to provide a return movement for the knockout. The application of this spring is not limited to dies.

Air-operated Vise: Hannifin Mfg. Co., Chicago, Ill. A vise designed especially for assembling work, though it may also be used on drilling and milling machines. The vise is closed instantaneously by the application of air. False jaws, similar to those used in a chuck, or plain, hardened steel jaws may be used. The capacity of the vise without the jaws is 7 inches, the height of the jaws is 5 inches, and the length overall is 19 inches.

Dead Front Switchboard: General Electric Co., Schenectady, N. Y. In this switchboard all live parts are inaccessible from the front, except the current and potential receptacles, and the live parts of these are recessed so that accidental contact with them is difficult. Grillwork screens prevent anyone except the person holding the key from entering the space at the rear. Disconnecting switches render the inspection and repairing of the circuit breakers easy and rapid.

Turbine-driven Fan: Terry Steam Turbine Co., Hartford, Conn. A turbine-driven fan applicable for boiler-room service. With the general adoption of high-speed reduction gears, it has become possible to utilize turbine drive for induced-draft fans. Many units of this type have been installed on boilers utilizing the heat of the gases from furnaces and cupolas. The turbines in this unit are built by the Terry Steam Turbine Co., but the fans are built by the Green Fuel Economizer Co.

Adjustable Drilling Brace: Adjustable Drill Brace Co., Boston, Mass. Drilling brace, consisting of steel tubing posts, that vary from 24 to 28 inches in length and from 1⅛ to 2⅛ inches in diameter. The post is secured to the base by an angle-plate which permits it to be adjusted to any angle. The arm is clamped to the post in a similar manner and can be swung through a large arc. Teeth on the angle-plate and the post clamp prevent the adjustment being changed by the drilling pressure.

Hacksaw Machine: L. S. Starrett Co., Athol, Mass. The main features of this machine are the treadle for raising the saw frame, saving both time and labor; an oil dashpot control for the descent of the blade, which allows the machine to be started when the frame is up and prevents stripping the saw teeth or breaking the saw; a stroke adjustment so that stock from 1 to 6 inches in diameter may be cut; and a frame locking device. A pump and lubricating tank are located inside the base.

A 20-inch Lathe with Quick-change Gear: Walcott Lathe Co., Jackson, Mich. Thirty-two threads, ranging from 2 to 112 per inch, are provided for by the quick-change gear-box of this lathe; and special, very fine, or coarse threads may be cut by changing one gear at the end of the lathe. Using the tumbler gears and cone only for thread cutting is said to simplify the design of the gear-box. The apron is of the double-wall type, and the gears are steel drop-forgings with wide face and coarse pitch.

Roll-turning Lathe with Enclosed Headstock: Youngstown Foundry & Machine Co., Youngstown, Ohio. A roll-turning lathe with a headstock that is fully enclosed. All the gearing is of steel with cut teeth and may be run in a bath of oil. The headstock cap acts as a support for the motor drive, but it may be removed with the motor, thus exposing all gearing when repairs are necessary. Hand-holes permit easy inspection of the gearing at all times. The lathe is equipped with push-button electric control mounted directly on the machine.

Critical Point Pyrometer: Gibb Instrument Co., Pittsburg, Pa. An instrument known as the "Crit-Point," that determines the critical point in heating steel. It is a well-known fact that steel loses its magnetic properties when it reaches the critical point, and it is on this principle that the "Crit-Point" is based. A magnetic indicator is applied to the steel in the furnace; when the steel has reached its critical point, a needle on the meter moves to a red line indicative of the critical point. This instrument does not measure temperature, but is intended solely to indicate the critical point for use in heat-treating steel.

Screw Press for Testing Punch and Die: Manhattan Machine & Tool Works, Grand Rapids, Mich. A screw press for the use of diemakers in shearing punches into dies. The bed of this press, which is 18 by 36 inches, has fifty-two ⅝-inch holes tapped in its upper surface, so that the die can be mounted in any position. As there is a clearance of 24 inches between the bed and the ram, the die may be blocked up on parallels, and thus provide clearance for springs, cams, etc. It is also possible to line up the punch and die and then raise the ram high enough for the pressure pads, stripper plates, springs, etc., to be mounted without removing the punch from the press.

THE "SIGN SLANGUAGE"

BY J. D. HACKETT [1]

Few large employers know how many of their foremen are still using the "sign slanguage" in communicating with the foreign workman. If they did, they would understand why production is so slow, why accidents occur, and why there are misunderstandings that end in strikes. The foreign workman who doesn't know English can't do very efficient work. He probably doesn't know what he is working at. He may not even know the name of the firm for which he is working. There are about a million men of this kind in the plants of the country today; and though it is not easy to measure efficiency loss, it can be easily shown that language does make a difference; otherwise why should men aspire to speak another language? If the efficiency of the foreigner could be raised 5 per cent, it would be a gain well worth the effort. It is known that difference in language is the cause of many accidents. For instance, in a recent case where two men died from gas, the newspaper report says: "Whether these men had been warned in a language in which they could understand the danger is a question. One could not speak English; the other only slightly." The one word danger in a language they could understand would have saved two lives. Another instance of the kind was where a foreman shouted to the workman to get out of the way; as Steve did not understand, he got a fractured skull. At first sight it might seem right to blame the foreman for this dereliction, but he is less to blame than the employer who allowed this condition to exist.

The type of employe should determine the method of solving this problem. When dealing with skilled workmen, it may be advisable to have a night school with a properly qualified teacher, or it may even be worth while to have classes for the men during working hours. But in the majority of cases the common laborer, illiterate even in his own language, is scarcely a fit subject for extensive instruction from an educational point of view. For these a less ambitious scheme should be adopted, unless the employer is a philanthropist.

The remedy in most cases is to teach the laborer, by means of the foreman, such few words as are necessary for the ordinary transaction of business. It is true that the foreman is not a very promising subject, but he is easier to teach than the workman. It is claimed that uneducated workmen have no more than four hundred words in their vocabulary, and a study of the relation between the workmen and foreman shows that very few words are necessary to cover every situation in the day's work. The employer, however, has shown so little interest in the situation that the foreman must be excused for having achieved the almost incredible feat of not knowing a word of the language spoken by his men, though in daily contact with them for years. This situation will last until the gravity of the present labor shortage forces the employer to make the best use of the material he has.

In order to reach the workman through the foreman, the latter should be provided with a card containing a few phrases phonetically rendered in the language of the workman. These phrases should embrace the ideas of command, warning, approval, and direction, which the foreman should be taught to use frequently. The phrases should be selected carefully and the literal translations of such idioms as "Look out" should be avoided. It is well to keep in mind the predicament of a Frenchman who occupied a lower berth on a particularly stormy voyage. His companion, in the upper berth, on the approach of a paroxysm, shouted "Look out," which command the Frenchman obeyed with disastrous results.

Apart from the facilitation of work which this method will bring, the workmen will be favorably impressed when a foreman attempts to speak even a few words which they understand. In addition, another important result is obtained; the workman in a short time will begin to understand the English equivalent. This method of language teaching may be carried out in the course of the work. It cannot, and should not, be taught in the schoolroom where workmen are not willing to go. An elaborate system is not necessary; the aim should simply be to teach the workmen and foremen to understand each other.

[1] Address: 4711 Cedar Ave., Philadelphia, Pa.

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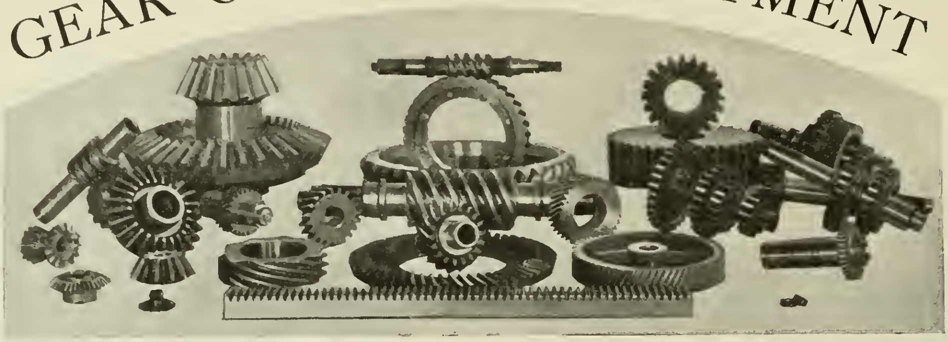

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WE can handle more work in this department. There is a large volume going through now but it takes quantities of large orders to tax the several hundred machines to a point where prompt attention cannot be given to all customers.

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Spur Gears (to 72 in. diameter). Bevel Gears (to 18 in. diameter).

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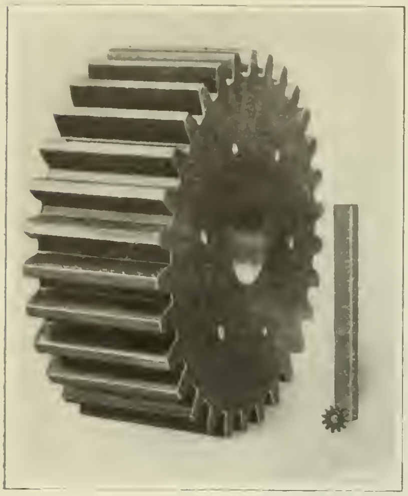
OFFICES: 20 Vesey St., New York, N. Y.; 652-654 The Bourse, Philadelphia, Pa. 626-630 Washington Blvd., Chicago, Ill.; 305 Chamber of Commerce Bldg., Rochester, N. Y.; Room 419, University Block, Syracuse, N. Y.; 2538 Henry W. Oliver Bldg., Pittsburgh, Pa.

REPRESENTATIVES: Carey Machinery & Supply Co., Baltimore, Md.; The E. A. Kinsey Co., Cincinnati, O., Indianapolis, Ind.; Pacific Tool & Supply Co., San Francisco, Cal.; Strong, Carlisle & Hammond Co., Cleveland, O., Detroit, Mich.; Colcord-Wright Machinery & Supply Co., St. Louis, Mo.; Perine Machinery Co., Seattle, Wash.; Portland Machinery Co., Portland, Ore.

LARGE NOISELESS PINION

The accompanying illustration shows two bakelite "Micarta—D" noiseless gears compared with a foot rule. The larger gear is 21 inches in diameter and has an 8-inch face. It is designed to transmit 100 horsepower at 425 revolutions per minute. A comparison of these gears will indicate the adaptability of this comparatively new material, which has been developed by the Westinghouse Electric & Mfg. Co., E. Pittsburg, Pa., for use in both large and small gears. It may be of interest to note that in making the large gear, no metal shrouds were used or needed. The claims made for these gears are that they are as strong as those made of cast iron, and in addition to being noiseless, are unaffected by atmospheric changes, cannot be destroyed by rats, can be stored indefinitely without deterioration and can be operated in oil without swelling.



Pinions made of Bakelite "Micarta—D," compared with Foot Rule

* * *

BRODERICK CLEANING AND PLATING MACHINE

The Broderick continuous-process cleaning and plating machine not only performs the actual plating process automatically, but cleans, rinses and dips the parts automatically. This machine has been placed on the market by the Munning-Loeb Co., Matawan, N. J. It consists of a series of tanks containing the cleaners, rinsing baths, dips and plating solutions arranged in the proper order and extending a distance of about fifty feet. Above the tanks there is a carrier system, consisting of two endless chains driven through sprockets by a ½-horsepower motor and carrying a series of vertical rods, which hold the parts to be plated. By a simple cam mechanism, each rod is moved forward and raised or lowered at any predetermined point, thereby passing the work through the different baths by raising it over the dividing walls between adjacent tanks and lowering it into the baths in the proper sequence of operations; the work is finally delivered to the starting point completely plated. The movement of work agitates the plating bath, which permits far greater current densities, without danger of burning, than are possible in still tank plating; this feature, together with the elimination of handling the parts, enables the plating to be done rapidly. It is also claimed that a greater uniformity of deposit may be obtained with the Broderick machine, because the time of immersion in the various baths is definitely fixed by the speed of the machine. This speed is adjusted by the plating foreman to give the best results.

The machine, while standardized in its component parts, can be modified to meet any unusual requirements merely by varying the number of standard units in its assembly and the arrangement of tanks and lifting cams. The speed is adjustable over a ratio of as high as 3 to 1, and this variation may be increased if necessary. For ordinary plating conditions it is found that a speed of about two feet per minute is satisfactory. At this speed the work completes the circuit of the tanks in about one hour, this time sufficing for all cleaning baths, rinses and dips, in addition to the actual plating. Where light deposits are desired, the speed may be increased and the time correspondingly reduced, while exceptionally heavy deposits are obtained by a slower speed and a greater time in the baths. The application of the machine in any plating plant is recognized as an individual engineering problem, and a suitable arrangement is offered after thorough investigation of the conditions.

* * *

A so-called Christmas savings fund has been instituted by the Cincinnati Planer Co., the Acme Machine Tool Co. and the Greaves-Klusman Tool Co. of Cincinnati, Ohio. The principle on which this fund is based is that 5 per cent of the total earnings of an employe for every month during which he complies with the conditions are placed at 3 per cent interest to accumulate until the day before Christmas, when a check for this amount is sent to him. In order to be entitled to this bonus, employes must not be absent more than one day in the month without excuse, nor late more than one day in the week without excuse. Under this arrangement, the Cincinnati Planer Co. distributed $12,500, the Acme Machine Tool Co. about $6000, and the Greaves-Klusman Tool Co. about $4000 to their employes at Christmas.

* * *

It is estimated that the potential water power of Canada is 17,000,000 horsepower; of this, only 1,590,500 horsepower has been developed. This power is available at all the present commercial centers, with the exception of some of those in the middle prairies. About 500,000 available horsepower is within seventy miles off Winnipeg; of this, only 60,000 horsepower has been developed. About 48,000 horsepower is within fifty miles of Calgary. The Western Canadian Power Co. is developing 25,000 horsepower at its plant on Slave River, thirty-five miles from Vancouver, but the company can easily obtain 100,000 horsepower when all its sites are fully utilized.

PERSONALS

A. B. Hazzard has taken the position of works manager of the Brown Magnetic Truck Co., Philadelphia, Pa.

Horace N. Trumbull has been appointed advertising manager of the S. K. F. Ball Bearing Co., Hartford, Conn.

Andrew L. Gath, formerly with the Manhattan Machinery Exchange, New York City, is now connected with Young. Corley & Dolan, Inc., 115 Broadway, New York City.

Joseph K. Long, occasional contributor to Machinery, has been transferred from Renovo, Pa., to Sunbury, Pa., where he is chief draftsman of the Pennsylvania Railroad shops.

James O. Smith, for ten years associated with the American Emery Wheel Works, Providence, R. I., latterly as vice-president, has resigned and joined the Hampden Corundum Wheel Co., Springfield, Mass., as sales manager.

Arthur V. Farr, who for the last three years has been advertising manager of the S. K. F. Ball Bearing Co., Hartford, Conn., has resigned and taken the position of sales manager of the Hess Steel Corporation, Baltimore, Md.

Newell C. Knight, salesman and advertising expert, has formed an advertising company under the name of the Knight Co. Offices have been rented on the top floor of the Home Insurance Bldg., 127 S. La Salle St., Chicago, Ill.

S. B. Taylor, sales manager of the S. K. F. Ball Bearing Co., Hartford, Conn., has been appointed vice-president, succeeding F. B. Kirkbride, who remains on the board of the company. Mr. Taylor will remain in charge of sales.

J. G. Waldron, for the past ten years with Wheelock, Lovejoy & Co., New York City, eastern agents for the Firth-Sterling Steel Co., has resigned and taken a position with Hamilton & Hansell, 17 Battery Place, New York City, exporters and importers of Swedish and domestic steel and iron.

G. A. Ungar, former representative of the S. K. F. Ball Bearing Co. in Cleveland, Detroit and Pittsburg, has been appointed technical manager and chief engineer, succeeding Uno Forsberg, who returns to Sweden after completing his work of forming the manufacturing organization of the S. K. F. Ball Bearing Co. in this country.

Herbert Chase, who has been connected with the Automobile Club of America for several years as laboratory engineer and chief engineer, has joined the office staff of the Society of Automobile Engineers, 29 W. 39th St., New York City, as assistant secretary. Mr. Chase was graduated as a mechanical engineer at Sibley College, Cornell University, in 1908.

F. E. R. Blomquist, mechanical engineer with the Kelsey Wheel Co., Detroit, Mich., has resigned his position to take up the active management of the Blomquist-Eck Machine Co., Cleveland, Ohio. The business of the Blomquist-Eck Machine Co. has grown so rapidly that more commodious quarters have had to be secured adjoining the present location. Additional machinery has been installed and the organization has been increased substantially. This has made it necessary for Mr. Blomquist to devote his entire time to the business of the Blomquist-Eck Machine Co.

COMING EVENTS

January 6-13.—National Automobile Show in Grand Central Palace, New York City.

January 25.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

May 21-22.—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 22-25.—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

SOCIETIES, SCHOOLS AND COLLEGES

Tanners Institute (Pratt Institute), Brooklyn, N. Y. Fifth annual report of Tanners Institute for the year 1915-1916.

Massachusetts Institute of Technology, Boston, Mass. Catalogue, December, 1916, of the officers and students, with a statement of the requirements for admission and a description of the courses of instruction.

Stevens Institute of Technology, Hoboken, N. J., dedicated the new William Hall Walker gymnasium November 18. The building, which was erected at a cost of $125,000, is elliptical in shape and is, as far as known, the first of this form to be built. It contains a ten-lap track, a large drill court, and the regulation college pool.

University of Illinois, Urbana, Ill., maintains fourteen Engineering Experiment Station Research Fellowships, in order to extend and strengthen the field of its graduate work in engineering. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments to the fellowships are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements are met, the degree of Master of Science will be conferred. Additional information will be furnished by the director.

NEW BOOKS AND PAMPHLETS

A Study of Oil Engines in Iowa Power Plants. By H. W. Wagner. 157 pages, 6 by 9 inches; illustrated. Published by the Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, as Bulletin 42 of the Engineering Experiment Station.

Sewage Disposal for Village and Rural Homes. By C. S. Nichols. 29 pages, 6 by 9 inches; illustrated. Published by the Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, as Bulletin 41 of the Engineering Experiment Station.

Practical Handling of Iowa Clays with Application of Ceramic Principles. By Homer F. Staley and Milton F. Beecher. 48 pages, 6 by 9 inches. Published by the Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa, as Bulletin 43 of the Engineering Experiment Station.

On the Making of Munitions. 55 pages, 7½ by 10 inches. Published by the Munition Boards Publicity Bureau, Municipal School of Technology, Manchester, England.

This is a classified index to the various articles that have appeared in some of the engineering periodicals on the manufacture of munitions since the beginning of the European war. While not complete, it will be most useful to all who are intent on securing references to the many articles that have appeared in the technical press of Great Britain and the United States.

Specifications and Tolerances for Weights and Measures and Weighing and Measuring Devices. 44 pages, 6 by 9 inches. Published by the Department of Commerce, Washington, D. C., as Circular of the Bureau of Standards No. 61.

These specifications were issued in order to obtain the greatest measure of efficiency from weights and measures laws and rules and regulations. Since the first adoption of these specifications and tolerances some additions and amendments have been made as opportunity was offered to study and draft requirements for new types of apparatus. The experience of several years has demonstrated that a set of standard requirements has now been developed which meets the needs of trades throughout the country. The circular will be sent free on request.

Cooperation in American Export Trade. Part I. Summary and report. 387 pages, 6 by 9 inches. Part II. Exhibits. 597 pages, 6 by 9 inches. Published by the Federal Trade Commission, Washington, D. C.

This report, made by the Federal Trade Commission in two parts, is the result of the commission's investigation into trade conditions in and with foreign countries, where associations, combinations and other conditions affect the foreign trade in the United States. Part II deals with exhibits, being made up of special reports from U. S. Consuls in various countries, excerpts from public hearings, replies from inquiries, etc. Examples of prices and trade agreements of foreign combinations are also given. The report is comprehensive and may be studied with much profit by American manufacturers generally who are intent on formulating a business policy that will provide for the exigencies likely to follow the close of the European war.

Thomas' Register of American Manufacturers. 3500 pages, 9½ by 12 inches. Published by the Thomas Publishing Co., New York City. Price, $15.

The eighth edition of this mammoth work, which is claimed to be the largest classified reference book is divided into five sections, as follows: Section I, finding list or index; Section II, lists of manufacturers classified according to business; Section III, manufacturers of the United States, arranged alphabetically by names, giving home offices, branches, names of officers, sales managers, purchasing agents, etc.; Section IV, leading trade names, brands, etc.; and Section V, appendix containing lists of banks, boards of trade and other commercial organizations, leading trade papers, leading manufacturers' representatives, etc. The sections are printed on white, yellow, pink and blue paper, thus facilitating reference to them. The classification of manufacturers contains 70,000 headings, and covers all manufactured products. The manufacturers' capital or size rating is included, ranging from $500 to $1,000,000. This feature is valuable when using the list for circularizing or other purposes, as it indicates the approximate size of the concerns.

The Elements of Refrigeration. By Arthur M. Greene, Jr. 472 pages, 6 by 9 inches; 192 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $4 net.

This work was prepared with the idea of bringing together in logical order the necessary data required to design, construct and operate refrigerating apparatus. It is suitable for the use of technical students, engineers and those operating refrigerating apparatus. A feature which makes it well suited for use in technical schools is a set of problems in the last chapter illustrating most of the computations which must be made in refrigerating work. The book deals with early methods of refrigerating, different systems of cold storage, refrigerating costs, air machines, and then takes up the thermodynamics of refrigerating apparatus. The types of machines and apparatus are described. Chapter V deals with heat transfer, insulation and amount of heat, and the following chapter with cold storage. Ice making and other applications of refrigeration, costs of insulation and operating costs are taken up in turn. The book is one that can be recommended to all needing a treatise on refrigeration, dealing with the practical and theoretical sides of the subject.

Advertising by Motion Pictures. By Ernest A. Dench. 255 pages, 5 by 7½ inches. Published by the Standard Publishing Co., Cincinnati, Ohio. Price, $1.50.

This book, by a motion picture expert who has given much attention to the commercial possibilities of motion pictures for advertising, demonstrating machinery, etc., was written for the purpose of emphasizing the value of the motion picture in the advertising and business educational fields. It should appeal to all classes of manufacturers desirous of demonstrating their machines and products through the eyes. It dwells on the advantages of telling an advertising story by motion pictures, and describes some of the film advertising methods used by manufacturers. Salesmanship demonstrations by the film and various aspects of the selling game are taken up, including selling shoes, automobiles, real estate, transportation, etc. The author touches on the entertainment side of the motion picture business, showing how manufacturers may use motion pictures to interest and attract employes. Data are included on the cost of equipment, fitting up theaters, etc., which should interest manufacturers in isolated communities especially where there is a scarcity of other means of entertainment.

Handbook for Machine Designers, Shop Men and Draftsmen. By Frederick A. Halsey. 561 pages, 9 by 12 inches; illustrated. Published by McGraw-Hill Book Co., Inc., New York City. Price, $5 net.

This work, first published in 1913, now appears in the second edition, revised and enlarged. Additional matter appears on thrust bearings, roller bearings, critical speed of shafts, geometrical progression of speeds, spur and herringbone gears, and other gearing subjects, including worm-gears, roller chains, friction clutches, spiral springs of the watch spring type, measurement of tapers, velocity and force relations of link work, relation of Brinell and scleroscope hardness numbers, heat-treatment of steel. New tables have been added including lengths of circular arcs, cutting speeds and revolutions, decimal equivalents of prime number fractions, etc. It is the author's plan to keep the work constantly up to date, and corrections, suggestions and contributions are solicited from users. The author recognizes the fact that it is impossible to keep a work of this kind abreast of the times without giving it constant revision and securing the cooperation of mechanical engineers, designers and others having use for the varied mechanical data that it contains.

NEW CATALOGUES AND CIRCULARS

American Blower Co., Detroit, Mich. Bulletin 13, describing "A B C," Type D and "Cyclone" disk ventilating fans.

Charles Stecher Co., 1574 Crossing St., Chicago, Ill. Catalogue of parts for hand screw machines of the plain head and friction head types.

Rochester Ball Bearing Co., Inc., 203 State St., Rochester, N. Y. Bulletin 10, comprising a descriptive price list of Rochester ball thrust bearings.

C. M. Conradson, Eau Claire, Wis. Circular of the Conradson No. 3 duplex helical drive, plain milling machine with longitudinal feed in either direction and both cross and vertical feed.

Stow Mfg. Co., Binghamton, N. Y. Miniature of bulletin 102, reproduced in small size for quick reference. This bulletin treats of Stow flexible shafts and their application to various tools.

Pennsylvania Railroad, Philadelphia, Pa. Safety calendar for 1917, for use in schools to impress on the minds of children the danger of crossing railroad tracks at unguarded "short-cuts."

Athol Machine Co., Athol, Mass. Catalogue 32, illustrating and giving dimensions, prices, etc., of Athol vises, display stands, taper attachments, pipe grips, wrenches, grindstones, countershafts, bench grinders, etc.

Cincinnati Automatic Machine Co., Cincinnati, Ohio. Catalogue of Hayden ¾- by 3-inch five-spindle automatic screw machines, containing information as to equipment, capacity, speeds, control, drive, etc.

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. Bulletin 129, illustrating Chicago hose, hose couplings and hose clamp tools. Bulletin E-45, superseding E-40, of "Duntley" direct-current portable electric hoists.

National Tube Co., Frick Bldg., Pittsburg, Pa. Circular illustrating graphically "National" pipe progress in twenty-eight years. It is stated that ninety per cent of the present pipe production of this country is steel pipe.

United Hammer Co., 141 Milk St., Boston, Mass. Circular of the Fairbanks power hammers, Dupont pattern, formerly manufactured by E. & T. Fairbanks & Co. of St. Johnsbury, Vt., and now made by the United Hammer Co.

Eclipse Interchangeable Counterbore Co., Inc., Detroit, Mich. Catalogue illustrating and describing the "Wiard" chuck made in three sizes. The catalogue also gives price lists of Eclipse interchangeable counterbores and holders.

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. Bulletin 34-W illustrating and describing "Giant" low-grade fuel oil engines. Bulletin 263 describing the Boyer railway speed recorder and giving instructions for applying and operating.

Manhattan Machine & Tool Works, Grand Rapids, Mich. Circular descriptive of the Manhattan toolroom screw press for the use of diemakers in shearing punches into dies, etc. The press is made with a large bed and ample clearance between the bed and ram.

McCrosky Reamer Co., Inc., Meadville, Pa. Catalogue 4 entitled "Cost-cutting Machine Shop Tools," giving specifications for McCrosky reamers, "Wizard" quick-change chucks and collets, expanding mandrels, "Wizard" variable-speed and reversing attachment, etc.

Midvale Steel Co., Philadelphia, Pa. Catalogue of Midvale high-speed tool steels, giving general information on the properties of high-speed steel, forging, annealing, heat-treatment, grinding, tests, etc. A list of the various grades of Midvale high-speed steel and the work for which each is adapted is included.

Gisholt Machine Co., 1212 E. Washington Ave., Madison, Wis. Circular entitled "How to Save Money on High-speed Steel," illustrating Gisholt tool-holders with inserted high-speed tools. With these tools it is possible to use high-speed steel tools down to the last inch. A table of dimensions and prices is given.

Beaudry & Co., Inc., 141 Milk St., Boston, Mass. Booklet illustrating and describing Beaudry hammers, made in two types—the "Champion" and the "Peerless"—and in sizes from 25 to 500 pounds weight of ram. Motor drive can be easily applied to these hammers, and a number of motor-driven hammers are illustrated.

Morse Chain Co., Ithaca, N. Y. Catalogue 15, covering small power drives, showing illustrations of the construction and action of the Morse silent chain and its application in a number of different industries. The catalogue is profusely illustrated with halftone illustrations of actual installations that indicate the wide range of application of silent chains.

Associated Manufacturers and Merchants, White Bldg., Buffalo, N. Y. Copies of new rules governing so-called dangerous trades that are now being considered by the New York State Industrial Commission. The rules apply to the manufacture of thermometers, mattresses, gloves, industries using

wood alcohol, cleaning and dyeing works and chemical trades.

Warner & Swasey Co., Cleveland, Ohio. Catalogues of universal hollow-hexagon turret lathes. These catalogues illustrate the hollow-hexagon turret lathe equipped for bar and chucking work and show the standard bar and chucking equipment. Various types and sizes of turret screw machines and turret lathes are illustrated and specifications for each are given.

New Departure Mfg. Co., Bristol, Conn. Loose-leaf sheets Nos. 79 FE to 82 FE, inclusive, describing various installations of ball bearings, among which are ball bearings in Jordan pulp mill, vertical grindstone shaft bearing mounting, ball bearings for gear-driven through shaft, ball bearings for bevel gear shafts and ball bearings for worm-gear-driven elevator cable winding drum.

Heald Machine Co., 20 New Bond St., Worcester, Mass. Catalogue of magnetic chucks, revised and brought up to date. The catalogue treats of magnetic chucks and their application, design and construction of the Heald magnetic chuck, rotary type magnetic chucks, rectangular or straight type magnetic chucks, special types, and demagnetizing switch, demagnetizer and generator.

Cincinnati Lubricant Pump Co., 120 Opera Place, Cincinnati, Ohio. Booklet entitled "Scientific Lubrication of Cutting Tools," treating of the history of cutting tool lubrication, functions of lubricants, volume of coolant necessary, water solutions as coolants, applications of coolants, and means of delivering coolants. This booklet also contains a description of the "Fulflo" centrifugal lubricant pump.

Pennsylvania Railroad, Philadelphia, Pa. Poster issued for the purpose of warning people against crossing the tracks or otherwise trespassing on railroad property. The new "Stop" poster will be displayed at places where the general public is accustomed to take short-cuts across the tracks or to use the railroad right-of-way as a highway. It will also be placed on all bulletin boards in the stations and waiting rooms of the Pennsylvania Railroad system.

Armstrong Cork Co., Pittsburg, Pa. Pamphlet descriptive of "Nonpareil" corkboard insulation for cold storage warehouses, ice plants, creameries, packing plants, fur vaults, refrigerators, etc. Pamphlet entitled "Fifteen Years on Brine Lines," illustrating the condition of "Nonpareil" cork covering after fifteen years of service on a 1½-inch brine line, which shows graphically the adaptability of cork covering for this work. Copies of these pamphlets will be sent free upon request.

Midvale Steel Co., Philadelphia, Pa. Catalogue 33 of alloy and tool steel, containing information on the properties, treatment, etc. A table is included which gives the temperatures to which steel should be heated to temper it for different kinds of service. A list of the brands of Midvale carbon tool steels and high-speed steels, and the uses for which they are suited, is also given. Sections are devoted to stellite, alloy steels, steels for hot working, etc. Section 5 contains many useful tables and gives critical temperature and physical property curves of Midvale steels.

Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio. Catalogue 70, entitled "Hydraulic Presses and Pumps." This catalogue contains 84 pages, 8 by 10 inches, describing and illustrating the line of hydraulic machinery built by the company. The types of machinery especially intended for export and use in foreign countries are described. The catalogue gives considerable general data, and in addition illustrates metal-working presses, veneer presses, baling presses, abrasive wheel presses, leather presses, butchers' and packers' presses, oil presses, cider, wine and grape-juice presses, hot plate presses, hydraulic valves and hydraulic pumps.

Pennsylvania Railroad, Philadelphia, Pa. Booklet entitled "Pennsylvania Railroad System—Historical and Descriptive, with Annotated Map." This booklet has been issued to preserve in permanent form the most interesting and picturesque incidents connected with the settlement and subsequent development of the region traversed by the Pennsylvania Railroad system. Another purpose is to set forth the present character of the various portions of the territory with reference to industry, mining, agriculture and commerce. A brief description is given of all the cities and of the more important towns, with the business advantages of each. The book is profusely illustrated, and is accompanied by a large folding map.

Wilson Welder & Metals Co., Inc., New York City. Catalogue 1, treating of electric welding. The book describes the Wilson system of welding, its development, scope and points of superiority. Details are given of the specially prepared metal electrodes which are not adversely affected by the heat of the arc. The equipment is shown by numerous half-tone and line engravings, and specifications for the motor-generator sets, etc., are given. The book concludes with results obtained from the use of the Wilson system, showing some interesting jobs of welding; physical tests of electrically welded joints; and tables of weights and measures, wiring table, specific gravity and fusing point of metals, high temperatures judged by colors and various temperatures of furnaces.

TRADE NOTES

Universal Machine Works, makers of toolpost turrets, have moved from 211 W. 59th St., New York City, to 626 Driggs Ave., Brooklyn, N. Y.

Himoff Machine Co., manufacturer of lathes, screw machines and gear hobbing machines, has moved from 138 Mott St., New York City, to more spacious quarters at 45 Mills St., Astoria, L. I.

Rockford Machine Tool Co., Rockford, Ill., manufacturer of shapers, planers, drilling machines and vertical milling machines, has completed a large addition to its plant, including a new office building.

Burdett Oxygen Co., 1401 Jackson Blvd., Chicago, Ill., has recently completed the erection of a new plant at 40th St. and Allegheny Valley Railroad, Pittsburg, Pa., and is now in a position to furnish oxygen to users in the Pittsburg territory.

Ott Grinder Co., 32 N. Clinton St., Indianapolis, Ind., has been incorporated with a capital of $50,000, and is now equipping a plant for the manufacture of its No. 2 universal grinding machine for the present, and for smaller and larger sizes later on.

H. E. Harris Engineering Co., Bridgeport, Conn., is planning extensive additions to its plant, with the purpose of tripling the present capacity. The company has taken a five-year lease of the property at 1041-1055 Broad St. and 116-118 John St., Bridgeport, Conn., where the offices and factory are now located.

T. A. Willson & Co., Inc., 3rd and Washington Sts., Reading, Pa., has leased a prominent spot at the National Advertisers Permanent Exposition on Garden Pier, Atlantic City, N. J., for the educational purpose of instructing the general public in the various uses of Willson goggles and safety glasses. A demonstrator will be constantly in charge.

Mansfield Lock Washer Co., Mansfield, Ohio, was recently organized for the manufacture of lock washers. The officers are W. H. Davey, president; Charles F. Ackerman, vice-president; A. E. Witter, secretary and treasurer; and F. E. Kessel, general superintendent. Mr. Kessel is the inventor of the machines that will be used in the production of the lock washers.

Link-Belt Co., Chicago, Ill., has made extensive additions to its Belmont works to keep pace with the demand for Link belts for conveying, elevating and power transmission purposes. The fifth furnace of the Belmont plant of the company at Indianapolis was blown in the middle of December, adding materially to the capacity of the plant for producing malleable link-belts.

Black & Decker Mfg. Co., Calvert and Lombard Sts., Baltimore, Md., has purchased a ten-acre tract on the outskirts of Baltimore with railway facilities, on which a factory will be erected for the manufacture of the "Lectroflater" (an electrically-driven air pump for garages) and the B & D electric drill. The business of the company in these lines is growing so rapidly that a new plant is necessary to take care of it.

Hodge Engineering & Contracting Co., Inc., Equitable Bldg., New York City, have been organized to act as expert advisers in connection with the manufacture of small arms ammunition and primers of all types. Theodore DeW. Moore, recently associated with the company, brings to it knowledge of the fire-arms and ammunition business gained by some thirty years' experience in its commercial and manufacturing branches.

Western Tool & Mfg. Co., Springfield, Ohio, manufacturer of "Champion" tool-holders, vises, shop furniture, hacksaws and foundry equipment, has made two large additions to its plant to take care of its rapidly increasing business. One of the additions is to enlarge the shop furniture department, which has grown very rapidly. The company has recently purchased the patents for the Victor universal vise, and is now ready to fill orders.

American International Corporation, 120 Broadway, New York City. Preliminary report of the president to the stockholders. The American International Corporation in February, 1916, acquired the entire capital stock of the Allied Machinery Co. of America, which conducts an export business in machine tools. It also has extensive business in other lines in foreign countries, including contracting, trading, rosin and turpentine manufacture, shipping, etc.

W. H. Nicholson & Co., 112 Oregon St., Wilkes-barre, Pa., have completed the new addition to their plant which has been under construction for some time. The new machinery required is being installed. The addition, which will increase the floor space about 100 per cent, was needed to meet the increasing demand for the Nicholson expanding mandrels, compression shaft couplings, "Wyoming" steam specialties, as well as gage, jig and fixture work.

Stocker-Rumely-Wachs Co. is the successor to the H. A. Stocker Machinery Co. and the Rumely-Wachs Machinery Co., and will be located at 117-121 N. Jefferson St., Chicago, Ill. The officers are H. A. Stocker, president; W. N. Rumely, vice-president; H. J. Reeve, treasurer; O. A. Wachs, assistant treasurer; and Edward H. Wachs, Jr., secretary. The capital stock of the new organization will be $225,000. The selling force of both concerns will be retained.

Grand Rapids Grinding Machine Co., Grand Rapids, Mich., is a new concern recently incorporated to manufacture a line of grinding machinery. The president and treasurer is S. Owen Livingston, formerly secretary and general manager of the Wilmarth & Morman Co. of Grand Rapids, and the vice-president and superintendent is J. DeKoning, formerly superintendent of the Wilmarth & Morman Co.'s shop. The secretary is Charles F. Hext, who will not at present actively participate in the business management.

Cosmic Chemical Co., Ltd., has recently opened offices at 74 Cortlandt St., New York City. This firm manufactures cutting oils, drawing compounds, greases and automobile soaps. It has developed, after years of experimenting, an artificial lard oil which is claimed to be equal to animal lard oil. A refinery consisting of six large buildings has recently been completed at Trenton, N. J., to meet the increasing demand for the company's product. The company is a close corporation and is fully equipped to meet any demands. Marvin F. Wood is the sales manager.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., announces an extension of its present bonus system to include salaried and office employes on hourly rates, by which they will receive a bonus of 8 per cent of their salary each month, providing their total excusable time absent and late during the month does not exceed six hours incurred on not over three occasions. An additional 4 per cent will be given each month to the employe who has not lost any time from work during the month through absence or tardiness, thus enabling those affected to obtain an increase in earnings of 12 per cent for 100 per cent attendance. Several thousand employes in the Pittsburg district will be benefited by the granting of the bonus.

Landis Tool Co., Waynesboro, Pa., has erected a new factory for the manufacture of its floor-type boring, milling, drilling and tapping machine. The building is of brick, concrete and steel, and of fireproof construction throughout. It is 105 feet wide, 176 feet long, and has a concrete floor, concrete tile roof, steel sash and steel partitions throughout. The building is divided into three sections. The main bay is 60 feet wide, 136 feet long, and is spanned by a ten-ton electrically operated crane. Parallel to the main bay is the machine shop, which is 45 feet wide, 176 feet long, and of saw-tooth roof construction. The northwest section of the building is two stories high, the office and drawing-room being located on the top floor, and the wash-room and locker-room on the first floor.

Thomson Spot Welder Co., Cincinnati, Ohio, which has been recently formed under the Massachusetts laws, has acquired all the patents for the process of spot-welding and spot-welding machines formerly held by the Thomson Electric Welding Co. and the Universal Electric Welding Co. It has also acquired all the physical assets and all the spot-welding patents, etc., of the Toledo Electric Welder Co., Cincinnati, Ohio, which is being liquidated after having been forced into litigation to admit the validity of the Harmatta patent. The butt-welding machine business formerly conducted by this company has been taken over by the Thomson Electric Welding Co., Lynn, Mass., who will manufacture these machines in the future and look after the needs of the Toledo Electric Welder Co.'s customers.

United Hammer Co., 141 Milk St., Boston, Mass., has issued an announcement in regard to the Fairbanks hammers. These have been manufactured since 1890; first, by the Dupont Mfg. Co. of St. Johnsbury, Vt., who marketed them under the name "Dupont" hammers. In 1902 the business was taken over by E. & T. Fairbanks & Co., St. Johnsbury, who have been manufacturing them since, giving the machines the name "Fairbanks" hammers, which title will be continued by the United Hammer Co. During the time the hammers were manufactured by E. & T. Fairbanks & Co. they were sold by their selling agent—the Fairbanks Co. of New York City, and branches in the East; by Fairbanks, Morse & Co., Chicago, and branches in the West; and by the Canadian Fairbanks Co. in Montreal, and by its branches in Canada. They were also sold in Europe by branches of the Fairbanks Co. About 1400 installations have been made.

Precision Die Casting Co., Inc., Syracuse, N. Y., was recently organized to take over the business of the Van Wagner Die Casting Corporation and the Precision Die Casting Co.; the two concerns being merged and capitalized at $315,000. The officers are T. G. Meachem, president; J. W. Knapp, vice-president and general manager; H. S. Tenney, treasurer; and E. J. Quintal, secretary. T. G. Meachem, the president, is widely known as the active head of the New Process Gear Corporation of Syracuse. This company continued making gears in a small way for years until Mr. Meachem took hold of the business, and its present size and standing is a monument to his energy and business ability. No changes will be made in the personnel of the Precision Die Casting Co.'s plant or organization, but such alterations and extensions will be made as are necessary to secure improved quality and better service in the production of die-castings.

Doehler Die-Casting Co., Court and Ninth Sts., Brooklyn, N. Y., realizing the increasing cost of living, has announced that a wage dividend will be paid to its employes beginning January 1, 1917. This dividend will amount to 10 per cent per annum to all employes, based on the wages actually received, including piece-work and overtime. The wage dividend will be declared quarterly, the same as the stock dividend. It will be subject to the following conditions: (1) An employe must be in the employ of the Doehler Die-Casting Co. without interruption for a full year before he can participate in the wage dividend; his dividend will be calculated from the date of completing the first year's employment to the date of declaration of the dividend. (2) The dividend will be paid in full to all employes who have been in the employ of the company for a full period of three years or more. (3) Two-thirds of the dividend will be paid to all employes who have been in the employ of the company for a full period of two years and less than three years. (4) One-third of the dividend will be paid to all employes who have been in the employ of the company for a full period of one year and less than two. It is further announced that beginning January 1, 1917, all employes who have been working on the basis of fifty hours per week will be put on a basis of forty-eight hours per week at the same pay. The company employs 1200 men and has a weekly pay-roll of approximately $25,000.

Training Apprentices[1]

The Pratt & Whitney System of Making Skilled Mechanics

The need of apprenticeships in American manufacturing plants is reflected in the great scarcity of trained machinists. Machine operators and specialists have their places, but men of general experience are also required. This article describes the apprenticeship system of the Pratt & Whitney Co. which was organized under the direction of B. M. W. Hanson for the express purpose of training men to be machinists. The company will depend upon these trained men for the future leaders in its factory.

THE modern development of the manufacturing industries has firmly established the principles of specialization. Specialized methods have made feasible the employment of a larger proportion of unskilled and semi-skilled men in the industries than was possible in the earlier days, and less attention has been paid to the question of renewing the supply of skilled workers by training apprentices. As a consequence, the scarcity of skilled labor has become apparent during the last decade, and during the past few years manufacturers have been forced to consider the problem of reviving apprenticeship systems along lines which will meet the new industrial conditions. In re-establishing apprenticeship systems, however, many difficulties have had to be overcome. The conditions in modern manufacturing plants make it out of the question for the foremen to give the same attention to the apprentices that was common a generation or more ago. The changed conditions have also made it necessary that the apprentice of today should be trained along broader lines than in the past—he must be taught some of the principles on which his work depends, as well as the mechanical operations, and he must be made to understand not only the methods, but the reasons for the methods, so that he can adapt himself to new processes when required.

As a consequence, some of the larger companies in the machine-building field have established a more modern type of apprenticeship system in their plants. The apprentice schools of the General Electric Co. at Lynn and Schenectady, the New York Central Railway Co., the American Locomotive Works, and the Solway Process Co. may be mentioned as examples. Some of these apprentice schools, however, have been developed specifically for training young men for a special branch of the industry, and it has been left largely to the machine-tool builders to develop apprenticeship systems for training all-around mechanics who can take their place anywhere in the machine-building field. The machine-tool builders, in fact, have in the past been the leaders in training skilled mechanics, and among the plants which have turned out some of the best mechanics of the country, that of the Pratt & Whitney Co., of Hartford, Conn., occupies a prominent place. This company has maintained apprenticeship systems continually since its inception in the middle of the past century; and during the past few years this system has been developed along the modern lines made necessary by the changed conditions in mechanical practice and methods of management.

Trade Schools and Apprenticeship Systems

When it became apparent that steps had to be taken to train skilled mechanics for the machine-building trades, trade schools were thought by many to present the solution of the problem. Some very good trade schools are maintained both by municipalities and by private enterprise, and these contribute a part of the training required. So-called half-time schools, which are maintained by the communities in which they are located in cooperation with manufacturing plants have also been tried with good results. In these, two groups of apprentices spend alternately one week in school and the next week in productive work in machine shops. This makes it possible for small shops to give their apprentices an opportunity for training. The expense of the teaching is, as a rule, borne by the public school system. Schools are also maintained by the coopera-

[1] For other articles on apprenticeship systems previously published in MACHINERY, see "Training the Apprentice," May, 1916; "More Light on the Selection of a Trade," May, 1916; "Training of Shop Teachers for Industrial Schools," September, 1915; "The Advantages of Manual Training High Schools," March, 1914; "A Modern Apprenticeship System," June, 1913; "Development of Skilled Mechanics," June, 1913; "Features of Apprenticeship System at the G. E. Co.'s Lynn Works," April, 1912; "Training of Machinists in the Trade School," July, 1911, and other articles there referred to.

tion of a number of employers whose apprentices attend classes during a limited number of hours each week. Evening schools are also maintained on a larger scale than ever, and tend to facilitate the education of apprentices. However, no one of these methods has proved to be as effective for the training of all-around machinists as the regular shop apprenticeship system. The real burden of training mechanics rests upon the industries themselves, to whom the supply of skilled mechanics is a necessity, and those companies that have recognized this and have taken steps to develop modern apprenticeship systems are making a real contribution to the solution of the all-important problem of maintaining a supply of skilled mechanics. The present article will review the Pratt & Whitney Co.'s apprenticeship system as studied by a member of MACHINERY's editorial staff.

Fig. 1. A Lesson in Shop Practice in the Class-room

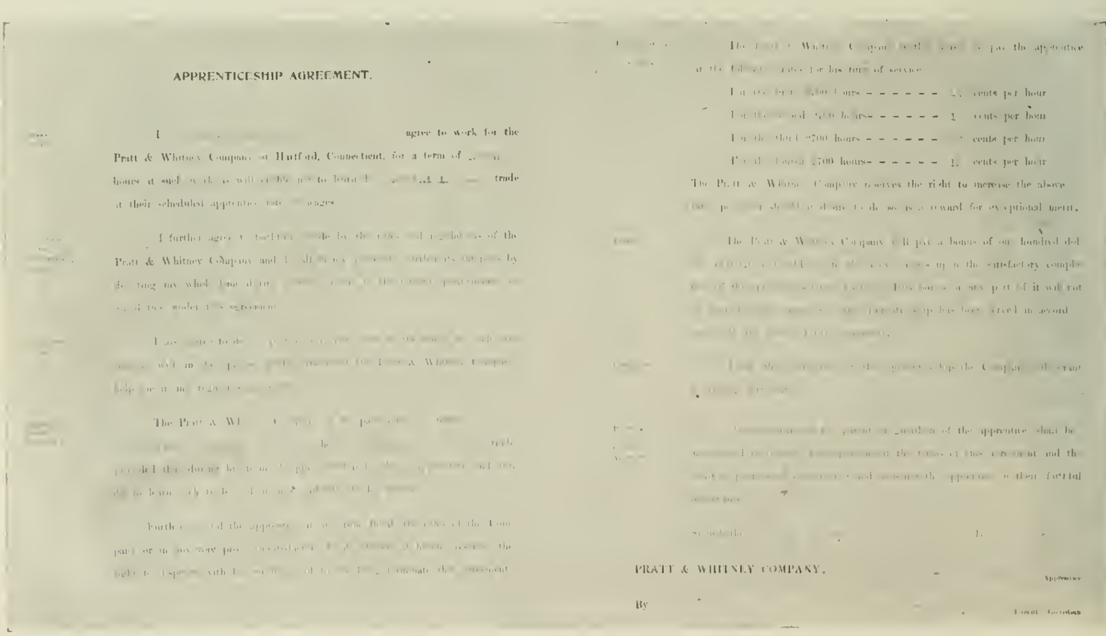
Pratt & Whitney Co.'s Apprenticeship System

The apprenticeship system of the Pratt & Whitney Co. has been developed under the direction of B. M. W. Hanson, vice-president and general manager of the company. In the development of this system, Mr. Hanson laid down five cardinal conditions that are essential to the establishment of a successful undertaking of this kind, as follows:

1. The object of the apprenticeship system should be to produce machinists.
2. The working conditions in the factory must be such that the interests of the workmen and the factory are as nearly as possible interwoven.
3. Every machinist in the employ of the company must be intelligent.
4. The company will depend upon its apprenticeship system for the future leaders in its factory.
5. Mechanical skill is not the only requirement a good mechanic should have; a great deal of attention must be paid to his moral and physical characteristics as well.

Great stress is laid upon the fact that the apprentice should realize that the calling of the machinist is an honorable and respectable one, and that all the men in the company's factory connected with mechanical work, from the vice-president and general manager down, are all primarily machinists. In referring to this point, in a recent interview, Mr. Hanson said: "I believe it is up to the management of machine shops to make the machinist's trade an honorable one, and I do not see any reason why the professional mechanic should not have as good a standing as the professional doctor or lawyer. If a doctor or a lawyer gives advice to his patients or his clients, and the latter do not obtain the result expected from the advice, they have to pay for it just the same; but whatever goods the mechanic delivers must be right, or he cannot get his pay. If a machine establishment ships a machine that does not do the work for which it is intended, it has to refund the money and take back the machine. Hence, the mechanical man is expected to do whatever he does right, and, considering the fact that more is expected of him than of many other members of the community, why should his work not also be considered as important and as honorable?"

In building up its modern apprenticeship system, the Pratt & Whitney Co. has therefore entered upon its task with a somewhat different spirit from that existing in the past. The fact has been recognized that it is as important to select the proper material for future mechanics as it is to test and select the material from which machinery is built. In a great many shops, a high-class purchasing agent is employed for buying



APPRENTICESHIP AGREEMENT.

PRATT & WHITNEY COMPANY,

By

Fig. 2. Pratt & Whitney Co.'s Apprenticeship Agreement

the materials used in production, but almost anyone is supposed to be capable of hiring men and taking in boys for training. This principle is now recognized as wrong, and great care is taken in selecting the proper material for training future mechanics.

Supervision of the Apprenticeship System

In the old-time apprenticeship system, the boys were under the direct supervision of the foreman in whose department they were employed and were dependent upon him for all the instruction they received. Some foremen were good instructors and had the ability to train good mechanics; others were poor instructors, and the results were discouraging. Under modern shop conditions, the foremen, whether they are good or poor instructors, have so many other duties relating to the productive efficiency of the shop that it would be impossible to expect them to instruct or supervise the apprentices to any extent. All that the foreman can be expected to do is to give the apprentice his work, briefly outline to him the method of procedure, and see that his productive capacity and habits meet the requirements. In a large shop, also, there are so many departments, and the boys must be distributed under so many different foremen, that if the training were done entirely by the foremen there would be a great difference in the mechanical education of the boys trained in the same shop. Hence, all the apprentices at the Pratt & Whitney Co.—at the present time 135 in number—are directly in the charge of a supervisor of apprentices, H. F. Penney, who is responsible for the operation of the apprenticeship system just as the head of any manufacturing department is responsible for the results of production. The supervisor selects the boys, distributes them to the various foremen throughout the plant, changes them from time to time from one department to another, directs their class instruction, and, in general, acts as their counsellor and friend. A special room is set aside and equipped for the use of the boys, and this serves both as a class-room and as a lunch and reading room, and here the supervisor also has his headquarters. The boys come in classes of about twenty at a time for certain periods each week during working hours to receive instruction and training supplementary to that obtained in the regular productive work of the shop. An effort is made during these class hours to give the boys a general understanding of the fundamental principles that underlie all mechanical industries, and to make them appreciate their own branch of work, as well as to give them technical and specialized trade instruction. The details of the courses of study are given in a subsequent part of this article. The class-room, as mentioned, also serves as a social center for the boys where they can gather to eat their lunch and to read and play games every noon. The supervisor makes it a point to be present at this hour; he eats his lunch with the boys, and finds in this way an excellent opportunity for gaining their confidence and friendship. This is one of the important features.

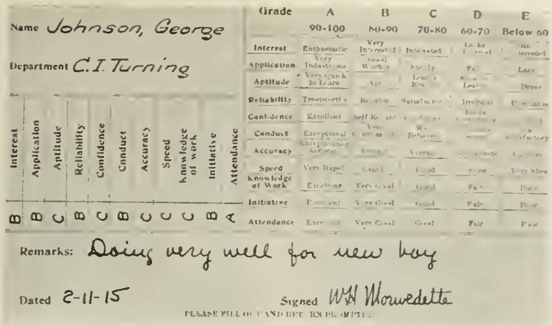
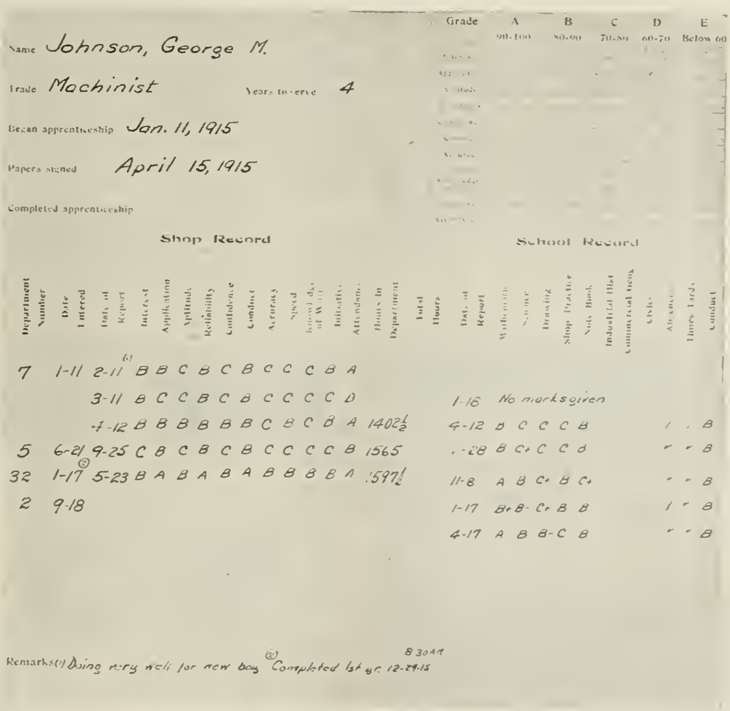

Name Johnson, George
Department C.I. Turning
Grade: A 90-100, B 80-90, C 70-80, D 60-70, E Below 60
Interest, Application, Aptitude, Reliability, Confidence, Conduct, Accuracy, Speed, Knowledge of Work, Initiative, Attendance
B B C B C B C C C B A
Remarks: Doing very well for new boy
Dated 2-11-15
Signed

Fig. 3. Foreman's Report on Work and Character of Apprentice

Qualifications for Admission to Apprenticeship Course

Any boy over sixteen, normally developed, who has successfully finished the regular grammar school course, is eligible to enter the apprenticeship course. Sufficient physical maturity is required, and if a regular grammar school education is lacking, the boy will not be accepted unless he can show evidence of some other qualifications that are especially desirable. An effort is made to obtain boys who have had some high-school education, and allowance is made in the length of the apprenticeship course of those who have completed a full high-school course and who can give a testimonial as to scholarship. This allowance varies from six months to one year, depending upon the nature of the course pursued while in school. The regular apprenticeship course is four years, but young men of twenty-one are given a three-year apprenticeship, as their age usually makes it possible for them to acquire an equivalent training in that time; they are, as a rule, more advanced both as regards intelligence and application to their work. In spite of the high requirements for admission, the company has had no difficulty in maintaining the number of apprentices in their works between 130 and 140, which is considered a normal quota at the present time, but this is being gradually increased. There is also a constant waiting list of apprentices. It is of interest to note that the boys entering the apprenticeship course are not drawn from the immediate locality only, but many come from distant states at the advice of friends or relatives, and the apprenticeship course in that way may be looked upon as a school of national importance.


Name Johnson, George M.
Trade Machinist Years to serve 4
Began apprenticeship Jan. 11, 1915
Papers signed April 15, 1915
Completed apprenticeship
Grade: A 90-100, B 80-90, C 70-80, D 60-70, E Below 60

Shop Record

7 1-11 2-11 B B C B C B C C C B A
3-11 B C C B C B C C C C D
4-12 B B B B B B C B C B A 1402½
5 6-21 9-25 C B C B C B C C C C B 1565
32 1-17 5-23 B A B A B A B B B B A 597½
2 9-18

School Record

1-16 No marks given
4-12 B C C C B B
..-28 B C+ C C B B
11-8 A B C+ B C+ B
1-17 B+ B- C+ B B B
4-17 A B B-C B B

Remarks (1) Doing very well for new boy (2) Completed 1st yr. 12-29-15 B 30 Art

Fig. 4. Record kept by Supervisor of Apprentices, covering all Reports made by Shop Foremen and Class-room Instructors

Selection of the Best Material

When a boy applies for an apprenticeship, he is asked to fill out an application blank, giving, among other things, the name of his parent or guardian, his parent's or guardian's occupation, his own age, height, weight and nationality, together with the nationality of his parents. The form also includes questions as to whether he uses tobacco or

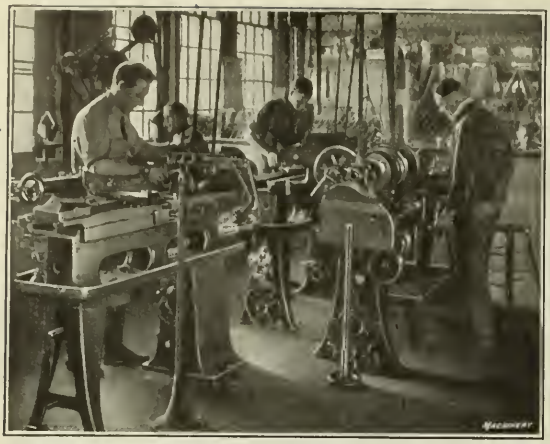


Fig. 5. Boys in their Third and Fourth Year working in Tool-room

Fig. 6. Apprentices in their Third and Fourth Year engaged in Toolmaking

intoxicating liquors, and as to whether he is naturally of robust health. Questions relating to education have then to be answered, and the reason given for seeking an apprenticeship, and also for selecting the Pratt & Whitney Co. as a place where to serve the apprenticeship. If the boy has had any previous business or mechanical experience, this is also noted on the application blank. When a boy inquires at the employment office concerning an apprenticeship, he is asked to fill out the application blank, and if he appears to be especially desirable, he is interviewed by the supervisor of apprentices on his first visit. If not, his application is filed and he is told to call again at some later date. Asking for a second visit has proved an effective method of eliminating those boys who are not in earnest. When the boy finally has been accepted, he is assigned to a manufacturing department where he is required to serve a trial period of three months.

The Trial Period

At the end of each month of the trial period, the foreman of the department to which the boy is assigned submits a written report of the boy's progress and general behavior. These reports are made on the special blanks shown in Fig. 3. Thus the supervisor is kept constantly informed as to the boy's ability and progress. The report contains information on the following subjects: interest, application, aptitude, reliability, confidence, conduct, accuracy, speed, knowledge of work, initiative and attendance, with a line for any special remarks. If the reports submitted during the trial period are satisfactory, the apprenticeship agreement between the company and the boy is signed. If the reports are not satisfactory and it seems evident that the boy is not fitted for the trade, he is frankly advised to seek some other line of work. After the trial period, similar reports are made at about six months' intervals, by the foremen in the departments where the boy works. Should the boy remain less than six months in any one department, a report is, of course, submitted by this department for the period of time that he has worked there. These reports are all copied onto the record sheet shown in Fig. 4, where the shop records as well as the class-room records of the boy, covering his whole apprenticeship period, are entered. On the back of this record the statements given in the application blank are entered, so that this card constitutes a complete record for each boy.

Shop Training

The shop training of the apprentices is obtained in the regular manufacturing departments of the company's plant. To insure an all-around experience, the boys are changed from one department to another as often as their progress warrants. The minimum stay in one department is usually six months, and as the boy advances in his apprenticeship, his stay in each department is usually lengthened, as he is then better able to profit by a thorough training in any one specific line. The following outline indicates the way in which an apprenticeship may be distributed throughout the plant: six months, cast iron turning department; six months, milling department; six months, steel turning department; six months, assembling department; six months, grinding department; nine months, planing department; nine months, tool-room. Owing to a number of variable conditions and also to the variation in the ability of the apprentices, no definite schedule is laid out, but the one given represents an average case.

In the shop the boys are directly responsible to the foreman of the department, who usually assigns them to a subforeman or gang boss, who, in turn, selects their work and gives them the necessary instructions. As mentioned, written reports are given to the supervisor as to the boys' progress and general behavior, and the supervisor seeks by frequent visits to the boys, while at their work, to keep closely in touch with them. An effort is made to impress the boys with the

Fig. 7. Apprentices taking a Lesson in Drawing—The Course is especially intended to teach the Reading of Working Drawings

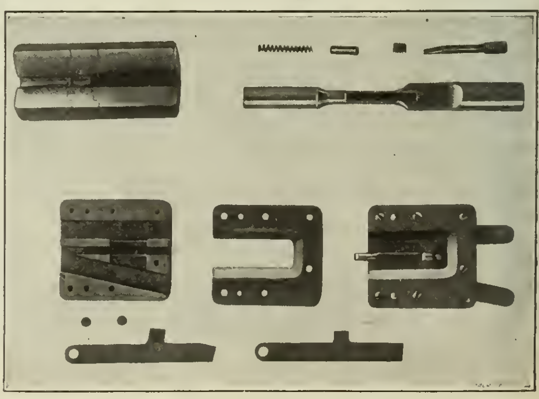


Fig. 8. Gages and Tools—Commercial Products—made by Apprentices in the Third and Fourth Year of the Course

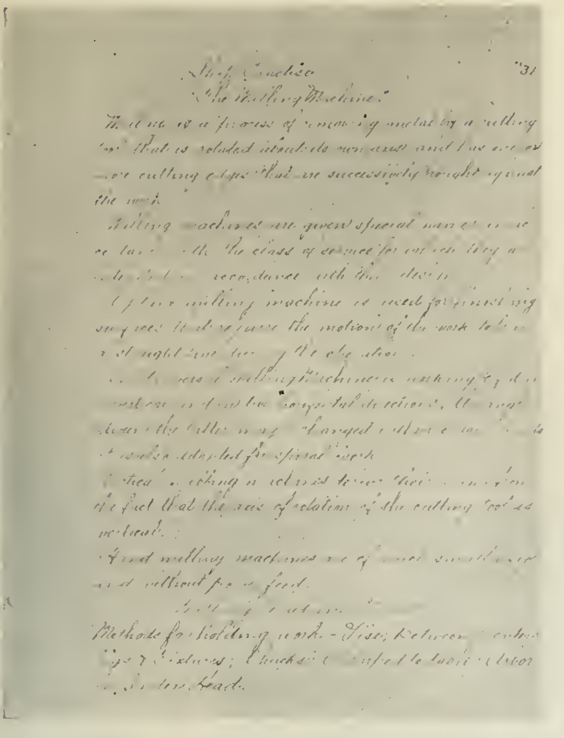


Fig. 9. Sheet from One of the Note-books kept by an Apprentice

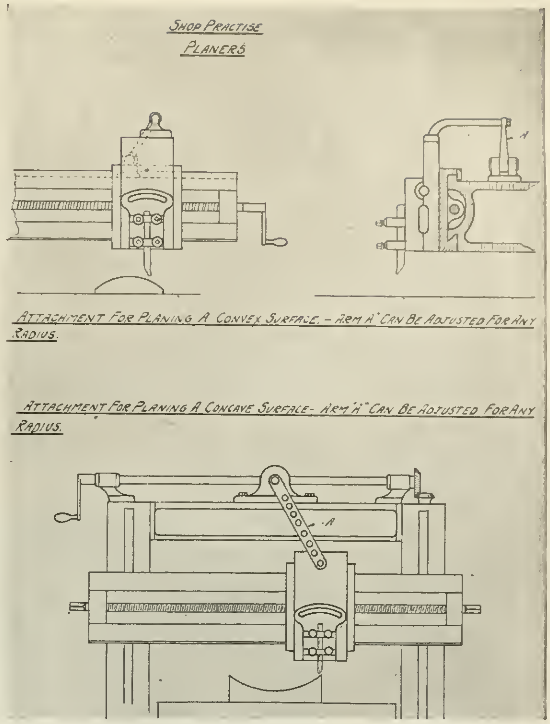


Fig. 10. Another Sheet from Apprentice's Note-book on Shop Practice

fact that their progress depends on their effort, and that the grade of work they receive is according to the ability they have shown. Thus, while no boy is accepted as a toolmaker apprentice, every boy is given the promise that if he shows the necessary skill and aptitude he will be given tool-room work before the termination of his apprenticeship. An example of the work done by tool-room apprentices is shown in Fig. 8. At present a special department is equipped in the company's plant for the manufacture of miscellaneous machine parts, such as vises, turret tools, oil pumps, etc. While operating on a strictly manufacturing basis, most of the work in this department is done by apprentices who begin their training here and are later transferred to the other departments as their skill warrants. Here the boys are under more direct supervision than in the regular manufacturing departments. When a boy in some other department fails to make the progress expected of him, he is brought back into this department, where he can be given the special assistance he requires.

Class-room Instruction

To supplement the shop work, the apprentices are given class-room instruction four hours each week. In order to interfere as little as possible with their work in the manufacturing departments, these four hours are included in one session, the hours for the different classes being from 8 to 12, or from 1 to 5. The classes consist of from eighteen to twenty boys each. The course of study is divided into four main headings, mathematics, drawing, science and theory of shop practice, the object being to impart as much of an understanding of the principles that underlie all shop work as is possible in the time devoted to this study. In addition to these subjects, a brief course is given in industrial history, commercial geography and civics.

Extent of Course

Considerable time is spent in a review of arithmetic. The boys are also taught how to use formulas given in handbooks, and to solve simple shop problems involving elementary geometry and the trigonometry of the right-angled triangle. The problems are selected from the regular shop work, which arouses great interest, as the boy can see the direct application of his mathematical studies to his work.

In drawing, the main object is to teach the boys to read blueprints and make simple sketches. During the first year,

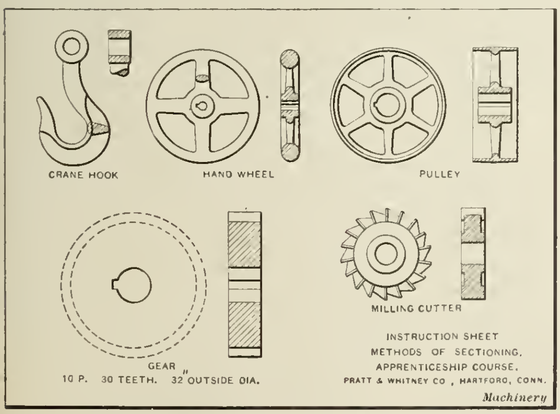


Fig. 11. Sample of Instruction Sheet used in Mechanical Drawing Course

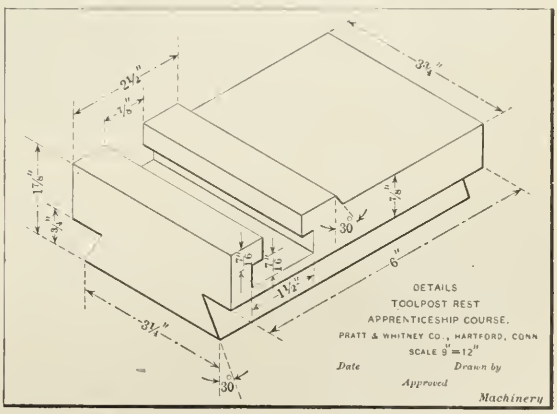


Fig. 12. Example of Isometric Projection View from which Boys work

the boys begin by making simple plates of letters. These are started in the class-room and finished at home, being brought back for inspection and correction. It has been found that the plates of lettering are of great value in teaching the boys to observe correctly and work neatly. The remainder of the first year is devoted to making working drawings of simple machine parts. As a model, the boy is given an isometric projection of the part (see Fig. 12) rather than the piece itself. It has been found that this method makes greater demands upon his powers to visualize the piece and select the proper views to present the object. The illustration shown in Fig. 12 is not a picture of the drawing the boy is to make, but simply a picture of the piece in isometric projection from which he is expected to make a regular mechanical drawing showing two or more views, according to the number that are required to present and dimension the piece properly. If a boy seems to have difficulty in visualizing the piece from the isometric drawing, a projection screen and a model of the piece itself are substituted in order to show him clearly how the piece will look in ordinary orthographic projection. During the later years of the apprentice course, most of the drawing work consists of sketching simple tools and machines, and making finished drawings from them. Throughout the course the standards, rules and drafting-room practice employed in the company's drafting-room are adhered to.

The course in science is devoted, during the first year, to the study of the first principles of mechanics and their application in simple machines. In the second year the elementary principles of heat, light, sound and electricity are covered. Such subjects as light and sound are dismissed with one or two brief lectures each. The subject of heat, however, is given more consideration, as there is an opportunity in this case to point out the effect of heat in connection with shrink fits, hot bearings, and other shop applications. In electricity, special attention is given to different types of motors, their characteristics and advantages, magnetic chucks and other electrical shop tools. In the third year a brief outline of chemistry is given, followed by a study of the various metals used in the machine shop, and the second half of the third year is devoted to the study of personal hygiene and public sanitation.

Fig. 13. Basket Ball Team—Athletics and Healthy Social Activities are encouraged

Theory of Shop Practice

In the theory of shop practice, explanation of the construction and operation of the various machine tools is given in more detail than would be possible during the regular working hours in the shop. During the first year the lathe serves as the basis of study. Beginning with the preparation of the stock, the boys are taught how to locate and form the centers; how to hold the work in the lathe; how to grind and set the tool; and how to select the proper speeds and feeds. Straight and taper turning, chuck and faceplate work, boring, thread cutting and special forms of turning are then treated in their regular order. Most of this instruction is given in the class-room and illustrated by sketches on the blackboard, but when desirable the class is taken to some machine department and the actual operations are observed and explained. Sometimes machines are brought into the class-room for more detailed study.

During the second year, a similar study is made of drilling machines, shapers, planers and milling machines, and in the third year grinding machines, small tools, hand tools and operations such as scraping and fitting are studied. During the fourth year a general review is made of all shop work, and the more difficult problems met with in tool-room work are introduced. At various times special attention is also given to such machines of the company's manufacture as the thread milling machine, the automatic milling machine, the vertical shaper, the spline milling machine, etc.

Instruction in General Subjects

During the last year of the apprentice course a deviation is made from the purely mechanical instruction of the first three years, and a series of lectures covering industrial history, commercial geography and civics is introduced. These subjects are intended to broaden the boy's conception both of his work and his relation to the community of which he is a part. In the industrial history course he is told of the development of the machine industry, the problems that confronted early mechanics, and, finally, the important part played by the company with which he is serving his apprenticeship in the industrial history of his country and the world. In commercial geography, he is given an understanding of the sources of raw materials and the markets of the world for finished products, and is given an idea of the problems that have to be solved in obtaining and transporting materials and products from one part of the world to another.

In civics, a brief outline is given of the nation's development. The principles of the structure of government—especially of municipalities and state government—are explained. Special stress is laid upon the dependence of a democracy upon the high standing of each individual's civic spirit.

Instructors and Division of Time for Different Studies

The instruction in general subjects, mathematics, science, etc., is given by the supervisor, but a large part of the instruction in the theory of shop practice is given by shop men who have been selected because of their personal skill and ability to impart the knowledge of their particular work to others. This idea of enlisting among the corps of instructors a number of shop men, especially sub-foremen, gang bosses, etc., tends to enlarge the circle of men who are personally interested in the welfare of the boys, and this, in turn, is of assistance to the boys in their shop training. This method of instructing the boys in shop practice creates a connecting link between the shop and class-room instruction, and is one of the most valuable features of the apprenticeship course.

The four hours devoted to class-room studies weekly are divided among the different subjects as follows: mathematics, one hour; drawing, one and one-half hour; theory of shop practice, one hour; and science, one-half hour. This time schedule is not rigidly adhered to. Whenever special conditions come up, making it desirable to devote either more or less time to any one subject, the supervisor uses his judgment in this respect. The time division given above, however, indicates approximately the length of time that has been found necessary to obtain the desired results.

Method of Instruction

No regular text-books are used for any of the courses. Instruction sheets have been prepared for certain subjects, especially for mechanical drawing, but the main part of all instruction is given by means of lectures with the assistance of the blackboard. In order to make sure that the boys get full benefit from this instruction, and in order to provide them with a permanent record of their work, they are required to keep a note-book which covers all their school work and which is submitted from time to time to the supervisor for criticism and inspection. In order to give added incentive for thoroughness, care and accuracy, a prize is awarded each year for the best note-books. The work on these books is done at home in the boys' own time. Some of the boys take great interest in this work and their note-books really become handbooks of shop practice, showing considerable ability. Sample sheets from one boy's note-book are shown in Figs. 9 and 10.

Compensation

The boys are taught to look upon their apprenticeship as a period of training and are made to understand that the apprenticeship course is a school in which their interest must be centered upon what they learn and not upon what they earn. Nevertheless, it must be recognized by anyone who would institute a successful apprenticeship system that the rates paid must be sufficiently high to make the boys self-supporting from the start; otherwise the system would be doomed to failure, as most of the boys could not afford to take a four-year course of this kind unless they could pay their way. There are four classes of apprenticeships at the present time instituted by the Pratt & Whitney Co.: A machinist, patternmaker, molder, and coremaker apprenticeship. In the four-year machinist apprenticeship, the rates are for each of the four years, respectively, 14, 15, 17 and 18 cents per hour, and for the three-year apprenticeship, 15, 17 and 18 cents per hour. In the patternmaker apprenticeship, comprising four years, the rates are the same as for machinists. The molder apprenticeship comprises three years, 20 cents per hour being paid for the first three months, 22 cents per hour for the remainder of the first year, 25 cents for the second year and 27 cents for the third year. The coremaker apprentices receive 14, 17 and 19 cents, respectively, for each of the three years of the apprenticeship. In each case, a bonus of $100 is paid to the apprentice upon the successful completion of his apprenticeship. The reason for the materially higher rates of molder apprentices is that, as a rule, these apprentices must be older or stronger than those for the other course, on account of the nature of the work; also, the work is less agreeable, and a special inducement is given in the form of higher wages during the apprenticeship years.

The boys often earn much higher wages than those indicated by the rates given, as they are enabled to increase their earnings both by working overtime and by means of piece-work. It is also possible for every boy to obtain a higher rate if his record is exceptionally good. Every boy that averages a certain mark for one year both in the shop and the class-room work is given an increase of one cent per hour as long as he maintains this mark. If his rating is still higher, he is given a two-cent increase under the same conditions. The boy thus recognizes early in his apprenticeship that his earning power is dependent upon his own efforts and skill.

Social Activities

In order to add an interest and to maintain a feeling of fellowship outside of the working hours, athletics have been introduced as a feature of the apprenticeship system. Teams have been organized and games are played, schools being chosen as opponents as far as possible. Places on the teams are dependent on shop and class-room records. There are no "athletic scholarships," and any boy that seeks recognition in these athletic activities recognizes that he can gain it only by meeting the requirements of the shop and class-room. All this tends to create a spirit of interest, good fellowship and loyalty, the shop being looked upon not merely as a place to work, but also as a school in which the young man is fitting himself for his life work.

Conclusion

It is freely admitted that the object of the apprenticeship system is to train skilled mechanics for the Pratt & Whitney Co., and every effort is made to induce the boys to stay with the company upon the completion of their apprenticeship. Most of them, in fact, do stay, and the foremen of the different departments are instructed to pay the graduated apprentice the market rate of wages commensurate with his proved ability. To determine his ability the supervisor and foreman consult together, and in this way it has been possible to pay wages attractive enough to hold a large number of the boys whom the company has trained. Many of those who leave to go elsewhere for new experience return after a short time to work for the company where they obtained their training.

Those who are of the opinion that an apprenticeship system is out of date or who are skeptical of its effectiveness would do well to study the modernized methods of apprenticeship training that have been put into effect by the Pratt & Whitney Co., and they would be well repaid for making a personal visit and observing the methods used by the company. The importance of proper training of apprentices is one of the greatest problems of the mechanical industries at present, and it is to be hoped that the example set by one of the foremost machine-tool builders in the country will be followed by others, so that, in years to come, there will not need to be the present lack of skilled mechanics. This article has been published not merely with a view to presenting what the Pratt & Whitney Co. has done to develop a modern apprenticeship system, but also to stimulate others and show what can be done in this respect, the methods that should be employed, and the results that are likely to follow.

* * *

COMBINATIONS FOR EXPORT TRADE

The Webb bill now pending in Congress is intended to permit combinations of American manufacturers for the sole purpose of promoting foreign trade. The object of forming such combinations is to enable American manufacturers to transact foreign business on a more efficient basis and to cope more effectively with foreign combinations, which are said to be adverse to domestic interests. It is pointed out that the small American manufacturers producing more than the domestic market will consume and desiring foreign trade, are confronted at the outset by a large expense and delayed returns incident to creating and maintaining a selling agency abroad. The Webb bill is designed to permit such manufacturers to cooperate, and not only support a common selling agency, but enter into agreements that would prove mutually beneficial. While it is not clear at present to what extent existing anti-trust laws would prevent such combinations, if made in good faith, it is supposed that American manufacturers are afraid to combine in the interests of foreign trade and that this condition must be remedied if the United States is to secure the full advantage of present opportunities. If this bill becomes a law, the combinations are supposed to be exclusively for facilitating and benefiting export trade without restraining or monopolizing trade within the United States. Some opponents of the bill contend that permission to combine for export trade might result in injury to American consumers and the smaller American manufacturers. This fear is considered groundless by those advocating the passage of the bill in view of the fact that the Federal Trade Commission shall have power to restrain and prevent action by combinations in foreign trade, which react as an undue restraint upon internal commerce.

DRILL CHUCKS

PRINCIPLES GOVERNING DESIGN AND METHODS OF OPERATION

BY JOSEPH HORNER[1]

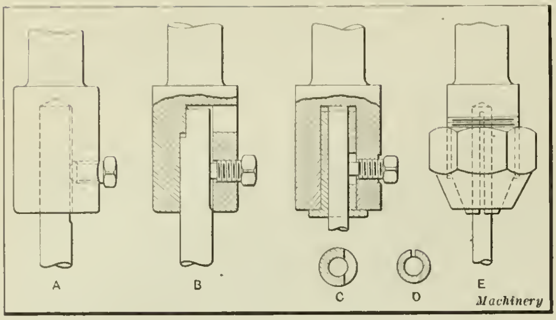


Fig. 1. Simple Types of Drill Chucks

THE scope and functions of a drill chuck are simple in comparison with those of an ordinary lathe chuck. In a drill chuck, a cylindrical shank, plain or grooved, has to be held in alignment and with sufficient firmness to resist slipping under the stress of work. But around this simple requirement a large number of mechanisms have been constructed, and the design is still in the course of evolution, tending to simplification rather than elaboration, as is the case in many kinds of appliances.

Methods of preventing slippage, which wastes time and damages shanks, must not interfere with the loosening of the tool. A chuck, therefore, should be constructed so that hard gripping of the drill will not result in jamming. Although many chucks are self-tightening and hold more firmly as the drill tends to slip, they are not necessarily difficult to unlock. Hardening of the working parts makes unlocking easier, for unhardened steel surfaces are compressed out of shape or torn, with consequent seizing of mating parts. Slippage is not so trifling a matter as it may appear, especially with regard to its effect on the shanks. Their tearing up and consequent deformation soon affects the truth of running, and although this is not such a vital matter in plain drilling, it is of great importance in the case of drills and tools used with jigs, and in operating counterboring, facing and other tools which are supposed to run true when secured in a chuck. Their irregular running may not at first affect results, but side pressure will eventually wear the pilots and produce accentuated errors. The same thing happens with ordinary drills of twist or straight flute form; if running eccentrically, they wear on one side and true drilling becomes impossible. Any chuck that grips a shank rigidly should run it truly, so recent practice favors the principle of a floating hold, by which all difficulties of this kind are eliminated, and lack of accuracy in the chuck mounting or spindle running has no effect on the working. The shank is fitted loosely, although driven in a positive manner, and the point of the tool is at liberty to wobble. It ceases to do so as soon as drilling commences, and the freedom to follow a true rectilinear path produces better work. Also, the drills are not so likely to wear, heat or break. The floating drive is of particular value in such operations as reaming, counterboring and countersinking, tapping, etc., and in connection with jigs, especially those employing short, stiff shanks.

The necessity for frequent changes of tools, brought about by the quantity of repetition work now done and by the fact that jigs are so extensively used, has made it necessary to discard some of the older chucks, because they are slow in loosening and tightening. While very good for holding shanks during a considerable period, they are too wasteful of time in handling the class of work just specified. If they are employed, the time consumed in substituting tools is so long in comparison to the running time that the benefits conferred by the use of specialized outfits and jigs are largely lost. The time lost is not only that spent in unlocking the chuck, but also that required to stop the rotation of the spindle and to start it again. In some classes of work it is necessary to use a dozen or more different tools in quick succession. For this reason, a chuck that can be released and regripped while the spindle is running at full speed would mean an immense increase in the output, and the trend of the latest designs is toward the attainment of this end. The cost of the tools is lessened by using collets or bushings, so as to adapt various sizes of shanks to one chuck.

The application of a chuck to a drilling-machine spindle is an alternative to holding shanks direct in the spindle aperture, and is really only a convenience to enable various tools to be substituted quickly. When the spindle only is used, the hole has either parallel or tapering sides, the latter being preferred. Many machines, particularly the lighter classes used by blacksmiths and small shops, have standard size holes with parallel sides in which the shanks are secured by set-screws of the plain or socket style. Drills with uniform shanks to fit these machines are furnished by the makers, and by using sockets, drills with smaller or larger shanks may be driven. This practice is suitable for the class of users concerned, but it does not meet regular workshop conditions so well. Truth of running is likely to become affected in time, the expense of drills with the uniform diameter shanks, especially the smaller sizes, becomes quite heavy, and there is no proper means of holding special drills or tools. Hence, a chuck with movable jaws that will grip any tool soon repays its cost.

When standard tapered holes are used in the spindles, the tools do not work out of truth, as in the case of a hole with parallel sides, and the set-screw, which is a clumsy device, is abolished. Its place is taken by the tang, which affords a positive drive when such is necessary. Besides, various sizes of shanks may be used by the employment of sockets and sleeves. This device does not provide a rapid means of changing drills, and is chiefly useful for medium and large size machines. In the small machines, the tapered hole is retained, and used as a medium for the fitting of a chuck; the latter has its body prolonged into a taper shank or has a shank fitted in a hole.

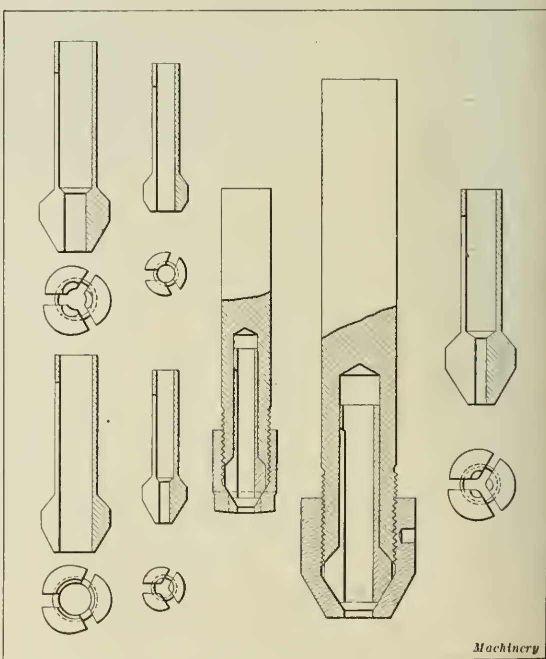


Fig. 2. Collet Chucks for Small Drills

[1] Address: 45 Sydney Bldgs., Bath, England.

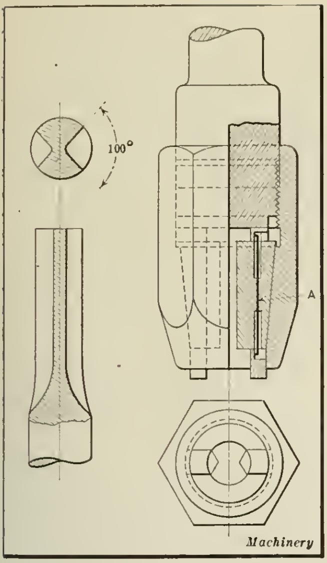


Fig. 3. Drill Chuck for Graham Grooved Shank

Early Chuck Designs

The earliest designs of chucks in which the shanks were held with a set-screw are still used in the rougher kinds of machines. The shank shown at *A*, Fig. 1, has a flat on which the set-screw bears and acts as a driver. The method of making a flat on the tail of the shank to catch against a flat in the chuck was soon developed, so that a positive drive independent of the set-screw resulted. At *B* is shown an example of this design. The set-screw is needed only to keep the drill from falling out of the chuck.

A collet or bushing may be fastened in place by letting the screw press on the shank, through a slot cut in the bushing, as at *C*, or by splitting through at one side, as at *D*. The latter device preserves the shank from the marring action of the screw tip. A neater method is to close the bushing by cone pressure, as in collet chucks. For single sizes, the chuck body can be split, threaded and coned so that the tightening of the nut binds the shank; this form is shown at *E*. Interchangeable collets should be formed with long stems, as illustrated in Fig. 2, which shows several sizes made by the Trump Bros. Machine Co.; these will hold drills ranging from 0 to 3/8 inch in diameter. The chuck shank is either held in a larger chuck or is turned on a taper to fit a spindle. The utilization of collets or liners to adapt one chuck for different diameters of shanks is not so common as formerly, because the same effect can be attained more simply and with less trouble by an adjustable jaw chuck. The liners are a source of trouble on account of dirt and must be wiped before they are placed in position; in addition, they wear in course of time, so that the shank is pushed to one side and runs eccentrically.

In the chuck made by the National Twist Drill & Tool Co. of Detroit, Mich., a coned nut is used to close in the sleeve fitting inside the body. There is a tang on the tail of the sleeve to engage with a slot in the body, giving a positive drive, and the sleeve is shaped internally to a Morse taper, or it has parallel sides and prongs to catch and drive a Graham grooved shank. Another design of chuck intended for these shanks is manufactured by the Cleveland Twist Drill Co., and is shown in Fig. 3. The jaws that clamp the V-grooves are fitted into slots in the chuck body and are forced inward by the turning of the nut, which has parallel bearings at the front and rear to preserve alignment. A flat spring *A* presses the jaw outward to release the shank when the nut is slacked off.

Scroll and Geared Chucks

The introduction of regular jaws enables a chuck to hold a certain range of diameters; the methods of actuating the jaws are varied. One of the earliest ideas was to follow the scroll design, and some chucks are still made on this principle, particularly those intended for use in the lathe to hold rods as well as drills. The mechanism is similar to that of an ordinary scroll chuck, the jaws being beveled off on the outside to give a clear view and to avoid risk of injury to the operator. Light chucks are worked by rotating a knurled ring, which has holes to give an extra grip when required. More powerful designs embody a gear scroll mechanism, with bevel or worm-gears turned by a key.

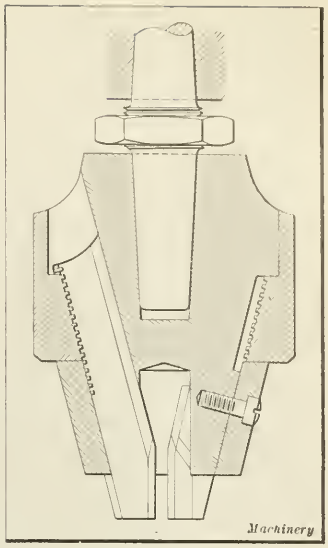


Fig. 4. Three-jaw Scroll Chuck operated by Knurled Sleeve

A more convenient adaptation of the scroll principle is that of cutting the scroll inside a coned ring and guiding the jaws in grooves at the same angle. This arrangement results in a more compact form of body, and since the jaws do not travel radially, as in the flat scroll device just mentioned, the nose formation of the chuck can be made more pointed; this is a handy feature in the case of small drills and fine work. The threads of the scroll are often square; but a buttress section is preferred by some as being better adapted to resist the direction of pressure. Fig. 4 shows the Skinner chuck, with square threads cut inside the knurled sleeve, which can be tightened by a spanner wrench. The chuck is made in three sizes, 0 to 7/32 inch, 0 to 11/32 inch, and 0 to 17/32 inch.

The geared chucks afford a more convenient method of operation than rotating a knurled sleeve, because the latter requires the spindle to be held from turning, thus necessitating the use of both hands. By turning the sleeve with a gear and key the necessary twisting action is transferred to a different direction and has no rotative influence upon the spindle. Extra power is also obtained, a more essential feature nowadays than some time ago, when high-speed steel was not in general use. The chuck which is made by the Jacobs Mfg. Co. of Hartford, Conn., shown in Fig. 5, has a bevel pinion formed on the key; this rotates the sleeve and turns the nut, which is made in halves. "Flat-back" models are built without the chamfer at the back of the body, so that the chuck is shortened and lightened and is more suited for use on pneumatic, electric or flexible drill shafts and for other work where the minimum of weight and size is desirable. Especially light chucks are also constructed by turning a large groove around the body and making some other parts thinner.

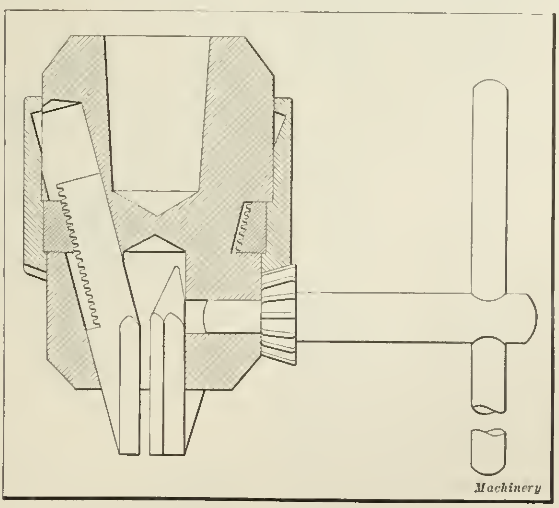


Fig. 5. Geared Chuck

The Almond geared chuck is made somewhat like the chucks that are not geared but are rotated by a knurled sleeve. The teeth are cut direct upon the nut, as in Fig. 6, which is hardened and split in halves. The sleeve only serves as a means of rotating with the fingers and to cover the jaw apertures, and need only be forced on the nut with moderate pressure, as none of the strain of turning with the

key comes upon it. The holes in the body that receive the key stem are provided with hardened bushings to give longer life and maintain alignment of the pinion. In the largest chuck of this series, a capacity from 3/8 to 1 inch diameter is afforded.

In one or two instances, the practice of having the ring of teeth inside has been adopted—as in the Skinner geared chucks—which have pinions laid in pockets. These are covered by the sleeve, except for an opening through which the key is passed to enter into the squared hole in the pinion. The external position is preferred, however, by many, as they claim that this permits a larger pinion and stronger teeth to be utilized.

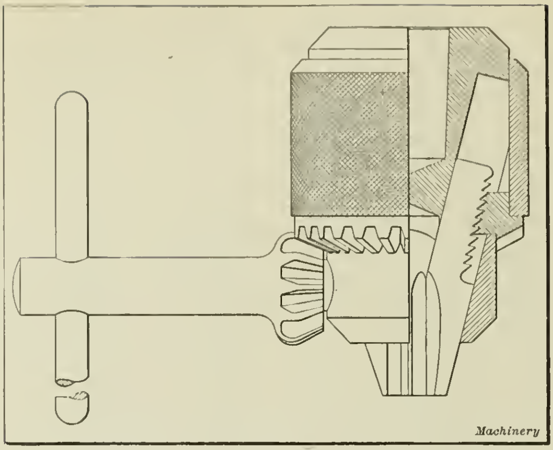


Fig. 6. Geared Chuck with Nut Separate from Sleeve

Two-jaw Chucks

A popular style of chuck is the two-jaw type actuated by a right- and left-hand square-thread screw. The jaws are notched out to interlock and grip from 0 up to the maximum capacity. The consequent breaking up of the surfaces into a number of separate "bites" assists in obtaining a firm grip for heavy work, a point of importance in high-speed drilling with hard feeding or gripping bars for deep turning or threading cuts. Auxiliary means are taken to strengthen the grip in some designs, such as by the use of side setting-up screws, as in the Westcott device shown in Fig. 7. After the drill has been centered by the jaws and they have been tightened, the side screws are set up, preferably on slight flats made on the shank. Another device is that of a forged steel cap attached to the chuck face with screws that permit a floating movement. A screw in the edge of the cap can be set up to bind the backs of the jaws together and so draw the gripping surfaces more tightly onto the shank. Yet another method is to provide a sort of draw-bolt through the jaws on the opposite side to the right- and left-hand operating screws, the bolt serving to prevent the spreading tendency of the jaws.

The Horton screw chucks are constructed with cylindrical jaws fitting closely in a reamed hole in the body—a neat and compact mode of fit—as shown in Fig. 8. For a positive drive some of these chucks have a pair of flat-ended set-screws tapped through on opposite sides of the body, behind the jaws, the screws being adjusted to engage with the squared end of a tap, drill or other tool. A special type is also built for holding either straight or tapered shanks by means of a duplicate set of jaws at the rear, which are set in accordingly. For a tanged taper shank, the rear set of jaws can be set to give a positive drive to the tang.

Several makes of screw chucks have provision for positive driving through a slotted plate or extra jaws at the top of the regular jaws. Thus a tanged or a squared drill or tap may be positively rotated without any need for tightening the jaws up hard. In the Pratt design the jaw slot is carried up sufficiently to receive a driver plate, Fig. 9, which has a slight amount of play for centering. When the flatted tang is passed up into the slot in the plate the latter catches against the sides of the chuck slot and acts like a lathe dog. Taper-shank drills require an adapter sleeve such as that shown in Fig. 9. In other chucks a pair of plates are attached, either on opposite sides of the bottom of the slot where the jaws stop or on the tops of the jaws. A similar device is sometimes adopted in the three-jaw chucks of the general type shown in Fig. 4, a transverse slot being formed in the body at the back of the jaws. One exception to the usual practice of notching out jaws to interlock is found in the Reid screw chuck, Fig. 10. This arrangement holds from 0 to maximum with three contact points.

Jaws Closed by Cone Cap

A number of chucks incorporate the principle of three (sometimes two) jaws, loose or pivoted, closed in by a coned cap which is moved longitudinally. Concentric action is obtained, and in many cases the mechanism can be made self-tightening. The chucks used on hand braces are simple examples of the type, consisting of a knurled sleeve pressing on the beveled noses of a pair of jaws. The ends of the latter rest against a V-shaped base, so that the closing in causes them to slide inward and so bear on their whole length on the shank, whether straight or tapered. In some instances, though the cap is used, it does not slide, but the jaws are pushed along by a tail plate, and the coercion of the coned cap produces the closing action.

In another design, made by the Oneida National Chuck Co. of Oneida, N. Y., and shown in Fig. 11, the knurled head of a screw moves the jaws. The head is slotted out to take the tang, thus affording a positive drive when desired. The interlocked jaws shown are for parallel shanks, but a pair for holding tapered shanks can be used. In the latter the inclination of the "bites" from front to back is made to suit any particular Morse taper desired. The positive drive by a tang fitting in the screw head is used also in this case. A more recent design is also made of this chuck with a ball bearing to take the thrust, and the tightening or loosening is effected by a large knurled part of the body behind the jaws. The jaws automatically tighten according to the pressure being exerted on the drill.

The chuck manufactured by the Rich Tool Co. of Chicago, Fig. 12, has jaws closed in by turning the nut, which is coned to match the backs of the jaws, and their tails are shaped to fit in a groove in

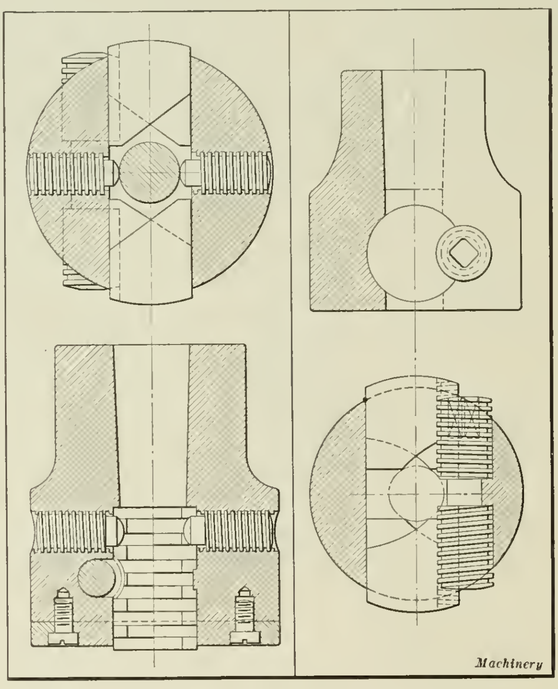


Fig. 7. Westcott Chuck with Side Screws for Extra Grip

Fig. 8. Screw Chuck with Cylindrical Jaws

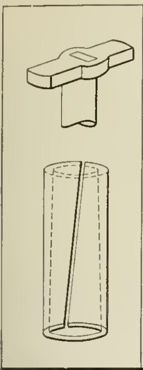


Fig. 9. Driver Plate and Taper Sleeve

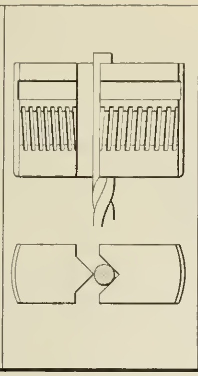


Fig. 10. Reid Chuck Jaws with Three Contact Points

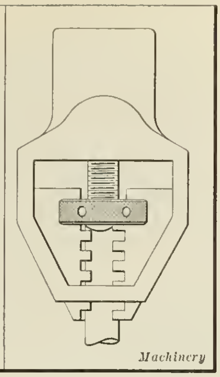


Fig. 11. Open Type of Chuck with Positive Drive

the body and prevent misplacement. The Rich drills and reamers with grooved shanks are held in this style of chuck and the jaws clamp an inward taper of the groove in the shank, which prevents the tool pulling out, so that a moderate amount of tightening of the nut suffices.

Chucks with Anti-friction Bearings

The action of a screw in tightening a coned cap around the jaws of a chuck is objectionable on account of the jamming that occurs, making release difficult. But this objection is easily overcome by introducing an anti-friction bearing consisting of a ring of balls or rollers which do not bind like plain surfaces. There are a good many makes of chucks working on this principle. In the Horton-Morrow chuck, made by the E. Horton & Son Co., of Windsor Locks, Conn., and shown in Fig. 13, the tightening is effected by a large fine-pitch left-hand screw *A*, which automatically tightens in the head *B*, as the drilling pressure increases. The jaws are carried in slots in a releaser *C* driven by a couple of pins engaging in slots in the end of the fine screw *A*. A small amount of play is allowed between the pins and slots so that the releaser possesses a little freedom. The slight rotation of the releaser caused by the opening action brings its coarse-pitch threads *a* into action, and an instant and easy release is obtained. The ball race is shown at *D*.

In the chuck made by Louis Wearden & Guylee, Ltd., of Bradford, Yorkshire, England, Fig. 14, only one screw *A* is used. This has a stout square thread and is formed integrally with the covering cap at the base. The act of screwing *A* into the body *B* raises the jaws *C* and makes them close in by reason of their coned backs pressing against the coned ring *D*. The thrust is received on the race *E* and the hardened washer above it, which prevents the screw from binding. Spring wires *F* and *G* lock the screw *A* and coned ring *D*, while another wire *H* gives the jaws a tendency to spring outward. To release the drill while the chuck is running, the knurled surface of screw *A* is struck sharply with the hand, delivering the blow in the direction of rotation.

An example of a roller-bearing chuck is shown in Fig. 15; this bearing has the advantage of large diameter balls and requires less space. The jaws *A* are propelled by a slotted head *B* into which they are tongued. The head is integral with a coarse-pitch double-thread screw running through the head *C*, and its movement outward or inward contracts or expands the jaws within the hood *D*. The rollers *E* take the thrust between the head *C* and the ring *F* screwed into the body *G*. This chuck is made by the Eclipse Machine Co. of Elmira, N. Y.

The Coit chuck, Fig. 16, made by the Narragansett Machine Co., Providence, R. I., has three jaws propelled by a slotted nut *A*, which runs up and down the screw on the shank *B* according to the way the knurled shell is turned or held by the hand clasp. The jaws, which have disk-shaped tails to catch in the slots in nut *A*, are kept straight by a screw *C* entering a slot in each. Pressure comes against the large flange *D* on the shank, and this is transmitted to the ring of balls above. The chuck automatically tightens as the drilling stress becomes greater.

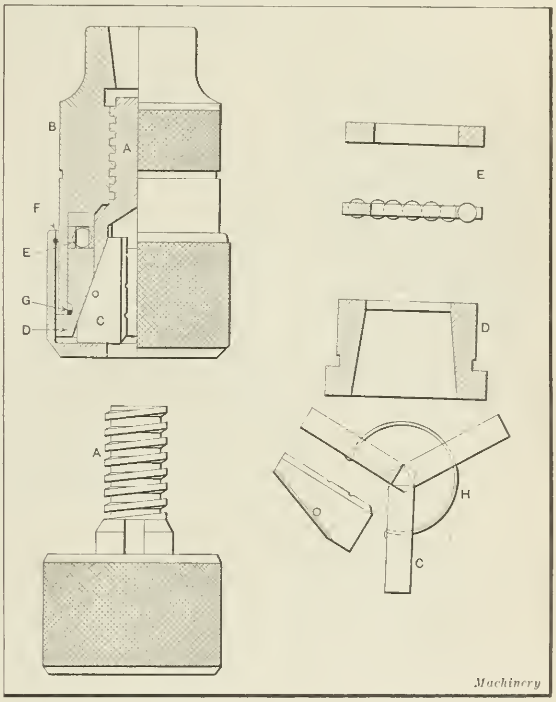


Fig. 14. Three-jaw Automatic Chuck

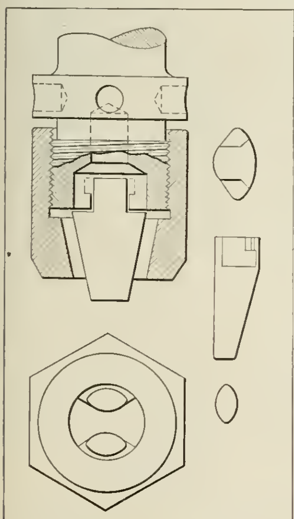


Fig. 12. Chuck for Grooved Shank

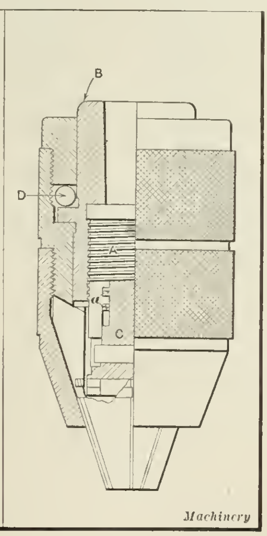


Fig. 13. Horton-Morrow Drill Chuck with Ball Bearing

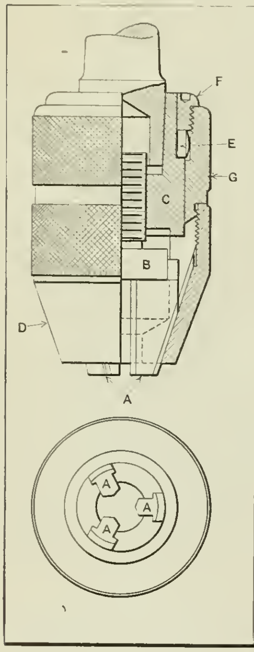
Self-tightening Chucks

The chucks of another group are built on the self-tightening principle of an eccentric action, which causes the jaws to roll or tilt, and in doing so to bring their surfaces more to the central axis. An attempt of the drill to slip produces extra tightening. Three designs are noticeable, one with round rollers, one with eccentric rollers, and one with lever-like pivoted jaws. In the type with round rollers, of which the Gronkvist, Fig. 17, is an example, the gripping results from the climbing of the rollers up the faces of the three-lobed internal cam. The clutch movement increases with any increase of drilling stress. Normally, the chuck is held closed by a coiled spring and the operator turns the outer knurled sleeve against the direction of rotation of the spindle to open the

jaws for the insertion of a drill. After this has been done, he releases the sleeve, and the jaws automatically grip the shank. As the rollers are quite smooth and hardened, they do not inflict any injury on the shanks.

The Wahlstrom Tool Co.'s chuck, Fig. 19, represents the eccentric roller device, the jaws being so shaped, as shown in the plan, as to roll up the cam faces inside the shell. The spring A keeps the shell turned so that the jaws are normally closed. If gripped momentarily by the hand while running, its rotation is stopped and its relation to the body altered so that the jaws open. After the insertion of the drill, the resistance developed makes the jaws roll up the cam faces.

In some chucks eccentric roll jaws are turned positively by teeth inside the shell, each jaw having a couple of teeth meshing with these. A clock spring normally keeps the chuck closed. The arrangement of the jaws is shown in Fig. 18. The principle on which these lever-like pivoted jaws are based is the same as that of certain safety catches for lifts and other mechanisms. The biting of the jaws into the moving element—the drill—forces them to move radially and increases their grip, so by disposing the three (or sometimes four) jaws



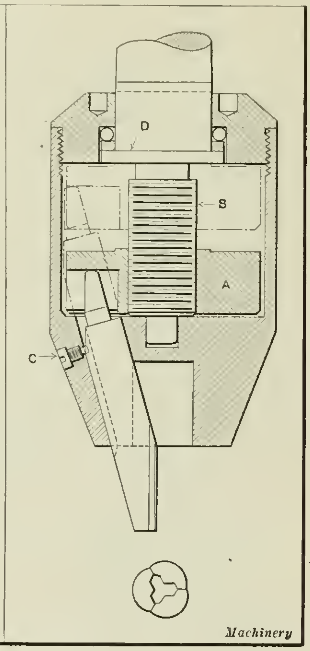
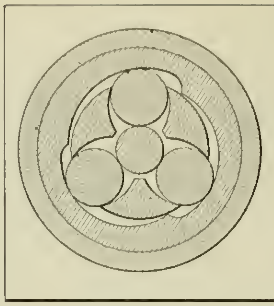


Fig. 15. Roller-bearing Chuck Fig. 16. Coit Ball-bearing Chuck

equally around the circle a concentric grip is obtained. As usual, a spring is fitted to close the jaws until the operator separates them by arresting the rotation of the knurled sleeve.

"Pocket" Style of Chucks

During the last three or four years there has been developed what might perhaps be most suitably termed the "pocket" style chuck, because it embodies the principle of a roller, ball, or pad dropping into a pocket and affording a drive to the tool or to its collet. The objection to these chucks is that, as there are no regular jaws to grip various diameters, it is necessary to make the tool shanks to a special formation, or (as must often be done) to employ special collets. These chucks are of the greatest advantage in repetition and jig work, where a set of tools must be utilized in the same spindle in rapid sequence. As a floating drive is given, its degree depending on the fit of the shank in the chuck, considerable advantage is gained in jig work, where a rigidly constrained tool is frequently undesirable on account of the tendency to wear the bushings. Even in ordinary drilling, the floating drive is advantageous, because the drill is enabled to run concentrically after commencing the hole, and no lateral spring arising from a slightly untrue drill or other cause will occur.



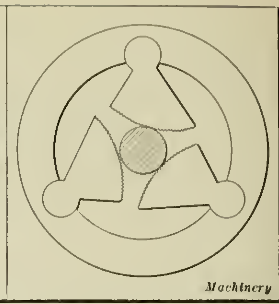
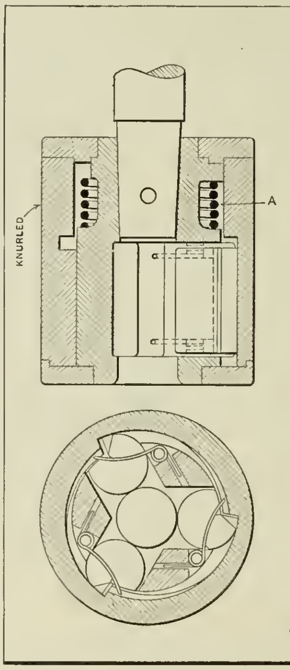


Fig. 17. Principle of Cam and Roller Action in Gronkvist Chuck Fig. 18. Principle of Pivoted-cam Jaw Action

Examples of each design, the pad, the ball, and the roller, are illustrated. The pad should offer the most powerful drive, but as the pressure is positive, there is apparently not much to choose between its flat line of contact and that of a ball touching at a spot on the diameter.

The chuck made for some years by John W. Barnes of Rock Ferry, Cheshire, England, is employed very largely, and is made either separately in the usual manner or integral with the end of a drilling-machine spindle. The tops of the tools or their collets are dome-shaped and automatically center themselves in the beveled top inside the body A, Fig. 21, and their bodies fit freely in the aperture, thus giving the float. The driving pads B fit loosely for the same purpose, and the curve of their backs is not the same as that of the inside of the sleeve C. In the plan, the left-hand pad is shown engaged, while the right-hand one is free. What causes them both to hold or release simultaneously is the difference in the diameter inside the sleeve. In the upper part it is less than at the lower, so that when pulled down to the position shown in the elevation the pads are forced inward and bear on the flats on the shank or the collet. When the sleeve is raised (while the spindle is running), the chambered part of the sleeve comes opposite the pads, and they are thrown into it by centrifugal force, leaving the drill free to be caught by the hand.

Fig. 20 shows a pad type of chuck, made by Vickers, Ltd., of Broadway, London, S.W., England, in which release is also effected by raising the sleeve. This shows a collet in place, with a taper hole and slot at the top for the drill tang.



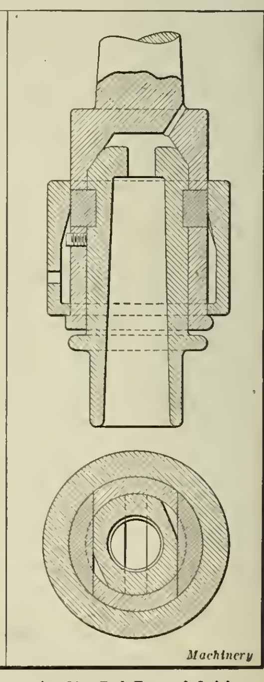


Fig. 19. Eccentric-jaw Automatic Chuck Fig. 20. Pad Type of Quick-change Chuck

Examples of ball chucks are shown in Figs. 22 to 25, the first being that made by E. G. Wrigley & Co., Ltd., of Soho, Birmingham, England. In this, the balls abut against a collet having flats at 180 degrees, and transmit the drive through it. The sleeve is shown down in the driving position, keeping the balls pressed into action. When it is raised to a height limited by the set-screw in the groove, the weight of the collet and tool forces the balls outward into the pocket. On the reverse action, the balls are pressed inward and engage and drive the collet.

The chuck shown in Fig. 24, manufactured by Morton & Weaver, Coventry, England, also uses two balls. In this case a coiled spring presses the sleeve down and maintains the balls in the driving position, so that the chuck can be used horizontally or upside down.

The Modern Tool Co. of Erie, Pa., manufactures the ball chuck shown in Fig. 23, in which springs are omitted. The force of gravity draws the locking sleeve down and thus pushes the balls against the grooves in the collet. The positive drive in these chucks is disadvantageous for the operations of tapping and studding, and the firm supplies a special friction drive for use in such cases. Two fiber disks transmit the drive, and the pressure between their faces may be regulated by a nut. A stud-holder is also furnished to use in conjunction with the friction drive.

The addition of a ball race to take the running wear and to render the sliding of the sleeve easier is illustrated in Fig. 25. This chuck is manufactured by Alfred Herbert, Ltd., of Coventry, England. The balls *A* bear upon the grooved body. The ball and spring *B* lock the sleeve as shown, so that the chuck can be used in a horizontal or an inclined position, as well as in the usual manner. The collets are slotted through at the top, so that they will drive a tang, and access can be had to the end of the latter for the purpose of driving it out.

An example of a disk used for driving is shown in Fig. 26 (made by the Wiard Mfg. Co., Detroit, Mich.). These disks act in a similar manner to the balls in the preceding example, and fall into pockets in the sleeve.

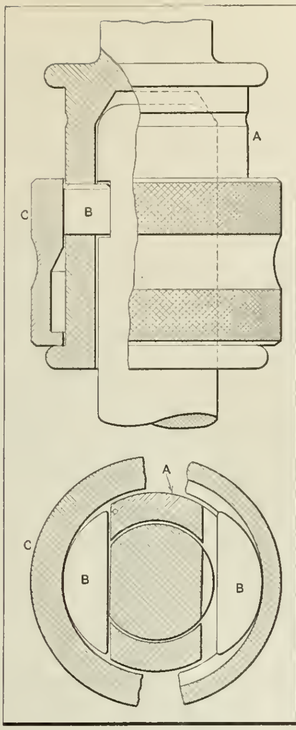


Fig. 21. Automatic Chuck with Floating Drive

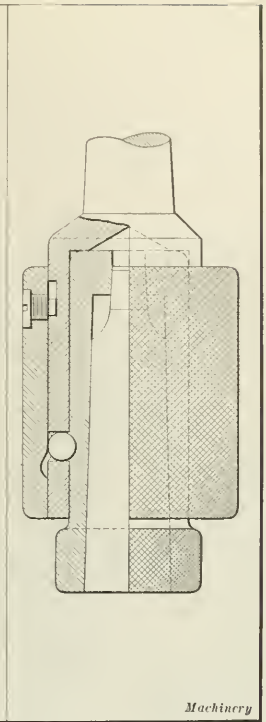


Fig. 22. Wrigley Ball Type of Chuck

* * *

GERMANY'S MOTOR MIXTURES

Owing to the shortage of gasoline in Germany, experiments have been made with mixtures of alcohol and benzol. The results of these, as given by the American consul at Lyons, are of especial interest in view of the increased cost of gasoline in the United States and the need of finding additional uses for benzol at the close of the war. In these experiments, a 1914 Mercedes touring car, with the ordinary carbureter, was run 4.66 miles at a speed of forty-two miles an hour with one pint of a mixture of equal parts of alcohol and benzol. When the mixture contained three parts of alcohol and one of benzol, a distance of 4.34 miles was covered at thirty-nine miles an hour. In the proportion of one part of benzol and five parts of alcohol, the mixture ran the car 3.72 miles at thirty-six miles an hour. With pure gasoline, the car was run 3.60 miles at forty-four miles an hour, and with pure benzol, the car was run 3.79 miles at forty-two miles an hour.

* * *

ACCIDENTS COST MONEY

Three kinds of accidents alone in Wisconsin last year cost workmen in that state over $800,000 in lost wages. Flying particles, resulting in eye injuries chiefly, caused a loss in wages of $323,000. Wearing goggles would have prevented much of this. Falls from stairs, ladders, scaffolds, etc., cost $300,000 more. Objects falling from cranes, trucks, etc., cost the injured men $195,000 in wages lost. An ounce of prevention is worth a pound of regret.

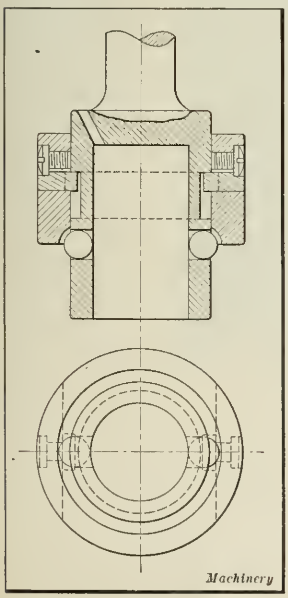


Fig. 23. Modern Tool Co.'s Quick-change Ball Chuck

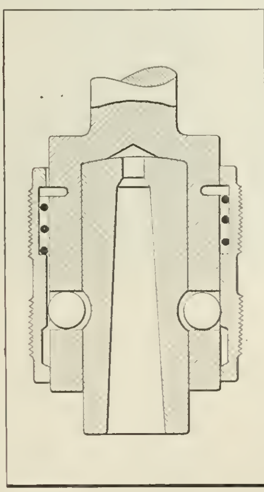


Fig. 24. Morton & Weaver Ball Type of Chuck

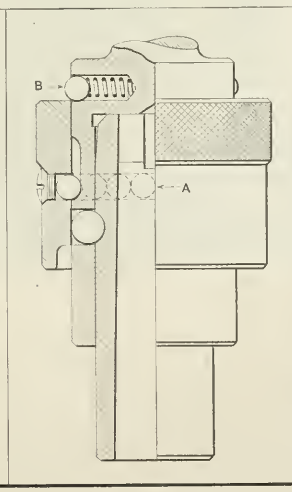


Fig. 25. Quick-change Chuck with Ball Race

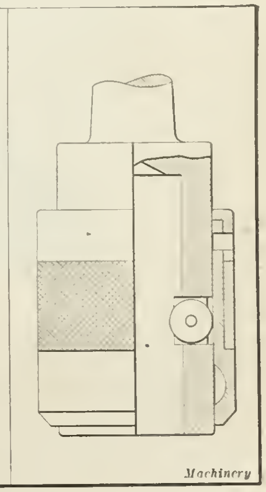


Fig. 26. Quick-change Chuck with Roller Drive

GAGE GRINDING

BY CHARLES F. SCHLEGEL [1]

While the maximum space between the surface of the magnetic chuck of the No. 2 surface grinder shown in Figs. 1 to 4 inclusive, and the smallest wheel that efficient grinding will allow is approximately eight inches, much longer rod gages may be ground on this machine with a high degree of accuracy. The writer has ground on such a grinder rod gages 42 inches long.

The operator should have a good set of size blocks for this work. A good set for the average machine shop consists of blocks ranging, by 0.001 inch, from 0.031 to 0.063 inch long, three blocks 0.03125, 0.0468, and 0.0625 inch long, respectively, to represent the fractions 1/32, 3/64, and 1/16, blocks ranging, by sixteenths, from 1/16 to 1 inch long, and blocks ranging from 1 to 10 inches in length. This set is not as expensive to make as first impressions may suggest, and it gives every measurement, by 0.001 inch, from 1/32 inch up to 11 inches by using a combination of not more than three of the size-blocks.

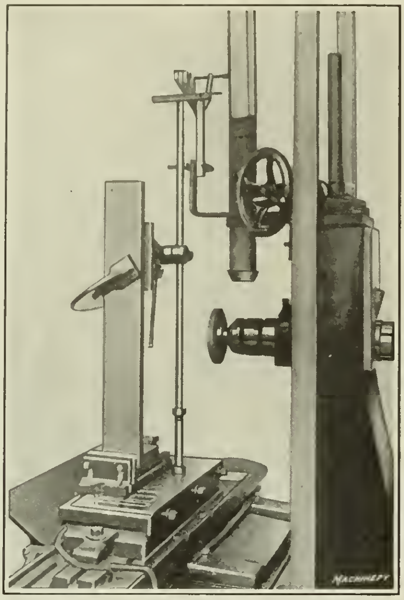


Fig. 1. Method of holding Work on Grinder

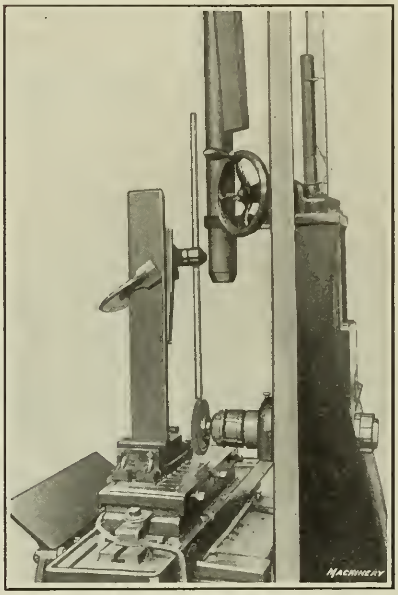


Fig. 2. Grinding Rod Gage

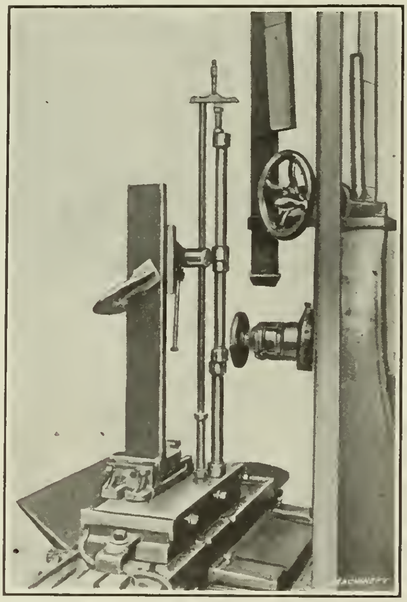


Fig. 3. Measuring Rod Gage

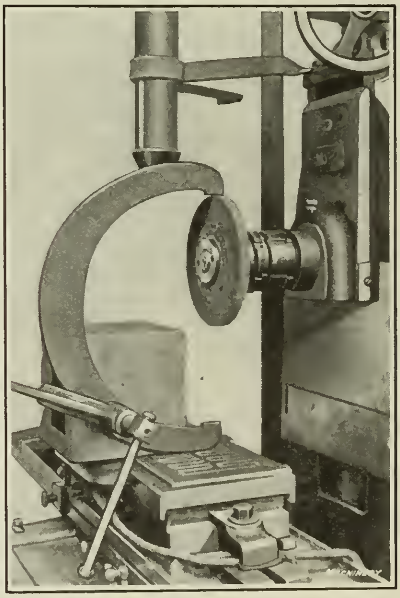


Fig. 4. Grinding Snap Gage at One Setting

There is no necessity of making any elaborate fixture for holding the rod gage in the machine. The articles shown in the illustrations are in common use in practically every shop and answer just as well. The rod holder is supported, as shown in Fig. 1, by a piece of 1- by 3-inch cold-rolled steel, of suitable length, held upright in the machine vise. The rod is held by a swivel holder, such as is used for holding a diamond while dressing off the emery wheel. This is clamped to the upright by a C-clamp of suitable size and is placed at such a height that when it grips the rod gage approximately in the center, the lower end of the gage, when vertical, will be about 5.035 inches from the surface of the magnetic chuck. This will leave sufficient space for a four-inch wheel and plenty of clearance to work in.

Having set this end in position so that it can be easily measured it is obvious that it should be ground last. So after loosening the binding nut of the swivel, the rod gage is turned end for end and, after squaring its sides with the surface of the magnetic chuck, approximately one-half of the stock left to be ground is removed. This is done by using the top of the emery wheel, the hood being removed as shown in Fig. 2. During grinding, the table should be moved back and forth and across by hand to avoid the jar caused by power feed. The rod is then turned back to its first position (it must not be loosened in the swivel) then accurately leveled and measured. This leveling is done by placing a parallel on top of the rod and leveling with an indicator (see Fig. 1), then turning the parallel horizontally through 90 degrees, and indicating again. This should be done two or three times, as leveling one way may throw it out another. Suppose the rod is 24.250 inches long, and that the mechanic is equipped with the size-blocks mentioned. Suppose also that 0.02 inch had been left for grinding and that 0.01 inch has been ground off one end; that the rod has been reversed so that the finished end is uppermost and leveled as just described. As the lower end is 5.034 inches from the magnetic chuck with 0.01 inch to be removed, the top of the rod is about 29 or 30 inches above the surface of the magnetic chuck. To measure this rod place the 10-, 9-, 8-, and 2-inch size-blocks one upon the other, as close to the rod gage as possible. This gives a height of 29 inches. The remaining fraction is then measured by the micrometer depth gage by placing the beam of the depth gage on top of the rod gage and running the spindle down on top of the size-blocks, as shown in Fig. 3. In this case, it should measure 29.294 inches, which equals the

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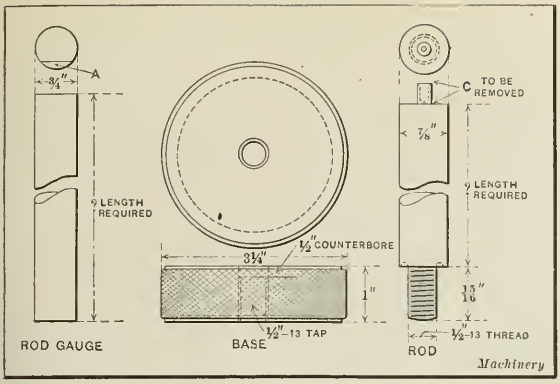

Fig. 5. Height Gage or Set Block for Planer

length of the rod, 24.250 inches, plus the space under the rod, 5.034 inches, plus the amount to be ground off, 0.01 inch. Then the bottom end of the rod may be ground, taking off a few thousandths of an inch at a time, but care must be taken to keep inside the 0.01 inch limit. After this is done, the 5-inch size-block should be placed on the magnetic chuck, directly under the rod gage, and the small size blocks from 0.034 inch to 0.044 inch used as feeler gages until one fits snugly between the bottom of the rod gage and the top of the 5-inch size-block. The difference between this block and 0.044 inch, in this instance, is the amount to be removed. This grinding should be done cautiously when nearing the 0.044-inch block so as not to go by but have a good snug sliding fit without having to use force to insert this block. Also care should be taken to see that there is no dirt or dust between any of the surfaces while measuring.

By this method of grinding, the gage is free to be measured, while working upon it, so the mechanic always knows just how he stands without having to resort to guesswork. Besides, a measurement of within 0.00025 inch can be maintained, which is close enough for all practical purposes where a long rod gage is likely to be used. It might be mentioned that it is a good plan to grind 0.002 inch off one end (before removing it from the grinder) about 1/8 inch from the edge, as shown at *A*, Fig. 5, to use as a lead and an approach to proper measurement. Where the rod gage is long, it should be fastened by a strap passed a little above its lower end to the upright standard in the vise, so as to avoid chattering.

Height Gages and Snap Gages

A very convenient height gage or set block for planer work is shown in Fig. 5. This gage differs from the rod gage by being made up of two parts, a base and spindle or rod. The base is 3 1/4 inches in diameter and 1 inch in thickness; therefore the rods should be 1 inch less in length than what is actually wanted. Any number of rods can be used with the same base, thus forming a variety as large as shop production requires. The base should be pack-hardened and ground; also both ends of the rod should be hardened. One end of the rod should be ground on centers in a universal grinder; however, care should be taken to have the threads fit loosely enough to allow the rod to stand true on the base. After the rod is firmly attached to the base and the center *C*, Fig. 5, removed, the remaining end may be ground in the same manner as the rod gage. However, as only one end is to be ground, the gage may be held by the swivel holder near the bottom end so as to eliminate chattering without using the extra brace.

Another place where the top of the wheel can be used to good advantage is in grinding snap gages, as shown in Fig. 4. When set as shown, the gage may be ground in one setting thus insuring the two surfaces being perfectly parallel. The space may be measured by the size-block system or by inside micrometers. After the correct size is obtained, a lead of 0.002 inch may be ground on one jaw, as described for the rod gage. Then the two front edges may be ground with a cup-wheel, which is done by raising and lowering the wheel and grinding both jaws until both can be touched lightly by the wheel without moving the cross-feed of the table; this will insure an even start for both jaws when used for measuring.

* * *

IMPROVED SHEAR-PIN DESIGN

BY C. L. LOTHROP, Jr. [1]

To prevent damage to operating machinery, the flight and bucket coal conveyors built by a well-known contracting company are fitted with shear-pins or break-pins. This shear-pin is installed between a large gear-wheel and the shaft which it turns, as shown in Fig. 1. In the event of a heavy stress coming upon the conveyor itself, such as the jamming of a link due to a bearing getting out of alignment, the driving shaft will stop; and with it the shearing arm. The gear-wheel will continue to revolve, being driven by the motor; and the shear-pin, shaped as shown in Fig. 2, will break at the point where the diameter is reduced.

While the device is intended to operate only on rare occasions, conditions sometimes occur which cause the shear-pin to break several times a day. When this happens, an additional burden of machining new pins is thrown upon the already overworked machinists, and the conveying machinery may be broken down a considerable length of time while waiting for the pins. An improved design, shown in Fig. 3, has been tested and found to function in a satisfactory manner. A hole was drilled through the two larger parts of the pin to receive a 3/4-inch bolt having a head on one end. On the other end, a nut was screwed, with a lock-nut holding it. The two hollow cylindrical parts were kept at the proper distance by a loose-fitting 3/16-inch washer, 1 inch in diameter. To prevent the hole from wearing to an elliptic shape, it was found necessary to make the 1 7/16-inch pins of mild forged steel, with the ends and hole casehardened, although tool steel might have done as well if the temper had been drawn before drilling and the pins had then been retempered. A fireman with a monkey wrench can put the conveyor in operation after a bolt is sheared, whereas when the solid pin was used, the services of a machinist were essential. The same result could have been obtained had the shear-pin holes in the gear-wheel and the shearing arm been bushed with hardened steel.

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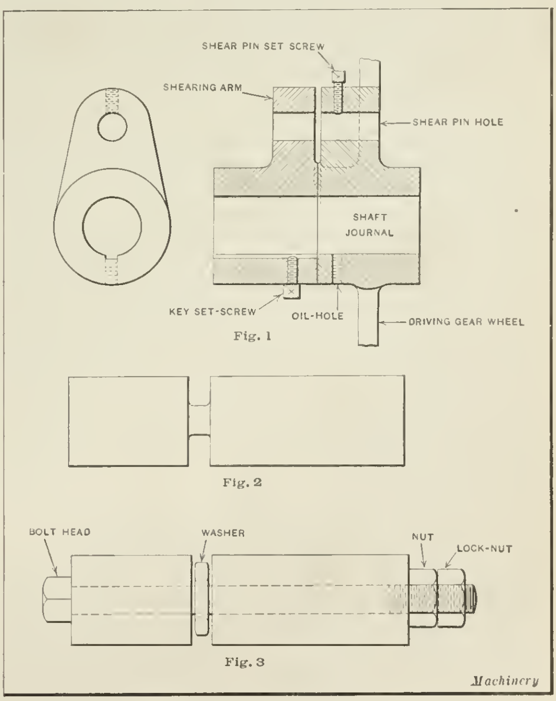

Figs. 1 to 3. Original and Improved Designs of Shear-pins

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REPAIR PARTS FOR MACHINE TOOLS SOLD ABROAD

One of the troubles likely to develop in some American shops as the result of the abnormal European demand for machine tools will be difficulty in supplying repair parts. The demand for machine tools was so abnormal and methods of distribution so irregular, that in many cases no proper records have been kept of the ultimate destination of machines, and of the characteristics of the machines furnished. The result will be that concerns in Great Britain, France, Italy, Russia and other countries will communicate with the American builder of machines in their plants requiring new parts, and much cabling and correspondence will be necessary before the American builders will be able to identify positively the parts wanted. This means expense, annoyance and delay.

But if this is the only trouble experienced by machine tool builders who have worked their plants day and night to fill orders, we may well congratulate ourselves. The fear has been expressed that a considerable number of purchasers of American machine tools made in a hurry will have unsatisfactory experiences with them, and become prejudiced against American machine tools in general. It perhaps was inevitable that this abnormal demand should turn the heads of some of the manufacturers and cause them to rush out poorly finished work. The well established concerns whose products are known internationally as being well designed and well made have, in general, continued to turn out the same dependable product as before, and have kept careful records of foreign shipments. Concerns that have steadfastly maintained their excellence of product and dealt fairly with their foreign customers will stand as high with them after the war as before it.

* * *

FIRE INSURANCE PREMIUMS

Every progressive manufacturer who contemplates the construction of a new factory or additions to an existing plant gives careful consideration to the provision of all the necessary facilities for securing high rates of production and enabling work to be done under conditions that will insure obtaining the required standard of quality. But in many cases it is apparent that the same care is not taken in investigating the requirements of fire insurance companies, so that advantage may be taken of the lowest premium rate that will afford adequate protection. Bureaus are maintained to which a manufacturer may make application for expert advice concerning safeguards that must be provided in a plant engaged in his line of work and other conditions that must be fulfilled in order to secure protection against fire loss; and by submitting plans to such a bureau it is frequently possible to obtain a heavy reduction in the premium without going to much extra expense.

A case in point is seen in the experience of a manufacturer who recently submitted plans of a new factory to the New York Fire Insurance Exchange. When experts in the employ of this bureau looked over these plans they found that the proper arrangement of fire doors had not been provided and that in one case a parapet extension of the fire wall had not been continued to the required height above the roof. These facts were reported to the manufacturer who immediately had his architect modify the plans in accordance with the bureau's finding. As a result, an additional investment of $350 saved $1000 in the insurance premium.

* * *

BUILDING UP AN ORGANIZATION

The manufacturing concerns that have achieved a reputation for square dealing and general reliability are those which by years of effort and training have built up an organization of efficient and loyal employes. Concerns that make a practice of attracting men from other organizations by offers of high salaries are not organically sound, nor are they likely to become sound and efficient by pursuing this method of recruiting. Manufacturers that employ machinists have found that a dependable organization is that which has been built up by training young men, and making places for them when they become journeymen.

Every manufacturing establishment requiring mechanics and skilled workmen should, as a matter of justice, educate a certain percentage of its employes each year in the elements of its trades. The practice is necessary in order to provide the number of workmen required in the industry, and it is the best kind of insurance against strikes and labor troubles generally. The men in a built-up organization composed mainly of employes who have spent the best part of their lives with the company and know its history, aims and ideals, feel themselves to be a part of the business and not mere hired men; they are not, as a rule, looking elsewhere for any chance to obtain employment at higher wages. On the other hand, an organization composed of self-seekers is unstable, because the men are disloyal. Loyalty cannot be obtained by the payment of mere wages; it is obtained only by fair treatment and by making the employes feel that they all are a necessary part of the organization.

* * *

MISUNDERSTANDINGS IN JOB WORK

A common cause of trouble between jobbing machine shops and their patrons is in the misunderstanding of what is wanted. Work is often sent in and a few verbal instructions are given, with the result that when the job is done it is not as desired, and one blames the other for the mistake. The owner of the parts thinks he knows exactly what he wants, and expects that the job shop proprietor or his men should be able to read his mind after a few words of explanation.

The job shop proprietor should generally insist on getting clear and definite instructions on the work wanted. If the customer will not or cannot furnish drawings, it would pay the proprietor to make sketches and get the customer's O.K. before starting work. Then there should be no "come-back" if it does not meet the customer's needs. He had the opportunity to correct his own mistakes and the misunderstandings of the shopmen when he examined the sketches.

All orders and agreements should be made in writing, and prices should be specified either as to hourly rate or total for the job. The job shop proprietor who consistently follows business methods in dealing with his customers will avoid many of the troubles common to job shop practice.

INDUSTRIAL EFFICIENCY

BY FRANK METZLER [1]

If the time to prepare for war is when peace obtains, the time to prepare for the domestic competative era that is to confront the manufacturer of tools and machinery at the close of the war is while we are experiencing the unusual pressure due to the production of war commodities. Industrial engineers are not alone in speculating on the aftermath of this feverish activity and, in many instances, heart-breaking suspense and the reaction to be experienced by both large and small manufacturers. Munitions have almost upset manufacturing reason. Many good, conservative men, whose word for results and deliveries was dependable, have lost quite materially in promising deliveries that were impossible. As time dragged on, the expense outran the profit and these men were replaced by others, and the successors, in turn, were followed by others, all with inflated ideas as to the possibilities of delivery; but each failed to profit by his predecessors' errors.

We are all familiar with the jaunty air of the manufacturer on receiving his first munition order. He is a man envied by his fellows. Later he has a more serious mien, then a worried expression, and, finally, we count the failures. In nearly every case the cause can be traced, not to an article impossible to manufacture, but to a management that failed to grasp the true situation concerning deliveries of tools and machinery, material, and a peculiar labor condition. Those issuing the contracts stipulated, in nearly every instance, delivery dates impossible to meet, and attached penalties for failure to meet them. The manufacturer was induced to believe in himself, his organization, and equipment, and agreeably signed. Then followed an investigation and analysis of his executive force and a decision to secure a more capable organization. Mechanical engineers and superintendents became mere passing acquaintances. Tools were designed on the run, so to speak, and scheduled against an equipment which, through continued failure of deliveries, was substituted by others. In the meantime, the hastily designed prospective tools were placed on an hourly basis in almost any shop with a semblance of equipment, only to be thrown into the scrap heap because they could not be used with the new equipment. Efforts were immediately begun to make up for the unlooked for delay, by high pressure and long hours. Engineers and superintendents alike failed to satisfy a management almost beside itself and haunted by the penalty in the contract. New men were secured. The previous tooling was criticised and new tools were designed, only to meet the same difficulties that attended the former. Some firms retooled their equipment four times before manufacturing proceeded. In addition, in no case (except those previously engaged in munition work) was the entire equipment charged in against the order which, through failure of deliveries, and the consequent penalty, became a constantly diminishing quantity. All the manufacturers figured that after the order was run off they would have an equipment for general jobbing purposes. In many instances, the cost of repeated tooling precluded any possible profit on the first order so the question resolved itself into the securing of a second order or failure. The small fortunes made by the small shop men, are sad reflections on otherwise capable managements. The prices paid for tools were outrageous, being as high as 200 per cent above normal, and all have repeatedly wondered at the cheerful endorsement of bills.

The fallacy of justifying an expenditure for equipment for general jobbing purposes might as well be recognized now as later. What sane manufacturer would deliberately buy the assorted equipment usually obtaining for munitions and instead of munitions do a general jobbing business, even in the abnormal present times? What then is to be said for those so equipped when times become normal? Without question the country will be confronted with an overproduction of certain classified machines, and the problem of keeping them employed is one to harass the most resourceful executive. When the full significance of this wild and extravagant buying of machinery and tools is appreciated, and manufacturers are sobered by the accumulating idle hours day after day, it is fair to assume that a wholesome regard for a more advanced knowledge of proper business methods must obtain. Such being the case, it follows that if, during normal business times, such as obtained before the war, it is found advantageous and profitable to employ a management embodying the most efficient means of conducting business, it would be doubly profitable now.

There is no question but that an orderly systematic flow of work is more conducive to profits and the meeting of due dates than the unorganized manner of approaching the problems of manufacturing. A trained corps of experts with the attending investigations and analysis will do far more than the average all-around good man who is generally relied upon to determine processes and proper methods. An apt illustration is to be found in the conditions surrounding the heat-treatment of steel; mills are experiencing trouble in supplying the market with the various brands of steels, and factories are experiencing trouble in heat-treating. This is not local; it is a general condition and the cause is self-evident. There was never more need of organized investigation and scientific application in this department than at present, when time is the greatest factor. Yet managers allow this department to continue as formerly, sustaining a loss in many cases not known to them, with the consequent delay on deliveries. Regardless whether the much heralded "war after the war" is to be realized or not, it behooves all manufacturers to investigate the more modern methods of conducting business.

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* * *

HEAT DENSITY

BY GEORGE P. PEARCE [1]

We hear a great deal about the B. T. U. value of fuels, that is the B. T. U.'s of potential chemical energy contained in one pound of various substances, but how many have considered the number of B. T. U.'s of heat that are in a cubic foot of space under various conditions? Let us assume 0 degrees F. as a base and see approximately what the heat density is for various conditions and substances. On a hot summer day, with the thermometer registering 110 degrees, there seems to be plenty of heat everywhere, yet a simple calculation will show that there is only 1.8 B. T. U. to the cubic foot.

The gasoline blast torch is generally looked upon as a very hot flame, but in the hottest part of that flame the heat density is less than expected; it is 10 B. T. U. per cubic foot. Hydrogen gas, with its enormous heat value, might be expected to make a better record than that, yet in the hottest part of a hydrogen flame burned in air the B. T. U.'s per cubic foot are just about 10.1; it has a heat density 1 per cent better than the gasoline flame in air. Not much is expected of carbon burned in air with its much lower heat value, so we are surprised when it shows a density of 12.3 B. T. U. per cubic foot. This, of course, is due to the greater density of the products of combustion. Incidentally we note why coal is such a satisfactory source of heat for boilers; it develops a high heat density and thus rapidly heats the tubes; of course other things enter into consideration as well. A great deal is said about acetylene, and it deserves credit, for this gas burned in air produces a heat density of 13.1 B. T. U. per cubic foot. So far the heat produced has been diluted by the presence of the inert gas nitrogen in the air. Eliminate this and burn acetylene in oxygen and a great change takes place, for now there are 24 B. T. U. in every cubic foot of the intense flame. Burn hydrogen in oxygen and there are 20 B. T. U. to the cubic foot.

It might be supposed that the limits for heated gases and vapors are being rapidly reached. However, ordinary steam just as it boils off water into the atmosphere contains 44 B. T. U. to the cubic foot. The oxy-acetylene flame takes a poor second place when compared with steam under these conditions. Some experimental high-pressure, high-efficiency, steam engines use superheated steam at 240 pounds per square inch and 300 degrees of superheat, and every cubic foot of this steam contains over 500 B. T. U. Strange as it may seem, saturated high-pressure steam at 235 pounds per square inch contains over 650 B. T. U. per cubic foot, and for carrying heat is

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superior in this respect to superheated steam. More astounding still is the humble cake of ice which at 32 degrees is prepared to deliver 937 B. T. U. per cubic foot when cooled down to zero. Boiling water is common enough, and as a heat container it holds over 12,000 B. T. U. per cubic foot.

Melted sulphur, at 800 degrees F., has a heat density about twice that of boiling water, or over 22,000 B. T. U. to the cubic foot. Melted aluminum, at 1214 degrees F., almost doubles this with nearly 43,000 B. T. U. per cubic foot. Melted glass, at 2377 degrees F., has nearly 75,000 B. T. U. in every cubic foot. Platinum, at 3300 degrees F., makes a big jump with its 182,200 B. T. U. per cubic foot. But common melted iron, at 2700 degrees F., leaves platinum away behind with 207,000 B. T. U. per cubic foot. However, they are all surpassed if a cubic foot of carbon is heated almost to its vaporizing temperature, say to 7000 degrees F., as a heat density of 700,000 B. T. U. per cubic foot is then obtained. It is impossible for a person to look at this heated carbon or stand near it, and probably it represents the greatest heat density known. It is found in every arc lamp. Perhaps when we obtain more data on the remarkable metal tungsten, which takes 5432 degrees F. to melt it and an unknown temperature to vaporize it, a still greater heat density may be had in melted tungsten just before it commences vaporizing.

* * *

PRESS-ROOM EFFICIENCY METHODS

BY G. R. SMITH[1]

While many times small things appear unimportant and the study of detail seems like a waste of time, this study is really a vital matter and one that must never be lost sight of in an endeavor to reduce cost and increase production. A lubricant on all drawn metal work makes the process easier on the tools, machines and work to be done. Usually, this lubricant is placed on the blanks by brushing them or by dipping them in the solution before placing them in the dies. In either case, this must be done by the operator or a laborer employed for the purpose; if it is done by the operator, the piecework price is made to cover this operation. A better plan is to use the drawing solution in the cutting of the blanks, instead of the lard oil generally used for that purpose.

In blanking operations on straight press work, the writer has used, to advantage, a soap, water and oil emulsion on brass and copper blanking, and a lard oil and chalk solution on steel blanking. They give the same results as pure lard oil in keeping the tools from heating and the metal from flaking off, scratching and sticking to the dies. By this plan, the blanks come to the drawing operation lubricated and ready to be fed at once into the dies, increasing the production and lowering the cost. On all work that is cut from the strip, this plan may be easily followed, as the strips can be oiled with this solution in place of the usual oil. While large blanks that are cut on the shear cannot be handled in this way, the saving on the small blanks more than pays for an oiling operation on the larger ones.

Use of Compressed Air

Many up-to-date shops use compressed air in the press rooms. It may be supplied by piping that connects the compressor tanks with each machine, or by a small pumping attachment bolted to the main casting of the machine. While compressed air is rather expensive, its great cost-reducing powers and economic value in shop manufacturing operations, especially press work, more than offset the first cost. It may be used for removing work from dies, blowing work through open-back presses into work boxes, removing work from certain style jigs in the drill press, keeping dies free from scale, chips, and dirt, removing punchings from tapped holes, furnishing power for automatic feed devices and for the side stroke in double-action dies; it has also been used as a bumper pad for the pressure ring in shell-drawing dies.

Positive Knock-out

The use of the top, or positive, knock-out is well known, but a word may save someone a lot of trouble and experimenting. An operator should not be permitted to remove work with a pair of pliers, old file, or the like if there is any chance whatever of having the work pull up on the punch and knock off at the top of the stroke with the positive knock-out. This plan lessens the cost of the operation, the danger to the operator's fingers, and the possibility of damage to the dies by the ram of the press descending with the file or other probe in them. The writer has drilled a hole from the top of the punch shank to carry a knock-out pin, with an inch or so of spiral spring in the center, when the stroke was too long to work with a solid pin. All springs should be removed from the stripper plates on the punch and the top knock-out used if there is any chance whatever of doing so, as the cost of operation will be reduced and the result will be more satisfactory. Sometimes it is necessary to place a piece of cushion rubber on top of the pin, that is, between the pin and the knock-out, when the stroke of the press and construction of the tools will not allow of any other method. The side attachment knock-out can be used when it is impossible to use the top, back, or positive knock-out.

In blanking washers, a knock-out with a tapped hole in the end may be used. A pin screwed into this hole will run down the center of the punch and push out the punchings in compound blanking and piercing dies, when the construction of the tools will not allow a stripper pad in the center for the knock-out pin to rest on.

Magnetized Punch

A magnetized punch is a practical and efficient tool; it has an electromagnet in the center and is arranged so that the current is switched off with the full rise of the press ram. It works well on steel parts, either in forming operations or blanking. The fault with the average sub-press and precision die is that it leaves the blank in the strip of stock from which the operator has to either pick or shake it out.

Spring Attachment for Straight Cut-off Work

In Fig. 1 is shown a small spring attachment that has been successfully used on straight cut-off work. This is simply a strip of flat spring steel, bent to the desired shape, passed through the bolt hole in the side arm of the press ram, and held in position by a wooden plug driven in the hole with it. This strip is bent so as to press on the end of the work when the latter is cut off by the punch as the ram of the press descends. Then, as the operator feeds the stock through the die he forces each piece out as it is cut, the spring holding it down so that it slides out easily. With this arrangement, work may be run on "continuous trip," which could not be run on trip in any other way. The cost of production can often be lowered 75 per cent by the use of this spring.

Stripping Work from Single Piercing Punches

In piercing small work, such as washer blanks, where a single punch is used, a piece of cushion rubber placed on the punch after it is set up will force the blank off the punch as it rises out of the die. This is an old device, but nevertheless is unknown to many. When rubber is not available corks will give the same result when the piercing punches are 1/4 inch or less in diameter and the stock is not over 0.030 inch thick. Placing a spiral spring around the punch, holding it in position by wire, will accomplish the same result. If a washer is clamped in such a position that the punch travels through its center, the work will be stripped as the punch travels back through the washer. A piece of flat stock with a hole drilled in it can be used for the same purpose, and is often much easier to arrange than a washer. These methods will be found of value in shops where a great deal of special work and jobbing is done and the tools cannot be made and kept on hand for each piece of work that comes along.

Cooperation of Two or More Operators on One Press

Recently, several operators were tried on an assembling job on a punch press, but none of them could finish more than one hundred pieces an hour. They could assemble one hundred pieces in fifty minutes and press them in ten. When two operators were put on the job, each assembled one hun-

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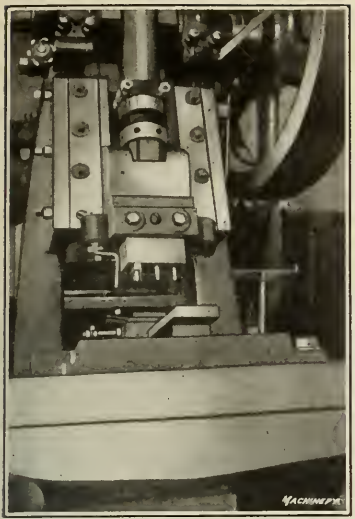


Fig. 1. Spring Attachment used on Straight Cut-off Work

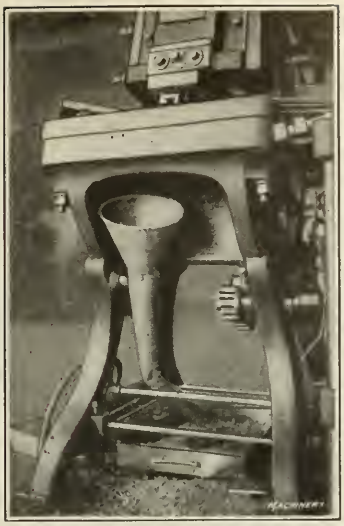


Fig. 2. Arrangement of Conveyor for separating Work from Scrap

Fig. 3. Shear Punch for removing Bolt Ends from Gear Blank

dred pieces an hour, thus earning his piecework allowance. A third operator was put with them and two could assemble enough to keep the third pressing all the time, with the result that three hundred pieces per hour were made and each operator made his piecework allowance. The production of this work was thus raised from one hundred to three hundred pieces an hour; the cost of producing was practically the same, but deliveries were made that before had been thought impossible. There was a slight saving in factory expenses, as three operators were working on one press, thus saving the cost of power for two machines that the other two operators would be running under normal conditions. In shops where conditions would allow, the assembling could have been done by much cheaper help, thus effecting a greater saving.

Use of Feeding Pliers

The use of pliers for feeding press work is a good safety measure. They will be found, in some cases, to be more efficient in handling small work than the operator's fingers, much safer, and, in case of accident, will cost less to the manufacturer. While the market is flooded with safety appliances for the punch press—many of them very good in their way—the one great factor, and the only absolutely sure precaution, is not to have the fingers between the dies when the ram descends.

Increasing Speed of Press

While the makers of power presses give certain speeds that should not be exceeded, and the executive who has charge of the machines should know what those speeds are, some machines can be safely speeded up on certain classes of work. While the writer would not advise the novice to tamper with the speed of a press, an increase of, say, ten to fifteen strokes per minute on certain classes of work that can be run on continuous stroke, or trip, involves no danger whatever to the machine, but does mean dollars saved to the manufacturer. The changing of driving pinions means time and an extra pinion, as well as the services of a millwright. But the speed of a press may be increased by winding an eighth or quarter inch of gummed tape on the pinion of a belt-driven press; this can be easily removed when it is desired to run the press on other work.

Sifting Washers from Scrap

In all shops where washers are extensively made, they must be separated from the scrap that comes from piercing the center hole. This is done in a number of ways, sifting being the most common. A sieve is used that will hold the washers but will allow the scrap to drop through. The writer has avoided this sifting operation in many cases by driving one end of a piece of steel wire into a block of wood and then placing it under the press in such a position that the washers will drop or string themselves on this wire, while the scrap falls in pans placed to receive it; the top end of the wire is turned down as a pilot. It is possible to stack a great deal of press work as it drops from the dies, thus saving time and expense that would be used in sorting and sifting operations. Small tin conveyors, such as shown in Fig. 2, may be used to divide the work from the scrap as it drops from the press.

Prevention of Scaling and Use of Shear Punch

Large blanks should be tumbled before drawing, to remove scale and give a smooth polished surface, equal parts of sea sand and granulated cork being placed in the tumbling barrel with the blanks. They come out as smooth and polished as when buffed. The cost of tumbling is slight, but the process will effect a large saving on the dies and give a much better shell. The scaling of small steel pieces, such as eyelets, small shells, ferrules, etc., in the annealing can be easily prevented by nickel or brass plating or dip before annealing. Brass does not scale and the plate thus protects the steel from scaling.

In Fig. 3 is shown a set of press tools that comprises a steel shearing punch and two clamps. Their use lowered the cost from fifty cents a piece to fifteen cents per hundred pieces. The work is a gear blank built up of laminations held in place by eighteen 1/4-inch steel studs protruding about 1/2 inch through a side piece of 1/4-inch boiler plate. These protruding ends were formerly cut off with a pneumatic chisel, one at a time, the operation paying fifty cents per finished blank. The studs on one side are now cut off with three strokes of the press, paying fifteen cents per hundred blanks. The only tool is the shearing punch which cost $3. The holding nest is two clamps bolted to the bedplate of the press, thus holding the blank in position, and allowing it to be turned as required by the operator.

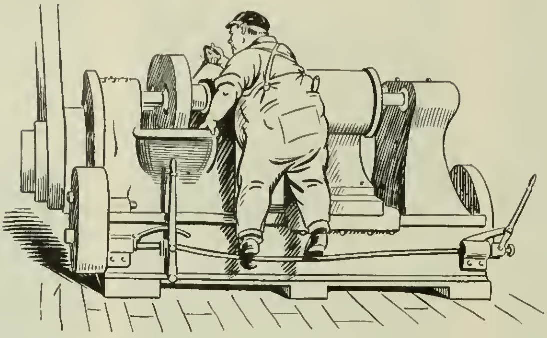
* * *

A device for testing the safety and carrying strength of floors, walls and columns has been invented by a building inspector of Seattle, Wash. This device, which he calls the "extensometer," is said to be so sensitive that it will measure 0.0001 inch. The device is used to measure the amount of change produced by a load, for when a floor slab is loaded, the under surface stretches and the upper surface is compressed. By measuring the amount of the change thus produced and taking into consideration the kind and quality of the material and the load, it is possible to figure the safe carrying capacity of the building. This device is particularly adapted for concrete structures, because the weak places of these are not otherwise easily discerned.

SNAPSHOTS ON THE ROAD

A HIGH WAGES ASPIRANT—FITTING ROUND PEGS INTO ROUND HOLES—FIRE PREVENTION HINT—THE EFFICIENCY EXPERT

DOWN in New England there is an old machine tool builder who has a reputation for making good, serviceable machines. Incidentally, he isn't strong on technical education, and sometimes the younger men in his organization are inclined to set him down as a back number. However, his "horse sense" often saves the day for them, as the following incident will show.



"—he's going to stand on that shaft to oil those top bearings"

One day he gave one of his machine designers a feed-control shaft to lay out. It was a long, horizontal shaft, located at the front of the machine about a foot from the floor. As the shaft had very little load to carry, the designer estimated that 7/8 inch diameter would be ample to give the necessary strength, and so informed his superior. But the old machine builder chuckled when the designer told him of his figure, shook his head, and said:

"Say, young fellow, you forget that when the machinist who runs this machine starts it up on Monday morning, he's going to stand on that shaft to oil those top bearings. Maybe he'll be a 200-pounder—better make that shaft 2 inches diameter and you'll be on the safe side for everything."

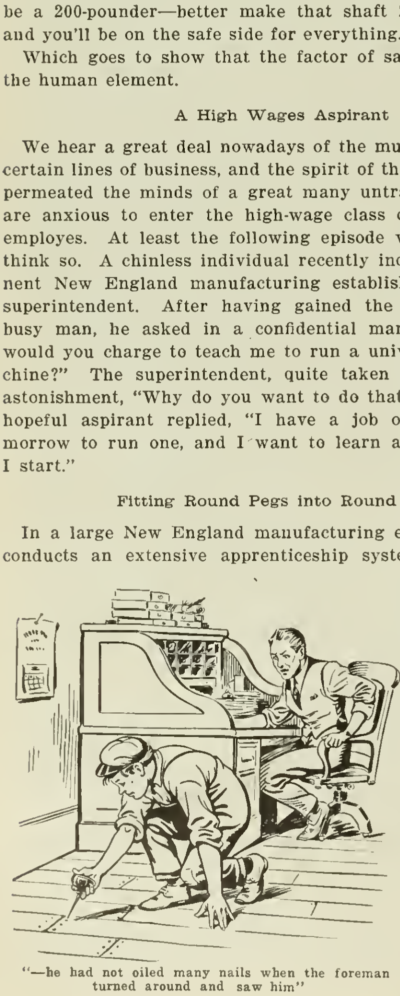
Which goes to show that the factor of safety must include the human element.

A High Wages Aspirant

We hear a great deal nowadays of the mushroom growth of certain lines of business, and the spirit of the times must have permeated the minds of a great many untrained fellows who are anxious to enter the high-wage class of munition plant employes. At least the following episode would lead one to think so. A chinless individual recently inquired at a prominent New England manufacturing establishment to see the superintendent. After having gained the audience of that busy man, he asked in a confidential manner, "How much would you charge to teach me to run a universal milling machine?" The superintendent, quite taken aback, replied in astonishment, "Why do you want to do that?" To which the hopeful aspirant replied, "I have a job offered me for tomorrow to run one, and I want to learn all about it before I start."

Fitting Round Pegs into Round Holes

In a large New England manufacturing establishment that conducts an extensive apprenticeship system, the boys are taken in on a two months' trial. If they prove to be adapted for a mechanical career, they then go on and complete the four-year course. The following incident will illustrate one of the ways in which the unfit are eliminated. In the early part of the course, all the boys work in one training room, from which they are later transferred to the various departments in which they are to work. At about eleven o'clock on Saturday morning it is customary to stop all the machines, divide the boys into squads, and commission each squad to wield a broom, brush, waste, or some other cleaning implement. Some of the older apprentices act as gang bosses, and one day an unsophisticated country youth, having completed his allotted portion of work at a quarter of twelve, asked his apprentice boss what else he could do. The apprentice boss, having a perverted sense of humor, suggested that he take his oil-can and thoroughly oil the heads of the nails that protruded from the wooden floor, starting over near the foreman's desk. This being the first Saturday the boy was there, and supposing this to be part of the general Saturday clean-up, he seized an oil-can and, starting by the foreman's desk, proceeded to oil each and every nail head, made shiny and smooth by constant wear. The process of elimination was greatly accelerated in the case of this youth, for he had not oiled many nails when the foreman turned and saw him.

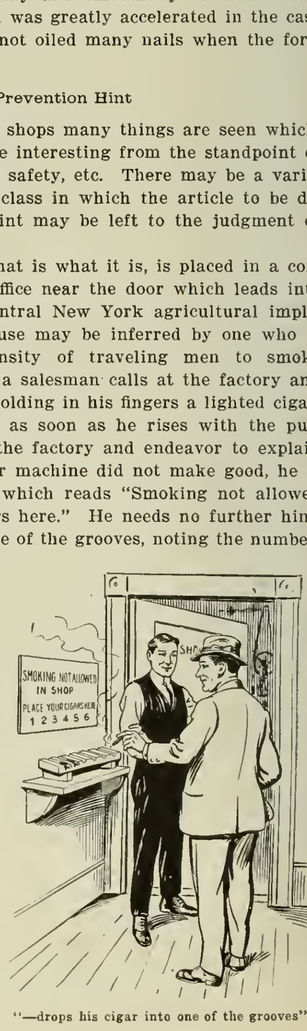


"—he had not oiled many nails when the foreman turned around and saw him"

Fire Prevention Hint

In roaming through the shops many things are seen which, though not mechanical, are interesting from the standpoint of general welfare, efficiency, safety, etc. There may be a variation of opinion as to the class in which the article to be described belongs. That point may be left to the judgment of the reader.

This cigar holder, for that is what it is, is placed in a conspicuous position in the office near the door which leads into the factory of a large Central New York agricultural implement manufacturer. Its use may be inferred by one who is familiar with the propensity of traveling men to smoke wherever they go. When a salesman calls at the factory and is ushered into the office holding in his fingers a lighted cigar, no remark is made. But as soon as he rises with the purchasing agent to go into the factory and endeavor to explain why his particular steel or machine did not make good, he is confronted with the sign which reads "Smoking not allowed in shop. Place your cigars here." He needs no further hint, but drops his cigar into one of the grooves, noting the number, and proceeds glumly into the shop with his guide. But when he returns, he finds his cigar safe and well preserved—from a sanitary standpoint. It is interesting to note that there is no provision made for the man who smokes a pipe; but, then, what excuse has a salesman for smoking a pipe when he's on the road?



"—drops his cigar into one of the grooves"

The Efficiency Expert

The efficiency expert, having been sent from the home office to infuse efficiency into a smoothly running and

highly productive shop organization, in which the superintendent takes considerable pride, entered light-heartedly upon his duties. He found the superintendent at his desk, planted himself in a chair beside him, and told him that he had been authorized to install certain systems in the plant. He hoped that they would be able to work harmoniously together, and that there would be no difficulty due to divided authority.

The superintendent, who had had some experience in the past with efficiency experts, replied: "I have no objection whatever to your installing any systems in this shop that you deem advisable as long as you do not interfere with the present efficiency of the plant or its output. But in case I find we are running to system instead of to output, you will agree that it will then be time to interfere."

So the efficiency expert will play around, spending some of the company's money, without interference so long as the present efficiency is not lowered and the output is not cut down.

* * *

LANTERN PINIONS IN CLOCKS

BY GUY H. GARDNER [1]

Every machinist who has investigated the interior anatomy of the family clock, as probably most of us have, must have been struck by the peculiarity of the pinions. These, instead of being cut as in machinery with which we are more familiar, are the so-called "lantern pinions," made of two disks between which are "rounds" of steel rod to serve as teeth or leaves. In earlier days, this form of pinion was sometimes employed in other than horological machinery because of the ease of its construction with limited tool equipment. For instance, a photograph of a windmill in New England, built before the Revolutionary War, shows wooden gears meshing with lantern pinions which were also made of wood. In some of these early examples of primitive millwright work, the rounds were made to turn in the shrouds, doubtless for the purpose of diminishing friction. Apparently, however, this construction was soon found to be erroneous, as the rounds were later made fixed.

Many machinists, wondering at the persistence of these lantern pinions in nine-tenths of American clocks, consider them "vestigial remnants" like the human appendix. Some seem to attribute their survival to ironclad conservatism, some to a supposedly greater cheapness of manufacture, while some deem the designers ignorant of more modern and more suitable modes of construction. The skill, knowledge, and progressive spirit of the makers of clocks need no vindication, for anyone who will spend a day in looking through one of their factories, observing tools, designs and methods, will be convinced that clockmakers are fully up to date.

Why, then, do they continue to use what a reader of MACHINERY, in a recent letter, calls "an outworn, unmechanical monstrosity"? Because it is neither outworn, unmechanical, nor a monstrosity. For the conditions under which the ordinary low-priced clock has to operate, it is far superior to the best cut pinion. When a pinion is to drive its gear, the lantern is out of the question, being entirely unsuited to this service; but in every part of a clock train, save one, the pinion is the driven member.

As we all know, the average cheap clock must be planned to run as long as possible without skilled attention. Most owners of watches have them cleaned occasionally, but how many ever take a clock to the repairer for cleaning until it utterly refuses to tick? Thousands and tens of thousands, moreover, are exported to countries that we consider uncivilized, where they are never cleaned or oiled, but must run until entirely worn out, and we may be sure that those purchased to replace them will not be of the same make, unless the "uncivilized" owner has found them longer lived than their numerous competitors.

Two qualities render the lantern pinion especially suitable for use in a movement that must operate under such conditions. An accumulation of dirt that would stop the action of any other form of tooth is simply pushed through between the rounds, and the pinion continues to perform its function. The second point of superiority is less obvious. Anyone who will draw, to scale, an epicycloidal-tooth gear, driving a lantern pinion, and study their action will find that a lantern pinion of seven or eight rounds will work as smoothly as a cut pinion of ten or twelve leaves. As the possibility of using coarser pitch makes the mating gear both cheaper and stronger, the claim of superiority of the lantern will be seen to rest on a solid foundation. Another point of some importance is that slight variations of center distance have a less detrimental effect than with other forms of pinions, so that a clock will continue running after its pivot holes are considerably worn and the accuracy of the original "depthing" sufficiently impaired to put a cut pinion out of commission. For clocks which, by reason of their greater cost, will presumably receive adequate care, the lantern pinion presents no advantages, and in them the cut pinion is commonly used.

The accuracy attained in the manufacture of the lantern pinions will surprise anyone who has regarded them as crude. A person may examine thousands without finding one that exceeds the limit of 0.0005 inch variation in pitch diameter, and the excellence of the fit of the rounds in the holes drilled for their reception is equally admirable. The one place where the pinion is the driving member is in the "motion work," which we might call the "back-gear," the train of two pinions and two wheels that causes the hour hand to make one revolution to twelve of the minute hand. Here, as far as the writer is aware, cut pinions are always used.

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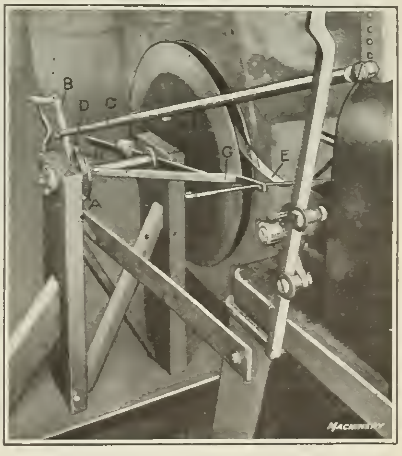
* * *

AUTOMATICALLY OPERATED STOCK REEL

An automatically operated stock reel belongs logically with an automatically fed press, and unless automatically fed presses are equipped with a good fool-proof reel like the one described below, there is no end to the trouble and expense that may be incurred. At the factory of the Frank Mossberg Co., Attleboro, Mass., there are several press jobs which run continuously from one year's end to another. It is through the courtesy of this company that we are enabled to present the accompanying illustration and information. The apparatus is constructed so that the reel proper can be easily removed to give free access for replenishing the stock. The reel is fixed to the main shaft, as is also the fine-pitch ratchet wheel A. The lever B swings freely on the main shaft and constantly oscillates while the press is running, power being transmitted to it from the press by the connecting-rod C. Lever B is oscillated once for every stroke of the press. Attached to lever B is the ratchet dog D, which is prevented from engaging with the teeth of ratchet A so long as the strip of stock E is hanging slack from the reel. As soon as the stock feeds far enough into the dies to take up the slack in the strip, the trip arm G is raised to the position shown, at which point the dog cam H, which is integral with it, has rotated far enough to allow the pin protruding from dog D to drop into a hollow on its periphery. This, of course, brings dog D into contact with ratchet wheel A, and at the next reciprocation of the lever B, the reel is rotated a full turn or some fraction according to the momentum given it. This runs out a considerable amount of stock, allowing the feed lever to drop down, which holds the dog out of engagement again until the stock becomes tight again. V. B.



Automatic Stock Reel attached to Rear of Press

OIL-GROOVING GEAR SHAPER SADDLES AND UPPER INDEX WHEELS

BY JOHN G. BRUEGGEMAN [1]

Proper distribution of the lubricant in bearings, especially vertical bearings, demands more or less elaborate oil-grooving, from the simple helical groove to the more complex irregular kind. Cutting such grooves by hand is a laborious, time-consuming, and generally unsatisfactory process; yet for machining these grooves quite elaborate mechanisms, usually embodying some sort of cam, are often required. Two cases where quite simple cam devices accomplish the purpose are the operations of oil-grooving the bearings in the saddle and on the upper index wheel of the Fellows gear shaper.

The oil-groove in the saddle bearing consists of three circular and three helical grooves, as shown in Fig. 1. The helical grooves run into the circular ones near their ends, further complicating the machining. This saddle bearing takes the ram carrying the cutter-spindle and is the most important and most used bearing on the machine. The up-and-down sliding motion to which it is constantly subjected takes place at fairly high speeds. The necessity for smooth-edged grooves, giving an even and ample distribution of oil, is obvious. The ram has a rack cut on the rear side from which it receives its motion. The bearing is therefore not circular, but has about one-third cut away as shown.

A simple but effective device for cutting these grooves was made by mounting a cam in the boring-bar of a horizontal

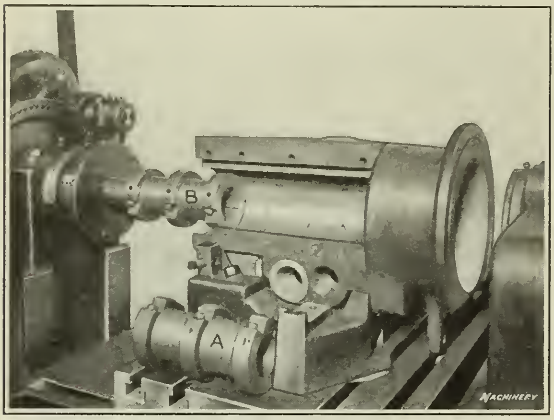


Fig. 1. Tools for cutting Oil-grooves in Gear Shaper Saddle

boring mill. The cam is shown in position in Fig. 2. The machining of the grooves is done in two operations, using the two sets of grooving tools *A* and *B*, Fig. 1. The three circular grooves are cut in one operation with the tool *A*, the cam being removed from the boring-bar. The center of the work is set horizontal with the center of the boring-bar and the table fed forward, bringing the work into the tool. The depth of the grooves is 0.120 inch. For the helical grooves, tool *B* is used; this has the three cutters ground to the helix angle of the grooves. The cam, mounted on the boring-bar, carries the cutters along the helical path of the grooves, then in a circular path for about 15 degrees where the helical grooves run into the circular ones, after which they are given a quick-return helical motion while sweeping over the part of the bearing which is cut away. The table is fed forward during the last part of the revolution, when the cut is repeated until the desired depth of groove is reached. The stationary roller *R*, Fig. 2, running in the cam groove, gives the boring-bar its endwise motion. The cutting time for each grooving operation is one and one-half minute. The aligning jig used is the same as is used for boring the saddles.

The external grooving on the upper index wheel is done by the application of a similar mechanism to the engine lathe; Fig. 3 shows the arrangement. The oil-grooves in this case are four simple helical grooves running backward and forward

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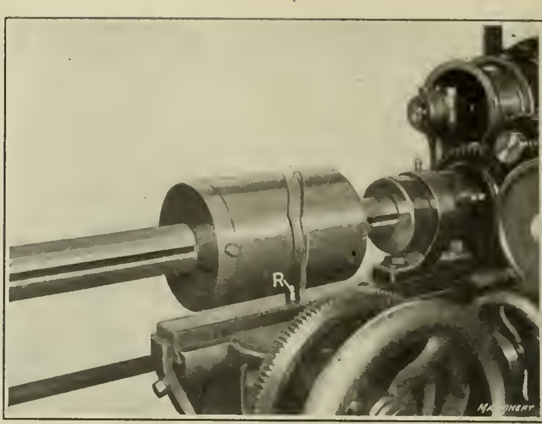

Fig. 2. Cam controlling machining of Helical Oil-grooves in Saddle

around the hub of the index wheel. The tool used for cutting them is a common grooving tool. The cam *C*, Fig. 3, is mounted on the feed-rod of the lathe; the bracket *B* holds the roller, which runs in the cam groove. The lathe feed is disconnected and the motion of the carriage is controlled entirely by the cam. The cam groove has only two lobes, but the lathe is geared so that the feed-rod makes two revolutions while the work makes one, so that the groove in the work has four lobes. The cutting time for this operation is about two minutes.

* * *

The tendency of manufacturing concerns during the past twenty years has been to establish their plants outside of cities and towns where land is cheap and free from the restrictions imposed on city property. From the engineering point of view, the location outside was advantageous. Large plants could be built one story high, using the sawtooth roof construction which provides for unlimited expansion and uniform daylight throughout. But from the labor point of view, such locations have serious objections. A large plant on the outskirts of a town may, and usually does, draw its labor supply from various sections of the town, and some of the employes will be on the far side, thus making necessary long car rides morning and night. There is a growing reversion to the multiple-story type building located nearer the center of local population, where it may be reached without long trips on the street cars.

* * *

A centrifugal machine for casting iron pipe has been developed by a Brazilian named J. J. Queioz, which casts pipe in permanent molds without cores. The molten metal is poured into the machine through a horizontal trough, from which it is discharged into the revolving mold. The mold is water-cooled and the pipe quickly sets so that it can be removed. It is claimed that the process is rapid, economical and that the product is superior to cast-iron pipe cast in sand molds.

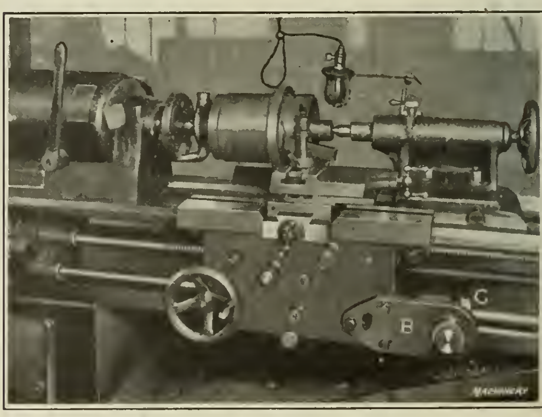

Fig. 3. Cutting Oil-grooves in Upper Index Wheel in a Lathe

Gaging and Inspecting Threads[1]—I

by Douglas T. Hamilton[2]

THE production of screw threads on an interchangeable basis is one of the most difficult problems encountered in applying the limit system. In a report presented to the American Society of Mechanical Engineers in April, 1912, several interesting questions in connection with this subject were brought up for discussion, but up to the present time the committee handling this matter has not presented a full report. Considerable difference of opinion exists in regard to the question of manufacturing tolerances on the various elements of a screw thread, and in the following this point, as well as several others of importance, will be reviewed.

Elements of Screw Threads

The elements of a screw thread are indicated in Fig. 1, and the following gives a list of the various names used to define the particular point or element of the thread referred to:

A is the pitch diameter of a screw and is measured by the distance between the pitch lines, which are located where the width of the land and the space are the same and equal to one-half the pitch. This element is also known as the angle diameter and the effective diameter.

B is the outside diameter of a screw and is twice the maximum radius of the screw measured at right angles to the axis. This element is also known as the full diameter and the external diameter.

C is the smallest diameter of a screw thread and is equal to twice the minimum radius of the screw measured at right angles to the axis. This element is known as the root diameter and the core diameter.

D is the pitch and is the distance between the centers of any two adjacent threads, measured parallel with the axis of the screw. The reciprocal of the pitch measures the number of turns per inch; therefore *D* is correctly expressed in fractions, for instance as ½ inch, but is commonly expressed as the number of threads per inch.

E is the included angle of the thread and refers to the angle between the slopes of the thread measured in an axial plane.

F is the slope of a thread and refers to the angular side of the thread which connects the crest and root.

G is the crest or prominent part of the thread, whether of the male screw or female nut. This part is also known as the top and the flat on U. S. standard form of threads.

H is the root, and refers to the bottom of the groove of the thread, whether of the male screw or of the female nut. This element is also known as the bottom.

The dimension *C* on the male thread or screw is measured at the root of the thread, whereas the same dimension on the female thread or nut is measured between the crests. These two dimensions are practically the same except for the allowance made for clearance. The lead of the screw is the distance that it travels in a longitudinal direction in one turn and differs from the pitch in that the latter measures the distance from center to center of any two adjacent threads.

In the case of the standard V-thread, shown at *A* in Fig. 2, there are five points to be measured in both the screw and the nut, making a total of ten in all. An error in any one of these points will prevent the screw and nut from going together properly. In the Cadillac form of thread, shown at *B*, four of these points are eliminated, leaving only the pitch diameter, pitch, and angle of thread to be considered on the screw and the nut.

Theoretically, the shape of the threads shown at *C*, *D* and *E* in Fig. 2 present ten elements that must be correct before the screw and nut will go together properly. The Acme thread, shown at *F*, has a clearance top and bottom, leaving only six out of the ten elements to be considered. In actual practice, the U. S. standard form of thread is made with a clearance top and bottom, and the chief points are to have the thread correct on the angular faces and the pitch and the pitch diameter correct. The tolerances, however, have never been generally accepted, and it is for this reason that so much uncertainty exists as to tolerances that should be given on threaded parts for various classes of work.

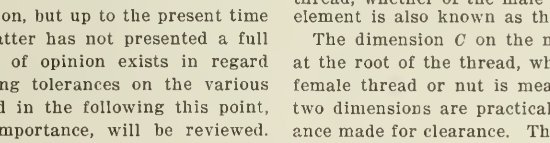

Fig. 1. Diagram illustrating Various Elements of a Screw Thread

Tolerances on Screw Threads

The three points that receive the most careful attention in the production of a screw thread are the pitch,

[1] For information on gages and gaging previously published in MACHINERY, see "Profile and Indicating Gages" in the November and December, 1916, numbers and articles referred to in connection with the first installment.

[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

the pitch diameter, and the included angle of the thread. In the U. S. standard thread, errors in pitch can be corrected by reducing the pitch diameter by an amount equal to about one and one-half times the error in pitch on the radius, or about three times the pitch error on the full diameter of the screw. In threaded parts that must fit together, however, this method of obtaining a fit is not recommended.

The permissible error in lead is dependent upon the length of the thread on the screw or in the nut. The longer the screws or the deeper the holes in the nut, the smaller will be the amount of error permissible in the lead. Another factor that must be considered in fitting a screw and a nut is the included angle of the thread. This element can be compensated for by a reduction or increase of the pitch diameter, depending upon whether the angle is greater or less than that required.

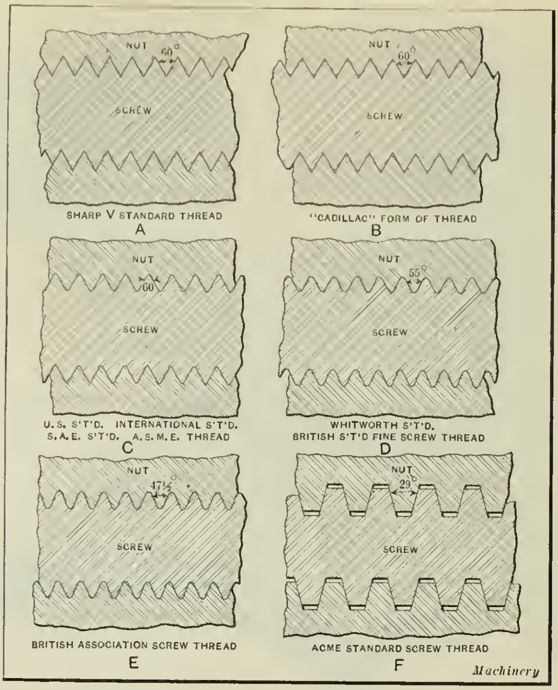

Fig. 2. Diagrams illustrating Various Forms of Screw Threads

The Engineering Standards Committee of Great Britain has given the subject of screw-thread tolerances considerable attention, and has established certain tolerances for different classes of fits. The formulas established for determining the tolerances and allowances on the outside and root diameters of the bolt and nut for the Whitworth and British standard fine screw threads are given in the following, and the data for the British standard Whitworth thread are also given in Tables I and II. The tolerances and allowances on the British standard Whitworth thread are found by the following formulas:

Tolerance on outside diameter of bolt $= -0.0035$ inch $\sqrt{D}$ (1)

Tolerance on root diameter of bolt $= -0.0045$ inch $\sqrt{D}$ (2)

Tolerance between bolt and nut $= +0.001$ inch $\sqrt{D}$ (3)

Tolerance on outside and root diameters of nut $= +0.0035$ inch $\sqrt{D}$ (4)

in which D = nominal diameter of the thread in inches.

The positive and negative signs refer to the direction in which the tolerance is permitted on the bolt and nut, respectively. The tolerance on the outside and root diameters of the nut established by Formula (4) is to be added to the allowance given by Formula (3).

The formulas used for determining the tolerances and allowances on British standard fine threads are as follows:

Tolerance on outside diameter of bolt $= -0.0025$ inch $\sqrt{D}$ (5)

Tolerance on root diameter of bolt $= -0.0035$ inch $\sqrt{D}$ (6)

Allowance of nut $= +0.001$ inch $\sqrt{D}$ (7)

Tolerance on outside and root diameters of nut $= +0.0025$ inch $\sqrt{D}$ (8)

The amount established by Formula (8) is also to be added to that obtained by Formula (7).

TABLE I. BRITISH STANDARD WHITWORTH SCREW THREADS—TOLERANCES FOR BOLTS

Nominal Diameter of Screw, Inches	Number of Threads per Inch	Tolerance on Pitch per Inch Length of Thread, Inches	Outside Diameter, Inches			Pitch Diameter, Inches			Root Diameter, Inches		
			Maximum	Minimum	Tolerance	Max. for a Screw of Correct Pitch[1]	Minimum	Tolerance	Maximum	Minimum	Tolerance
1/4	20.0	0.0035	0.2500	0.2482	0.0018	0.2180	0.2162	0.0018	0.1860	0.1837	0.0023
5/16	18.0	0.0033	0.3125	0.3105	0.0020	0.2769	0.2748	0.0021	0.2414	0.2389	0.0025
3/8	16.0	0.0032	0.3750	0.3729	0.0021	0.3350	0.3326	0.0024	0.2950	0.2922	0.0028
7/16	14.0	0.0031	0.4375	0.4352	0.0023	0.3918	0.3891	0.0027	0.3460	0.3430	0.0030
1/2	12.0	0.0030	0.5000	0.4975	0.0025	0.4466	0.4436	0.0030	0.3933	0.3901	0.0032
9/16	12.0	0.0029	0.5625	0.5599	0.0026	0.5091	0.5059	0.0032	0.4558	0.4524	0.0034
5/8	11.0	0.0028	0.6250	0.6222	0.0028	0.5668	0.5633	0.0035	0.5086	0.5050	0.0036
11/16	11.0	0.0027	0.6875	0.6846	0.0029	0.6293	0.6255	0.0038	0.5711	0.5674	0.0037
3/4	10.0	0.0027	0.7500	0.7470	0.0030	0.6860	0.6820	0.0040	0.6219	0.6180	0.0039
13/16	10.0	0.0026	0.8125	0.8093	0.0032	0.7485	0.7442	0.0043	0.6844	0.6803	0.0041
7/8	9.0	0.0026	0.8750	0.8717	0.0033	0.8039	0.7994	0.0045	0.7327	0.7285	0.0042
15/16	9.0	0.0025	0.9375	0.9341	0.0034	0.8664	0.8616	0.0048	0.7952	0.7908	0.0044
1	8.0	0.0025	1.0000	0.9965	0.0035	0.9200	0.9150	0.0050	0.8399	0.8354	0.0045
1 1/8	7.0	0.0024	1.1250	1.1213	0.0037	1.0335	1.0280	0.0055	0.9420	0.9372	0.0048
1 1/4	7.0	0.0024	1.2500	1.2461	0.0039	1.1585	1.1526	0.0059	1.0670	1.0620	0.0050
1 3/8	6.0	0.0023	1.3750	1.3709	0.0041	1.2683	1.2620	0.0063	1.1616	1.1563	0.0053
1 1/2	6.0	0.0023	1.5000	1.4957	0.0043	1.3933	1.3865	0.0068	1.2866	1.2811	0.0055
1 5/8	5.0	0.0022	1.6250	1.6205	0.0045	1.4969	1.4897	0.0072	1.3689	1.3632	0.0057
1 3/4	5.0	0.0022	1.7500	1.7454	0.0046	1.6219	1.6143	0.0076	1.4939	1.4879	0.0060
1 7/8	4.5	0.0021	1.8750	1.8702	0.0048	1.7327	1.7247	0.0080	1.5904	1.5842	0.0062
2	4.5	0.0021	2.0000	1.9950	0.0050	1.8577	1.8493	0.0084	1.7154	1.7090	0.0064
2 1/8	4.5	0.0021	2.1250	2.1199	0 0051	1.9827	1.9739	0.0088	1.8404	1.8338	0.0066
2 1/4	4.0	0.0020	2.2500	2.2447	0.0053	2.0899	2.0807	0.0092	1.9298	1.9230	0.0068
2 3/8	4.0	0.0020	2.3750	2.3696	0.0054	2.2149	2.2053	0.0096	2.0548	2.0479	0.0069
2 1/2	4.0	0.0020	2.5000	2.4945	0.0055	2.3399	2.3300	0.0099	2.1798	2.1727	0.0071
2 5/8	4.0	0.0020	2.6250	2.6193	0.0057	2.4649	2.4546	0.0103	2.3048	2.2975	0.0073
2 3/4	3.5	0.0019	2.7500	2.7442	0.0058	2.5670	2.5563	0.0107	2.3841	2.3766	0.0075
2 7/8	3.5	0.0019	2.8750	2.8691	0.0059	2.6920	2.6810	0.0110	2.5091	2.5015	0.0076
3	3.5	0.0019	3.0000	2.9940	0.0060	2.8170	2.8056	0.0114	2.6341	2.6263	0.0078

Machinery

[1] The maximum pitch diameter is decreased when the screw is incorrect in pitch by the amount compensating for such error given in Table III.

TABLE II. BRITISH STANDARD WHITWORTH SCREW THREADS—TOLERANCES FOR NUTS

Nominal Diameter of Screw, Inches	Number of Threads per Inch	Tolerance on Pitch per Inch of Length of Thread, Inches	Outside Diameter, Inches			Pitch Diameter, Inches			Root Diameter, Inches		
			Maximum	Minimum	Tolerance	Maximum	Min. for a Nut of Correct Pitch[1]	Tolerance	Maximum	Minimum	Tolerance
1/4	20.0	0.0035	0.2523	0.2505	0.0018	0.2203	0.2185	0.0018	0.1883	0.1865	0.0018
5/16	18.0	0.0033	0.3151	0.3131	0.0020	0.2796	0.2775	0.0021	0.2440	0.2420	0.0020
3/8	16.0	0.0032	0.3777	0.3756	0.0021	0.3380	0.3356	0.0024	0.2977	0.2956	0.0021
7/16	14.0	0.0031	0.4405	0.4382	0.0023	0.3952	0.3925	0.0027	0.3490	0.3467	0.0023
1/2	12.0	0.0030	0.5032	0.5007	0.0025	0.4503	0.4473	0.0030	0.3965	0.3940	0.0025
9/16	12.0	0.0029	0.5659	0.5633	0.0026	0.5131	0.5099	0.0032	0.4592	0.4566	0.0026
5/8	11.0	0.0028	0.6286	0.6258	0.0028	0.5711	0.5676	0.0035	0.5122	0.5094	0.0028
11/16	11.0	0.0027	0.6912	0.6883	0.0029	0.6339	0.6301	0.0038	0.5748	0.5719	0.0029
3/4	10.0	0.0027	0.7539	0.7509	0.0030	0.6909	0.6869	0.0040	0.6258	0.6228	0.0030
13/16	10.0	0.0026	0.8166	0.8134	0.0032	0.7537	0.7494	0.0043	0.6885	0.6853	0.0032
7/8	9.0	0.0026	0.8792	0.8759	0.0033	0.8093	0.8048	0.0045	0.7369	0.7336	0.0033
15/16	9.0	0.0025	0.9419	0.9385	0.0034	0.8722	0.8674	0.0048	0.7996	0.7962	0.0034
1	8.0	0.0025	1.0045	1.0010	0.0035	0.9260	0.9210	0.0050	0.8444	0.8409	0.0035
1 1/8	7.0	0.0024	1.1298	1.1261	0.0037	1.0401	1.0346	0.0055	0.9468	0.9431	0.0037
1 1/4	7.0	0.0024	1.2550	1.2511	0.0039	1.1655	1.1596	0.0059	1.0720	1.0681	0.0039
1 3/8	6.0	0.0023	1.3803	1.3762	0.0041	1.2758	1.2695	0.0063	1.1669	1.1628	0.0041
1 1/2	6.0	0.0023	1.5055	1.5012	0.0043	1.4013	1.3945	0.0068	1.2921	1.2878	0.0043
1 5/8	5.0	0.0022	1.6308	1.6263	0.0045	1.5054	1.4982	0.0072	1.3747	1.3702	0.0045
1 3/4	5.0	0.0022	1.7559	1.7513	0.0046	1.6308	1.6232	0.0076	1.4998	1.4952	0.0046
1 7/8	4.5	0.0021	1.8812	1.8764	0.0048	1.7421	1.7341	0.0080	1.5966	1.5918	0.0048
2	4.5	0.0021	2.0064	2.0014	0.0050	1.8675	1.8591	0.0084	1.7218	1.7168	0.0050
2 1/8	4.5	0.0021	2.1316	2.1265	0.0051	1.9930	1.9842	0.0088	1.8470	1.8419	0.0051
2 1/4	4.0	0.0020	2.2568	2.2515	0.0053	2.1006	2.0914	0.0092	1.9366	1.9313	0.0053
2 3/8	4.0	0.0020	2.3819	2.3765	0.0054	2.2260	2.2164	0.0096	2.0617	2.0563	0.0054
2 1/2	4.0	0.0020	2.5071	2.5016	0.0055	2.3514	2.3415	0.0099	2.1869	2.1814	0.0055
2 5/8	4.0	0.0020	2.6323	2.6266	0.0057	2.4768	2.4665	0.0103	2.3121	2.3064	0.0057
2 3/4	3.5	0.0019	2.7575	2.7517	0.0058	2.5794	2.5687	0.0107	2.3916	2.3858	0.0058
2 7/8	3.5	0.0019	2.8826	2.8767	0.0059	2.7047	2.6937	0.0110	2.5167	2.5108	0.0059
3	3.5	0.0019	3.0077	3.0017	0.0060	2.8301	2.8187	0.0114	2.6418	2.6358	0.0060

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[1] The minimum pitch diameter is increased when the nut is incorrect in pitch by the amount compensating for such error given in Table III.

Tolerances on Pitch and Pitch Diameter

In regard to errors in pitch and pitch diameter, it should be understood that with an angular thread the error in pitch manifests itself not only in the direction of the axis of the screw, but also at right angles to the axis. Therefore if an error in pitch is tolerated, a corresponding allowance should be made in the pitch diameter to compensate for the transverse effect of the pitch error introduced. If the limits for pitch diameter are determined by Formulas (11) and (12), respectively, which are intended to cover both the errors of that element and the allowance required to compensate for the transverse effect of pitch error, it follows that the error in pitch must be limited to such an amount that the corresponding allowance in pitch diameter is never greater than the tolerances given.

The maximum permissible error in pitch, which as previously explained is connected with the tolerance on the pitch diameter, is determined by the following formulas, the thickness of the nut being assumed to be equal to the diameter of the bolt.

Tolerance in pitch per inch of length of thread in nut for British standard Whitworth thread $= \dfrac{\pm 0.0025}{\sqrt[4]{D}}$ (9)

Tolerance in pitch per inch of length of thread in nut for British standard fine screw threads $= \dfrac{\pm 0.0015}{\sqrt[4]{D}}$ (10)

Applying Formula (9) for a British standard Whitworth 1/4-inch bolt, the actual error permissible in the length of thread in the nut will be found to be less than $\pm$ 0.001 inch.

The tolerances on the pitch diameter, which include in each case the allowances made to compensate for the maximum pitch error, are determined by the formulas given in the following:

Tolerance on pitch diameter of British standard Whitworth thread $= 0.005\sqrt[4]{D^3}$ (11)

Tolerance on pitch diameter of British standard fine threads $= 0.003\sqrt[4]{D^3}$ (12)

TABLE III. ALLOWANCES TO COMPENSATE FOR ERRORS IN PITCH OF BRITISH STANDARD WHITWORTH SCREW THREADS

Nominal Diameter of Screw, Inches	Allowances in Pitch Diameter to Compensate for Errors in Pitch of						
	± 0.0005 Inch per Inch	± 0.0010 Inch per Inch	± 0.0015 Inch per Inch	± 0.0020 Inch per Inch	± 0.0025 Inch per Inch	± 0.0030 Inch per Inch	± 0.0035 Inch per Inch
1/4	0.0003	0.0005	0.0008	0.0010	0.0013	0.0015	0.0018
5/16	0.0003	0.0006	0.0009	0.0013	0.0016	0.0019	0.0022
3/8	0.0004	0.0008	0.0011	0.0015	0.0019	0.0023	0.0026
7/16	0.0004	0.0009	0.0013	0.0018	0.0022	0.0026	0.0031
1/2	0.0005	0.0010	0.0015	0.0020	0.0025	0.0030	......
9/16	0.0006	0.0011	0.0017	0.0023	0.0028	0.0034	......
5/8	0.0006	0.0013	0.0019	0.0025	0.0031	0.0038	......
11/16	0.0007	0.0014	0.0021	0.0028	0.0034	0.0041	......
3/4	0.0008	0.0015	0.0023	0.0030	0.0038	0.0045	......
13/16	0.0008	0.0016	0.0024	0.0033	0.0041	0.0049	......
7/8	0.0009	0.0018	0.0026	0.0035	0.0044	0.0053	......
15/16	0.0009	0.0019	0.0028	0.0038	0.0047	......	......
1	0.0010	0.0020	0.0030	0.0040	0.0050	......	......
1 1/8	0.0011	0.0023	0.0034	0.0045	0.0056	......	......
1 1/4	0.0013	0.0025	0.0038	0.0050	0.0063	......	......
1 3/8	0.0014	0.0028	0.0041	0.0055	0.0069	......	......
1 1/2	0.0015	0.0030	0.0045	0.0060	0.0075	......	......
1 5/8	0.0016	0.0033	0.0049	0.0065	0.0081	......	......
1 3/4	0.0018	0.0035	0.0053	0.0070	0.0088	......	......
1 7/8	0.0019	0.0038	0.0056	0.0075	0.0094	......	......
2	0.0020	0.0040	0.0060	0.0080	0.0100	......	......
2 1/8	0.0021	0.0043	0.0064	0.0085	0.0106	......	......
2 1/4	0.0023	0.0045	0.0068	0.0090	......	......	......
2 3/8	0.0024	0.0048	0.0071	0.0095	......	......	......
2 1/2	0.0025	0.0050	0.0075	0.0100	......	......	......
2 5/8	0.0026	0.0053	0.0079	0.0105	......	......	......
2 3/4	0.0028	0.0055	0.0083	0.0110	......	......	......
2 7/8	0.0029	0.0058	0.0086	0.0115	......	......	......
3	0.0030	0.0060	0.0090	0.0120	......	......	......

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In the case of a bolt of incorrect pitch, the pitch diameter must be reduced by the amount necessary to compensate for the pitch error; that is, the pitch diameter requires an allowance for this purpose. Thus the tolerances on the pitch diameter and pitch are linked together, so that if the pitch is correct the tolerance on the pitch diameter has the full value given in Table I, but if the pitch is in error, the permissible limits or variations in pitch diameter are reduced by the allowance given in Table III. In the case of a nut, the minimum pitch diameter is increased by the allowance given in Table III.

For instance, in the case of bolts having a known pitch error, the maximum pitch diameter given in Table I must be decreased an amount equal to that given in Table III, the minimum pitch diameter remaining the same. For example, in calculating the amount of allowance necessary in the pitch diameter for a British Whitworth 1-inch bolt having, say, a pitch error of + 0.0012 inch per inch, the amount of compensation, as found by interpolation from Table III, is 0.0024 inch; so that the limits on the pitch diameter of the bolt are:

Maximum pitch diameter = 0.9200 — 0.0024 = 0.9176 inch;

Minimum pitch diameter (unchanged) = 0.9150 inch.

While for a 1-inch British Whitworth nut having the same pitch error, the changes in the pitch diameter are:

Maximum pitch diameter (unchanged) = 0.9260 inch;

Minimum pitch diameter = 0.9210 + 0.0024 = 0.9234 inch.

TABLE IV. TOLERANCES ON INCLUDED ANGLE OF SCREW THREADS (THE ENGINEERING STANDARDS COMMITTEE)

Form of Thread	Range of Size, Nominal Diameter, Inches	Tolerance on Included Angle, Degrees
British Standard	1/4 to 9/16	± 1.5
Whitworth	5/8 to 2 1/8	± 1.0
Thread	2 1/4 to 3	± 0.5
British Standard	1/4 to 13/16	± 1.5
Fine Thread	7/8 to 3	± 1.0

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Tolerances on Included Angle of Thread

As has been mentioned, the included angle of the thread ranks in importance with the pitch and the pitch diameter. Errors in angle can be such as to prevent interchangeability, so that it is necessary to establish limits for the included angle of the thread. The tolerances on British standard Whitworth and British standard fine threads are given in Table IV. Reference to this table will show that the coarser the pitch, the smaller is the permissible error in the included angle. The reason for this is that a coarser pitch has a greater amount of thread surface in contact than a finer pitch, and consequently must be made to closer limits.

TABLE V. TOLERANCES ON PITCH DIAMETERS OF U. S. STANDARD SCREWS, TAPS AND GAGES (LOOSE FIT TOLERANCES)

Nominal Diameter of Screw, Inches	Number of Threads per Inch	Basic or Pitch Dia. of Max. Screw	Pitch Diam. of Min. Screw	Tolerance between Max. and Min. Pitch Diam. of Screw	Tolerance between Max. Screw and Min. Pitch Dia. of Tap	Tapped Hole, Pitch Diameter		Tolerance on Tapped Hole	Gage, Pitch Diameter		Difference between "Go" and "Not Go" Ends of Gage	Difference between Min. Gage and Max. Screw
						Max.	Min.		Max.	Min.		
1/4	20	0.2175	0.2160	0.0015	0.0005	0.2200	0.2180	0.0020	0.22020	0.21820	0.0020	0.00070
5/16	18	0.2764	0.2748	0.0016	0.0006	0.2790	0.2770	0.0020	0.27920	0.27720	0.0020	0.00080
3/8	16	0.3344	0.3327	0.0017	0.0006	0.3380	0.3350	0.0030	0.33820	0.33520	0.0030	0.00080
7/16	14	0.3911	0.3892	0.0019	0.0009	0.3950	0.3920	0.0030	0.39520	0.39220	0.0030	0.00110
1/2	13	0.4501	0.4481	0.0020	0.0009	0.4540	0.4510	0.0030	0.45420	0.45120	0.0030	0.00110
9/16	12	0.5084	0.5063	0.0021	0.0010	0.5124	0.5094	0.0030	0.51260	0.50960	0.0030	0.00120
5/8	11	0.5660	0.5638	0.0022	0.0010	0.5700	0.5670	0.0030	0.57020	0.56720	0.0030	0.00120
11/16	11	0.6285	0.6262	0.0023	0.0010	0.6325	0.6295	0.0030	0.63270	0.62970	0.0030	0.00120
3/4	10	0.6851	0.6827	0.0024	0.0010	0.6901	0.6861	0.0040	0.69030	0.68630	0.0040	0.00120
13/16	10	0.7476	0.7451	0.0025	0.0010	0.7526	0.7486	0.0040	0.75280	0.74880	0.0040	0.00120
7/8	9	0.8029	0.8004	0.0025	0.0011	0.8080	0.8040	0.0040	0.80820	0.80420	0.0040	0.00130
15/16	9	0.8654	0.8627	0.0027	0.0011	0.8705	0.8665	0.0040	0.87070	0.86670	0.0040	0.00130
1	8	0.9188	0.9159	0.0029	0.0012	0.9270	0.9220	0.0050	0.92725	0.92025	0.0050	0.00145
1 1/8	7	1.0322	1.0292	0.0030	0.0012	1.0384	1.0334	0.0050	1.03865	1.03365	0.0050	0.00145
1 1/4	7	1.1572	1.1541	0.0031	0.0012	1.1634	1.1584	0.0050	1.16365	1.15865	0.0050	0.00145
1 3/8	6	1.2668	1.2635	0.0033	0.0013	1.2741	1.2681	0.0060	1.27435	1.26835	0.0060	0.00155
1 1/2	6	1.3918	1.3884	0.0034	0.0013	1.3991	1.3931	0.0060	1.39935	1.39335	0.0060	0.00155

Machinery

TABLE VI. TOLERANCES ON PITCH DIAMETERS OF U. S. STANDARD SCREWS, TAPS AND GAGES (CLOSE FIT TOLERANCES)

Nominal Diameter of Screw, Inches	Number of Threads per Inch	Basic or Pitch Dia. of Max. Screw	Pitch Diam. of Min. Screw	Tolerance between Max. and Min. Pitch Diam. of Screw	Tolerance between Max. Screw and Min. Pitch Dia. of Tap	Tapped Hole, Pitch Diameter		Tolerance on Tapped Hole	Gage, Pitch Diameter		Difference between "Go" and "Not Go" Ends of Gage	Difference between Min. Gage and Max. Screw
						Max.	Min.		Max.	Min.		
1/4	20	0.2175	0.2160	0.0015	0.0005	0.2190	0.2180	0.0010	0.21920	0.21820	0.0010	0.00070
5/16	18	0.2764	0.2748	0.0016	0.0006	0.2780	0.2770	0.0010	0.27820	0.27720	0.0010	0.00080
3/8	16	0.3344	0.3327	0.0017	0.0006	0.3365	0.3350	0.0015	0.33670	0.33520	0.0015	0.00080
7/16	14	0.3911	0.3892	0.0019	0.0009	0.3935	0.3920	0.0015	0.39370	0.39220	0.0015	0.00110
1/2	13	0.4501	0.4481	0.0020	0.0009	0.4525	0.4510	0.0015	0.45270	0.45120	0.0015	0.00110
9/16	12	0.5084	0.5063	0.0021	0.0010	0.5109	0.5094	0.0015	0.51110	0.50960	0.0015	0.00120
5/8	11	0.5660	0.5638	0.0022	0.0010	0.5685	0.5670	0.0015	0.56870	0.56720	0.0015	0.00120
11/16	11	0.6285	0.6262	0.0023	0.0010	0.6310	0.6295	0.0015	0.63120	0.62970	0.0015	0.00120
3/4	10	0.6851	0.6827	0.0024	0.0010	0.6881	0.6861	0.0020	0.68830	0.68630	0.0020	0.00120
13/16	10	0.7476	0.7451	0.0025	0.0010	0.7506	0.7486	0.0020	0.75080	0.74880	0.0020	0.00120
7/8	9	0.8029	0.8004	0.0025	0.0011	0.8060	0.8040	0.0020	0.80620	0.80420	0.0020	0.00130
15/16	9	0.8654	0.8627	0.0027	0.0011	0.8685	0.8665	0.0020	0.86870	0.86670	0.0020	0.00130
1	8	0.9188	0.9159	0.0029	0.0012	0.9225	0.9200	0.0025	0.92275	0.92025	0.0025	0.00145
1 1/8	7	1.0322	1.0292	0.0030	0.0012	1.0359	1.0334	0.0025	1.03615	1.03365	0.0025	0.00145
1 1/4	7	1.1572	1.1541	0.0031	0.0012	1.1609	1.1584	0.0025	1.16115	1.15865	0.0025	0.00145
1 3/8	6	1.2668	1.2635	0.0033	0.0013	1.2711	1.2681	0.0030	1.27135	1.26835	0.0030	0.00155
1 1/2	6	1.3918	1.3884	0.0034	0.0013	1.3961	1.3931	0.0030	1.39635	1.39335	0.0030	0.00155

Machinery

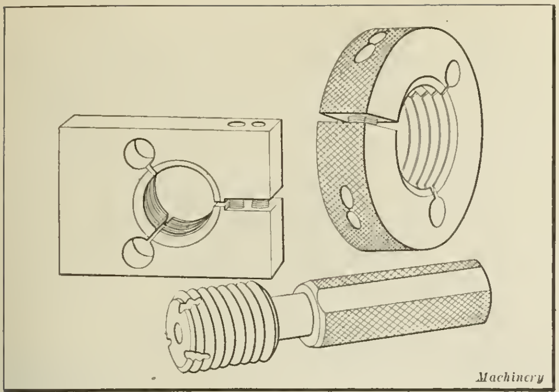


Fig. 3. Reference Thread Gages

Tolerances on U. S. Standard Screw Threads

As mentioned, the committee appointed by the American Society of Mechanical Engineers to study the subject of tolerances on screw threads has not furnished a complete report. Several concerns, however, have adopted tolerances for their own use, some of which have been compiled and put into convenient form. Table V gives tolerances for U. S. standard screws and gages for loose fits, and Table VI gives those for close fits. Reference to these two tables will show that the tolerances on the tapped hole and the tolerances on the pitch diameter of the gage are the only two factors that are materially changed. The loose-fit limits are, in most cases, twice the close-fit limits. It will also be noticed that the manufacturing tolerances on the pitch diameter of the gage are given as 0.0002 inch up to 1 inch diameter and as 0.00025 inch for

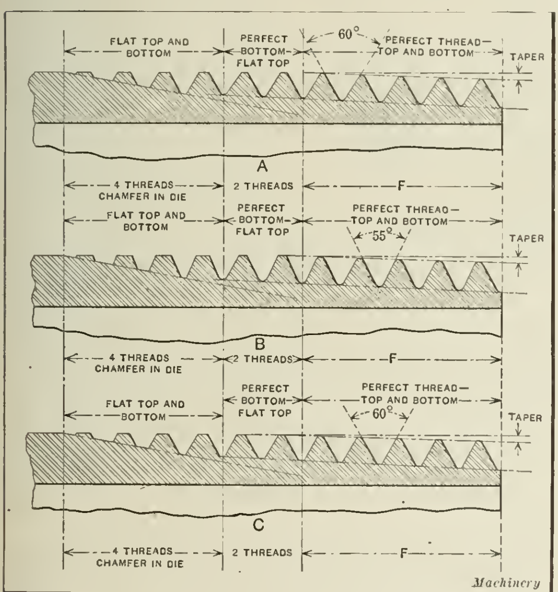


Fig. 4. Briggs and Whitworth Standard Forms of Pipe Threads; also Modified Briggs Standard Form

1 inch and over. The gage pitch diameters are made greater than the diameter of the maximum and minimum tapped holes, so as to provide for wear, especially on the "Go" end of the gage, as will be described later.

Manufacturing Tolerances on Reference Thread Gages

In the measurement and inspection of threaded parts even greater care is necessary than in gaging a plain hole or shaft. The chief reason for this is that a thread has so many elements that must be taken into consideration that a careful study of the conditions to be met is necessary. Master or reference screw gages should be made much more accurately than working or inspection gages; and owing to this fact, master gages, as a rule, are left soft in order to eliminate any chance for warpage or shrinkage in hardening.

For reference thread gages, the tolerances in pitch are generally given per inch of length of thread and vary from 0.0005 inch per inch for pitches greater than ten threads per inch to 0.001 inch per inch for finer pitches. The tolerance on the pitch diameter, as has been mentioned, is also governed to a certain extent by the tolerance on the pitch. Most manufacturers, however, endeavor to hold the pitch diameter to

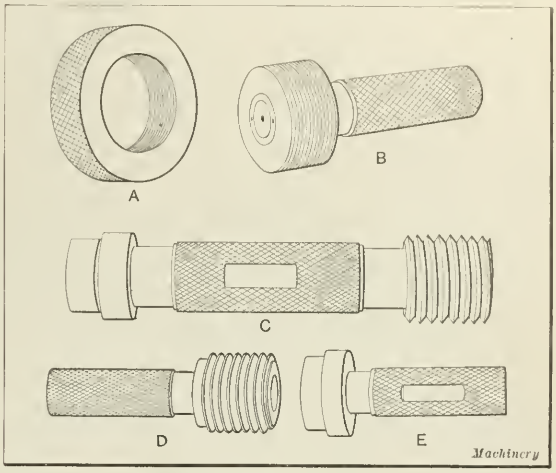


Fig. 5. Various Forms of Reference Gages for Whitworth Standard Threads

tolerances of ± 0.0001 inch. If the error in pitch is uniform, that is, equally distributed for the length of the thread, the tolerance on the pitch diameter can be held very close. For example, on a 10-pitch gage the error of 0.0005 inch is distributed over ten threads, making the average error in pitch only 0.00005 inch.

The included angle of the thread is one of the three elements that affect the pitch diameter in a similar manner to the pitch, and where close tolerances are adhered to on the

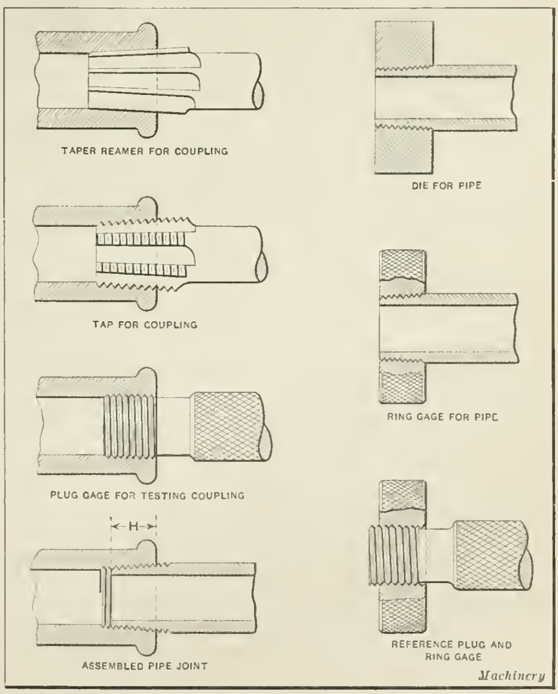
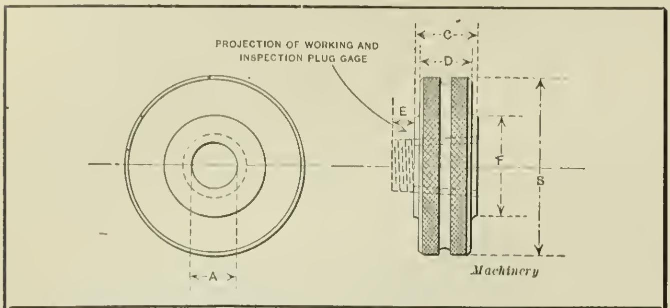


Fig. 6. Tools and Gages used in machining and gaging Pipe Fittings to Briggs Standards

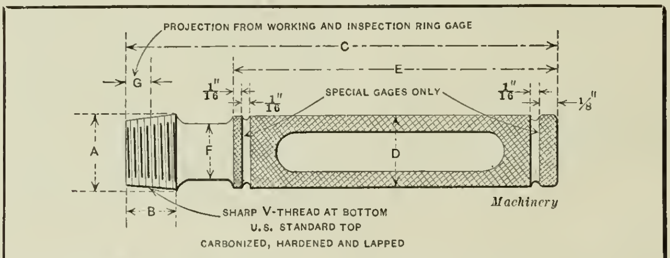
TABLE VII. PROPORTIONS FOR BRIGGS STANDARD REFERENCE PIPE RING GAGES (CADILLAC MOTOR CAR CO.)



Nominal Bore of Pipe, Inches	Approximate Outside Diameter of Pipe, Inches	Number of Threads per Inch	Diameter of Tap Drill, Inches	Dimensions in Inches					
				A	B	C	D	E	F
1/8	13/32	27	21/64	0.340	1 5/16	0.264	13/64	0.1110	3/4
1/4	17/32	18	27/64	0.441	1 3/8	0.402	11/32	0.1805	7/8
3/8	11/16	18	9/16	0.576	1 7/16	0.406	11/32	0.1805	1
1/2	27/32	14	11/16	0.712	1 5/8	0.534	15/32	0.2500	1 1/8
3/4	1 1/16	14	29/32	0.922	1 7/8	0.546	31/64	0.2500	1 1/4
1	1 11/32	11 1/2	1 1/8	1.157	2 3/16	0.625	9/16	0.3040	1 3/4
1 1/4	1 11/16	11 1/2	1 15/32	1.500	2 13/16	0.719	21/32	0.3040	2 1/16
1 1/2	1 29/32	11 1/2	1 23/32	1.740	3 1/4	0.750	11/16	0.3040	2 1/2
2	2 3/8	11 1/2	2 3/16	2.213	3 11/16	0.757	11/16	0.3040	3

pitch diameter it is essential that the included angle be held to very close limits. The coarser the pitch of the thread, the smaller is the amount of error permissible in the included angle, and for this element the tolerances range from ± 0.10 degree for the coarser pitches to ± 0.25 degree for the finer pitches.

TABLE VIII. PROPORTIONS FOR BRIGGS STANDARD REFERENCE PIPE PLUG GAGES (CADILLAC MOTOR CAR CO.)



Nominal Bore of Pipe, Inches	Approximate Outside Diameter of Pipe, Inches	Number of Threads per Inch	Dimensions in Inches						
			A	B	C	D	E	F	G
1/8	13/32	27	0.397	0.264	3	3/8	2 5/16	1/4	0.1110
1/4	17/32	18	0.528	0.402	3 1/4	7/16	2 7/16	3/8	0.1805
3/8	11/16	18	0.662	0.406	3 1/2	9/16	2 5/8	7/16	0.1805
1/2	27/32	14	0.822	0.534	3 3/4	5/8	2 5/8	9/16	0.2500
3/4	1 1/16	14	1.033	0.546	4	3/4	2 3/4	11/16	0.2500
1	1 11/32	11 1/2	1.290	0.625	4 1/4	7/8	2 7/8	13/16	0.3040
1 1/4	1 11/16	11 1/2	1.639	0.719	4 1/2	1	3	15/16	0.3040
1 1/2	1 29/32	11 1/2	1.881	0.750	4 1/2	1	2 7/8	15/16	0.3040
2	2 3/8	11 1/2	2.354	0.757	4 1/2	1 1/8	2 7/8	1 1/16	0.3040

Manufacturing Tolerances on Working and Inspection Thread Gages

As working and inspection thread gages must be hardened if satisfactory service is to be obtained from them, and as they wear much faster than reference gages, greater tolerances are permissible. As a general rule, the pitch is held to a tolerance of ± 0.001 inch per inch of length, and the pitch diameter is governed to a certain extent by the tolerance on the work. When the working and inspection gages are laid out in connection with the limit system of manufacture, the tolerances permitted on the "Go" and "Not Go" ends of the gage should be laid out with respect to the tolerances on the work. For instance, the maximum or "Not Go" end of the plug should be made larger than the maximum hole by an amount equal to the maximum manufacturing tolerance permissible on the gage, and the "Go" end should be made larger than the minimum tapped hole by an amount equal to the manufacturing tolerance permitted on the gage.

When the gage is new, of course, it will not enter the minimum tapped hole, but as a tap in most cases cuts larger than its actual size, the gage will enter holes slightly larger than those cut with a minimum tap. Another advantage of this practice lies in the fact that the greatest amount of wear is secured from the gage before it is worn too small. The manufacturing tolerances permitted on the pitch diameter of thread gages vary from + 0.0001 to + 0.00025 inch, depending on the size and pitch of the gage. For example, on a screw-thread plug gage for a 1/4 by 20 screw, the tolerance on the pitch diameter of the "Go" end of the gage would be expressed 0.2180 + 0.0002 inch — 0.0000.

The tolerance on the included angle of the thread is generally held to practically the same limits as the reference gages. As any variations in the included angle of the thread directly affect the pitch diameter and as errors in lead also affect the pitch diameter, it is imperative that errors in the included angle of the thread be reduced to a minimum.

Reference Thread Gages

Reference thread gages are made either from a good grade of tool steel and left soft or from machinery steel carburized and hardened. The soft gages, when carefully used, are more accurate than the hardened ones, owing to the elimination of warpage or distortion, which usually takes place during the carburizing and hardening process. Reference thread gages of comparatively coarse pitch can be ground with a diamond charged lap, and when this practice is followed the hardened reference gage is superior to the soft one. Ordinary lapping, however, cannot be depended upon to correct the lead of a distorted gage; for this reason reference thread gages are usually left soft. A common form of reference thread gage consists of a plug and templet, as shown in Fig. 3. Here two forms of templets are shown, one of rectangular and the other of circular form. Both types are adjustable and are set to the master plug. In manufacturing plants where the limit system is employed, these types of reference thread gages are of little or no value because they cannot be used for setting the working or inspection gages, which are not set to a standard size but provide for tolerances on the work. In addition, as will be subsequently explained, a ring thread gage is of little value in testing the thread on a screw, as it is difficult to tell what element of the screw is in error.

In making reference screw gages for the U. S. standard form of thread, a flat of one-eighth the pitch is provided on the

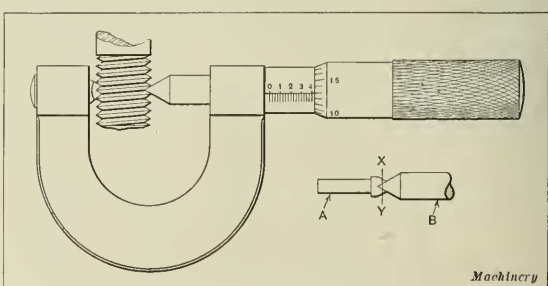


Fig. 7. Screw Thread Micrometer

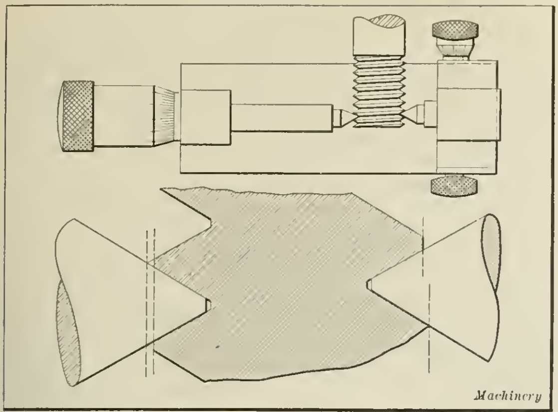


Fig. 8. Adjustable Thread Micrometer

outside diameter of the plug, whereas the bottom is made to a sharp V-shape in order to clear fine chips and dirt that may collect in the threads. The front end of the plug is also provided with three angular grooves to collect dirt and dust. The crest of the threads in the ring is made with a flat of one-eighth the pitch and the bottom is made to a sharp V as in the plug.

Fig. 5 shows a group of reference gages for British Whitworth standard threads. Ring A and plug B are left soft, and, of course, are used for reference purposes only. The form shown at C is provided with a threaded end and a plain cylindrical end having two shoulders, which represent the root and the outside diameter. D and E show two reference plugs that fill the same function as plug C.

Reference gages for use in connection with the limit system of manufacture should be made as shown in Fig. 24 in the October number of MACHINERY. This enables the inspection and working gages to be readily checked to determine when they are worn beyond the tolerances.

Pipe-thread Reference Gages

There are two common forms of pipe-thread standards in use, *viz.*, the Briggs standard and the British standard, as shown at A and B in Fig. 4. The Briggs standard, however, is also made in a modified form, as shown at C, resembling the U. S. standard form of thread. The original Briggs standard pipe thread has an included angle of 60 degrees, and is slightly rounded at the top and bottom, so that the single depth of the thread, instead of being exactly equal to the pitch times 0.866 inch, is only four-fifths the pitch, or equal to the pitch times 0.8 inch. For the length of the pipe end throughout which the screw thread continues "perfect," the following formula is used:

$$(0.8\,D + 4.8) \times \frac{1}{n} \qquad (13)$$

in which D = outside diameter of tube, in inches;

n = number of threads per inch.

This distance is referred to as dimension F in Fig. 4. Located back of the perfect threads is a section, including two threads, having a perfect bottom and a flat top; and still farther back is a portion having imperfect threads, which is formed by the chamfer or bell-mouth in the threading die. The perfect threads are cut on a taper equal to 3/4 inch to the foot, or 1/16 inch to the inch.

Fig. 6 shows the various tools necessary for machining and gaging a Briggs standard pipe joint. The joint should be tight when the pipe has entered the fitting a distance equal to H; but to allow for errors in manufacture, the thread on the pipe is cut two threads farther. The fitting should be tapped two threads deeper than as shown at H for the same reason. For the value of H for different sizes of pipe threads, see MACHINERY'S HANDBOOK. Tables VII and VIII, respectively, give proportional sizes for Briggs standard reference pipe ring and plug gages as used by the Cadillac Motor Car Co. These gages are made from a good grade of machine steel carburized and hardened, and are then lapped.

In the British standard form of pipe thread shown at B in Fig. 4, the thread form used is the standard Whitworth form having an included angle of 55 degrees, and the top and bottom are rounded similar to the standard form. The diameter of the screw is made to such size that the coupling or joint can be screwed on by hand to within four or five threads of the end of the threaded portion. The length of threads on standard pipe ends is found by the following formula:

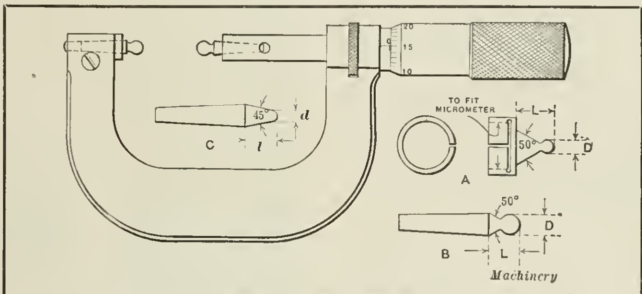
$$L = \sqrt[5]{D^2} - \tfrac{1}{8} \text{ inch} \qquad (14)$$

in which L = length of thread, in inches;

D = nominal bore of pipe, in inches.

The length of thread in the coupling or joint should not be made less than twice the length of thread on the pipe ends, and the length of thread at the end of a fitting must not be made less than the nominal length of thread on the corresponding end of the pipe.

TABLE IX. DIMENSIONS OF BALL POINTS USED IN MEASURING SCREW THREADS



No. of Threads per Inch Calculated for	No. of Threads per Inch Used for	D, Inches	L, Inches	No. of Threads per Inch Calculated for	No. of Threads per Inch Used for	d, Inches	l, Inches
3 1/2	3 1/2	0.164	9/32	18	18–20	0.031	3/32
4	4	0.143	9/32	22	22	0.026	1/16
4 1/2	4 1/2	0.127	9/32	24	24–26	0.023	1/16
5	5	0.111	9/32	28	27–30	0.020	1/16
6	6	0.095	5/32	32	32–34	0.018	1/16
7	7	0.081	5/32	36	36–38	0.016	1/16
8	8–9	0.070	5/32	40	40–46	0.014	1/16
10	10-11	0.059	3/32	52	48–60	0.011	1/16
12	12-13	0.049	3/32	66	62–72	0.0086	1/16
14	14–15	0.042	3/32	..	.....	.....	....
16	16	0.036	3/32	..	.....	.....	....

Measuring Screw Threads with Micrometer Calipers

The simplest instrument and the one most commonly used for measuring screw threads where only a few are to be inspected is the micrometer caliper. In order to use the micrometer caliper for this work, and especially for measuring the pitch diameter and angle of thread, it is necessary either to provide the instrument with special measuring points or to make use of the common wire method.

Screw Thread Micrometer

One of the many methods of measuring in the angle of the thread is by use of the thread micrometer shown in Fig. 7. The fixed anvil A is V-shaped, so as to fit over the thread, while the movable point B is cone pointed, so that it may enter the space between any two threads. The extreme end of the cone is removed so as not to contact with the bottom of the thread. The anvil is also provided with a clearance at the bottom of the V-groove so that both the anvil and the cone-pointed spindle will contact only with the sides of the thread. When the cone point and the anvil are in contact, the zero line on the thimble represents a line drawn through the plane X–Y. If the caliper

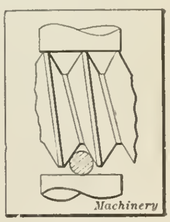


Fig. 9. Diagram illustrating One-wire System of measuring Threads

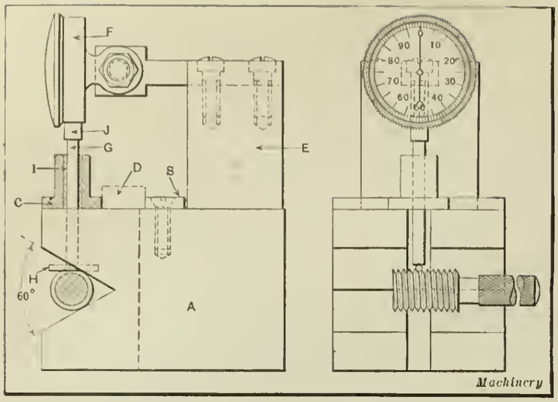


Fig. 10. Another Method of using One-wire System for Thread Measurement

is opened, say to 0.375 inch, it means that the two planes are 0.375 inch apart. The cone point is adapted for measuring all pitches, but the fixed anvil is limited in its capacity, and to cover all pitches it was necessary to provide different anvils for the various pitches.

To find the theoretical pitch diameter that is measured by this micrometer it is necessary to deduct the single depth for the thread from the outside diameter. Expressed in a formula for the various types of threads, the pitch diameter equals:

For sharp V-thread,[1] $D = d - \frac{0.866}{N}$ (15)

For U. S. and A. S. M. E. standard threads, $D = d - \frac{0.6495}{N}$ (16)

For Whitworth standard thread, $D = d - \frac{0.640}{N}$ (17)

in which D = caliper reading or pitch diameter;
d = nominal outside diameter of thread;
N = number of threads per inch.

Another Thread Micrometer

In the thread micrometer shown in Fig. 7, the offset of the center line of the anvil and cone-pointed spindle necessary to take care of the helix angle of the thread was provided for by holding the anvil so that it was free to rotate and by employing various anvils for different pitches of threads. In the micrometer shown in Fig. 8, the anvil is mounted in a slide and the amount of offset is controlled by a micrometer. To measure a thread of a certain pitch, the anvil is set off center an amount equal to one-half the pitch of the thread being measured.

[1] As it is not practicable to make a V-thread theoretically sharp, the outside will measure less than the nominal size, the pitch diameter remaining the same.

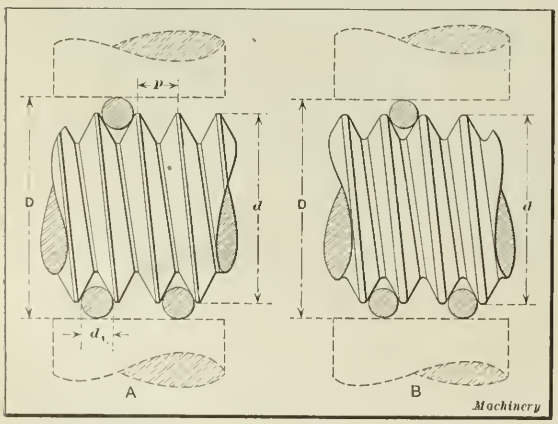


Fig. 11. Three-wire Method of measuring Screw Threads

Measuring Screw Threads with a Micrometer Having Ball Points

The regular screw-thread micrometer has the disadvantage of being delicately constructed and of requiring careful and frequent adjustment. It is preferable to use the standard screw-thread micrometer for reference only and to measure screw plugs or screws by means of the standard micrometer fitted with different types of points.

There are many types of points used; the illustration accompanying Table IX shows three. The type shown at A is made to slip over both measuring points of the micrometer, and to get satisfactory results must be carefully made. However, these points, as a rule, do not fit solidly over the anvil and spindle of the micrometer even if they are split, and are apt to cause errors in measurement. Better types of points are shown at B and C. The ball point shown at B can be used for measuring threads as fine as 16 pitch. When a thread is finer than this, the neck becomes so small that there is not sufficient strength, and the point is formed as shown at C. This point can be used for measuring threads as fine as 72 threads per inch. By referring to Table IX, it will be noticed that the first column gives the number of threads for which the diameter of the point has been calculated, and the second column gives the other pitches for which this size of point can be used. These points will fit approximately half way between the top and root of the thread in the U. S. standard screw or threaded plug. Of course they are used for reference only, and are set by means of a standard screw plug. They do not check the angle of the thread, as does a regular screw-thread micrometer, but the angle can be obtained by using different sizes of points, and comparing the size near the root of the thread with one size of ball, using a larger ball for the pitch diameter, and a still larger one near the top. If these three measurements agree with the standard gage, the angle of thread is correct.

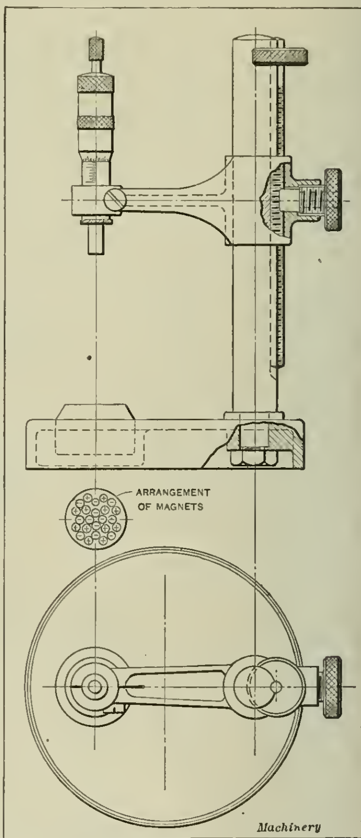


Fig. 12. Magnetized Stand for Use in measuring Threads by Three-wire Method

One-wire System of Measuring Screw Threads

The pitch diameter of screw threads may be measured with an ordinary micrometer and one wire arranged as indicated in Fig. 9. If the outside diameter of the screw is large or small, allowance must be made for this in taking the measurement. If the screw is over size, one-half the amount that it is over size must be added to the dimensions obtained by the formulas. If it is under size, one-half the amount that it is under size must be deducted. One wire is easier to handle than three wires, but is not as generally used for other reasons, which will be given later. This method can also be used on coarse-pitch threads where the micrometer spindle will not

reach from one thread to the next, which is necessary with the three-wire system. Assuming that D is the micrometer reading over the wire when the pitch diameter is correct, and T. P. I. represents threads per inch, the formulas for measuring with a micrometer and one wire are:

For sharp V-thread:

$$D = 1.5 \times \text{diameter of wire} - \frac{0.866}{\text{T. P. I.}} + \text{standard outside diameter} \qquad (18)$$

For U. S. standard thread:

$$D = 1.5 \times \text{diameter of wire} - \frac{0.7577}{\text{T. P. I.}} + \text{standard outside diameter} \qquad (19)$$

For standard Whitworth thread:

$$D = 1.583 \times \text{diameter of wire} - \frac{0.8004}{\text{T. P. I.}} + \text{standard outside diameter} \qquad (20)$$

The size of wire is governed by the pitch and form of thread. The best size to use is about two-thirds the pitch. Mistakes can easily be made if too large a wire is used. A wire smaller than six-tenths or larger than nine-tenths the pitch should not be used.

Thread Measuring Indicator Using One Wire

A thread measuring device for comparing screws with gages or working gages with master gages is shown in Fig. 10. This was designed to eliminate the personal element in measuring threaded parts or gages, as it has been found that in using thread micrometers, whether equipped with conical or ball points, measurements made by different men, or even by the same man, differ at times, and show variations as much as 0.0001 inch to 0.0003 inch. This tool has the objection mentioned in connection with Fig. 9 that the condition of the outside diameter of the thread is likely to affect the accuracy of the reading. It is based on two fundamental facts of trigonometry; one, that the axis of a cylinder held in an angular groove lies in the plane that bisects the angle, and that if the angle of the groove is 60 degrees, this axis will be at a distance from the vertex of the angle equal to the diameter of the cylinder.

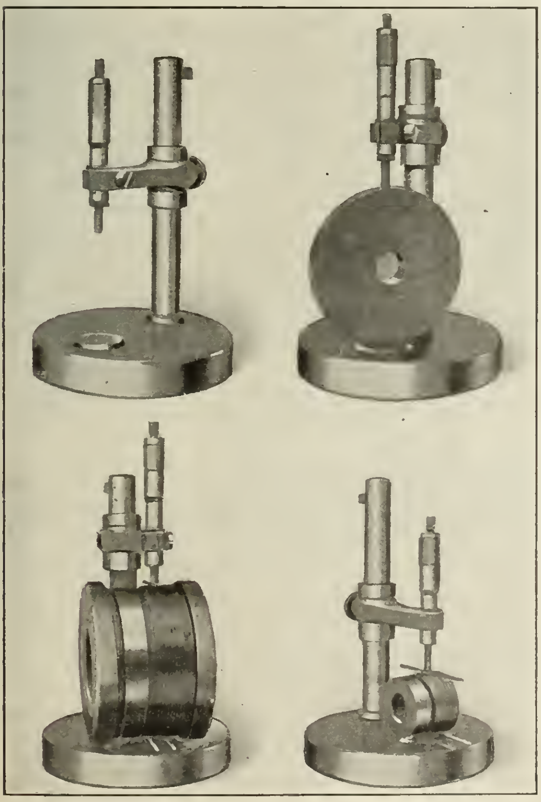


Fig. 13. Special Stand shown in Fig. 12 in Use measuring Refefence Thread Gages

Fig. 14. Method of using Johansson Reference Blocks for measuring Screw Threads

Referring to Fig. 10, it will be noted that the tool consists of a block A with a 60-degree groove in it and with a straightedge B fastened to the top face by screws and dowels. The straightedge is so placed that the attachment C can be adjusted to bring its axis to line up with the axis of the thread plug being measured, by inserting a standard measuring block D. On top of block A is another block E which carries the dial indicator reading to 0.0001 inch. Attachment C carries rod G, which extends down through the slot cut in block A and rests upon a wire H laid between the threads of the work. To prevent wire H from dropping out, rod G is magnetized; and to prevent the magnetism from interfering with the free movement of rod G, the rod is surrounded by a brass bushing I, and is held from dropping out by a set-screw, not shown.

The wire H is made of drill rod and is hardened and ground to exact size; an assortment of wires is provided for the different pitches of threads to be measured. A wire having a diameter equal to three-quarters or seven-eighths of the pitch works satisfactorily, but to facilitate calculation, it is well to keep an even number of thousandths, 0.120 for instance, instead of 0.125 inch.

If it is desired to compare a piece of threaded work with a standard, the standard is first clamped in the block A; then a size-block D, equal in thickness to the diameter of the standard, is inserted between attachment C and straightedge B. Rod G is then brought to bear on a wire laid in the threads of the standard, and the indicator spindle is brought over in contact with rod G and a reading taken. The same process is repeated by removing the standard and inserting the piece to be measured; the difference between the two pieces will then be read off on the indicator in 0.0001 inch.

This device can also be used for originating measurements by replacing the dial indicator with a micrometer spindle, which carries an indicating needle, thus eliminating the necessity for "feel" on the part of the inspector. For originating measurements, however, the most satisfactory way is to use a standard measuring machine, as described in the October number of MACHINERY.

Three-wire Method of Measuring Screw Threads

The three-wire method of measuring screw threads has the advantage over the one-wire method in that the outside diameter need not enter into the calculation in order to determine the pitch diameter. The three wires are arranged as shown at A and B in Fig. 11. One wire is placed in the angle of the thread on one side of the screw or threaded plug and the other two on the opposite side; the measurement is taken over the wires with a regular micrometer. The limit of this method is reached when the pitch of the thread is such that the micrometer anvil or spindle will not reach across the two wires. If the pitch diameter is correct, the micrometer readings for the various forms of threads are:

For sharp V-thread:

$$d = D - 3d_1 + 1.732p \qquad (21)$$

$$D = d - 1.732p + 3d_1 \qquad (22)$$

For U. S. and A. S. M. E. standard threads (*A*, Fig. 11):

$$d = D - 3d_1 + 1.5155p \quad (23)$$

$$D = d - 1.5155p + 3d_1 \quad (24)$$

For Whitworth standard thread (see *B*, Fig. 11):

$$d = D - 3.1657d_1 + 1.6008p \quad (25)$$

$$D = d - 1.6008p + 3.1657d_1 \quad (26)$$

For British Association standard thread:

$$d = D - 3.4829d_1 + 1.81814p \quad (27)$$

$$D = d - 1.81814p + 3.4829d_1 \quad (28)$$

For German Lowenherz thread:

$$d = D - 3.2368d_1 + 1.75p \quad (29)$$

$$D = d - 1.75p + 3.2368d_1 \quad (30)$$

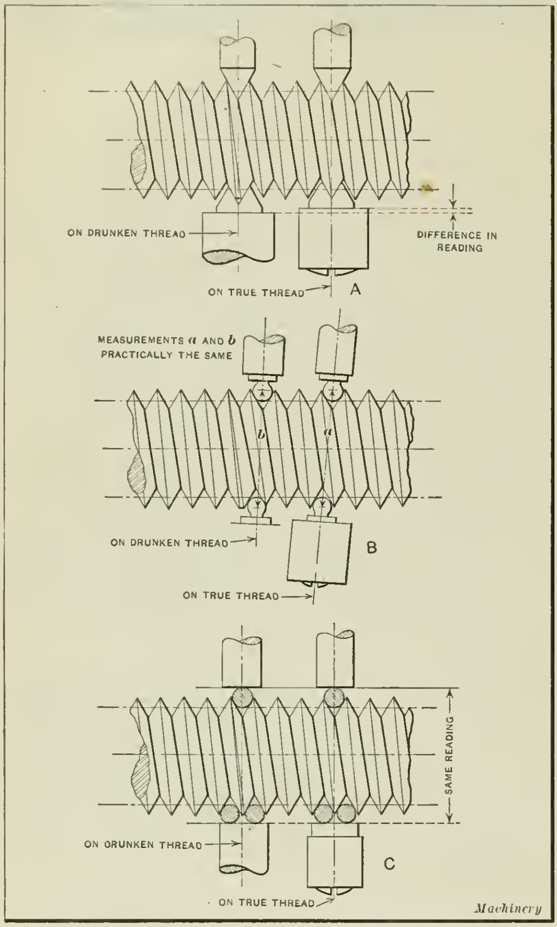


Fig. 15. Diagram illustrating Failure of Ball Point and Three-wire Method of Measurement to detect Drunken Threads

in which D = micrometer reading over wires;
d = standard outside diameter of screw;
d_1 = diameter of wires;
p = pitch.

Taking the U. S. standard thread formula as an example, assume that the standard outside diameter d is 0.5 inch. The number of threads per inch is 13; hence, the pitch is 0.0769. The diameter d_1 of the wires used is 0.050 inch. Then:

$$D = 0.500 - (1.5155 \times 0.0769) + 3 \times 0.050$$
$$= 0.500 - 0.1166 + 0.150 = 0.3834 + 0.150$$
$$= 0.5334 \text{ inch.}$$

Methods of Using Three-wire System

Difficulty is sometimes encountered in applying the three-wire system owing to the necessity for retaining all three wires accurately in the grooves of the thread. One method of overcoming this objection consists in the use of a special stand, as shown in Fig. 12. This stand consists of a cast-iron base carrying a column to which is clamped a micrometer head that is adjusted by a vertical screw. Directly beneath the micrometer head and embedded in the base, is a gun-metal bushing holder in which is placed a series of magnetized cylindrical pins arranged as shown in the plan view. These pins prevent the wires on the anvil from rolling off and also enable them to be accurately placed. The magnets are arranged with their negative and positive poles as indicated. In applying the instrument the micrometer is adjusted until it registers the exact size of the cylindrical reference gage, as shown in Fig. 13. Then the dimensions measured over the wires can be read off directly from the micrometer, care being taken to see that the temperature of the reference gage and the gage being tested are the same.

Another simple but satisfactory method of applying the three-wire system is shown in Fig. 14. In this case use is made of the Johansson standard holder and the regular thickness blocks. The holder retains two carefully ground and lapped blocks, which are spaced the required distance apart by using the regular Johansson thickness blocks. Against the face of one block two wires of the required size are placed and the plug to be measured is then brought up against these. A third wire is used to test the accuracy of the work by being tried in the grooves on the opposite side. This makes a very sensitive test, as there is no pressure to consider except the weight of the small wire, which is almost negligible. It is therefore possible for the inspector to detect the slightest error. The limit of tolerance on this gage is 0.0002 inch.

Comparison of Ball Point and Anvil Type of Thread Micrometer

Several forms of measuring points are employed for comparing the pitch diameters of threaded work. That used in the Brown & Sharpe thread micrometer is shown at *A* in Fig. 15. This may be used for positive measurements as well as for comparison. At *B* and *C* are illustrated other principles of measuring, the former using a ball-point micrometer, and the latter three wires of suitable diameter, measured with the regular micrometer caliper. The arrangements shown at *A* and *C* may be used either for positive measurements or comparison with other threads. The device shown at *B*, however, owing to the tilting of the micrometer, should be used only for comparative measurements between threads of the same form.

A recent experiment proved that the method shown at *B* can only be relied upon in certain cases, even for comparative measurements, and the same holds true of that shown at *C*. The way in which this was discovered brings up an interesting point in machine-tool construction as well as in thread measuring. A manufacturer bought a lathe for cutting accurate threads, which was provided with an accurate lead-screw. A serious error, however, developed in mounting in the machine. It was provided with a loose thrust collar between the shoulder of the lead-screw and the face of the bearing bracket which took the thrust in feeding the carriage. This thrust collar was poorly squared up, being some thousandths inch thicker on one side than on the other. Unfortunately, the thrust surfaces on the lead-screw in the bearing between which it was placed were also poorly faced, running out sideways to an appreciable extent. As a result, the lead-screw in revolving received an irregular endwise movement resulting from the varying positions of the untrue loose washer between its untrue thrust surfaces. The machine thus cut an irregular, or drunken, thread. This fact was brought to the attention of the makers of the machine, who measured the lead-screw with a ball-point micrometer, also a sample screw cut by it, and pronounced it O. K. The purchaser of the machine, however, brought out a measuring tool of the type shown at *A*, which at once indicated varying diameters in different parts of the threads on the work, giving evidence of the irregularity of which he complained. The reasons for this were evident. The ball-point micrometer shown at *B* measured the groove cut by the thread tool; and as this is always set at the same depth and is unvarying in shape, the error was not detected. The same conditions are met with the three-wire method shown at *C*. The lower anvil of the point at *A*, however, since it spans the abnormal thread, instead of making contact with the side of the adjacent threads, indicates the irregularity by giving an increased reading for the pitch diameter.

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

CENTRIFUGAL FORCE—A CORRECTION

A. H.—I read with great interest the answer on centrifugal force on page 63 of MACHINERY for September. I cannot, however, follow the geometry of the proof. In Fig. 1, angle NMN_1 is always equal to one-half MON, no matter how small the latter may be. Will you please explain a little more fully?

A.—The writer intended to have drawn the line MN tangent to the circle at N, in which case, the angle NMN_1 would have been exactly equal to MON. Note that the lines MN_1 and N_1N in Fig. 2 represent velocities, not distances, and their lengths are not therefore comparable with the lengths of lines having the same letters in Fig. 1. J. J.

ORIGIN OF INSERTED-BLADE REAMERS

W. F.—I would like to know who was the inventor of the reamer with inserted blades.

A.—The name of the inventor of the inserted-blade reamer is not known. Inserted-blade reamers and inserted-cutter lathe tools were used in the Portsmouth Navy Yard shops of the British government as early as 1830, according to a statement appearing in a book, "Turning and Mechanical Manipulation," by Charles Holtzpffal, a work published in 1843. The particular type of inserted-blade reamer shown in Holtzpffal's book had four blades of approximately square section, set 90 degrees apart. The blades were fitted snugly in longitudinal grooves, and apparently no clamping device was provided or required.

SHORT RULE FOR CALCULATING WEIGHT OF WATER

H. M. L.—Please give an easy, accurate rule for calculating the weight of water, the volume being given in cubic inches.

A.—The weight of water varies considerably with the temperature; also, any impurities held in solution will affect its weight. In practice, it is sufficiently accurate to take the weight of a cubic foot as 62.4 pounds. In this case, 1 cubic inch weighs $\frac{62.4}{1728} = \frac{13}{360}$ pound $= \frac{12}{360} + \frac{1}{360} = \frac{1}{30} + \frac{1}{30} \times \frac{1}{12}$ pound. Hence, divide the number of cubic inches by 30; divide the quotient by 12; then add the two quotients. For example, what is the weight of a gallon of water? One gallon contains 231 cubic inches; $231 \div 30 = 7.7$; $7.7 \div 12 = 0.64\,1/6$; $7.7 + 0.64\,1/6 = 8.34\,1/6$ pounds. Note that the fraction 13/360 is convenient for use on the slide-rule. J. J.

CENTER OF GRAVITY OF ARC AND SEGMENT OF CIRCLE

W. J. B.—On page 266 of MACHINERY'S HANDBOOK, a formula is given for finding the center of gravity of an arc of a circle, which reduces to $a = 0.6366r$ for a semicircle. On page 267, a formula is given for finding the center of gravity of a circular segment, which for a semicircle reduces to $a = 0.4244r$. This latter constant is just two-thirds that of the former; should they not be alike, or have I made some mistake in reducing?

A.—Both constants are correct; in the first case, we are dealing with a line, and in the second case, with an area. Both formulas may be verified experimentally as follows: Take a piece of very fine, stiff wire and bend it into the form of a semicircle; then balance it on a knife-edge in such a way that the two ends will be parallel to the line formed by the knife-edge. The distance from a line through the two ends and the knife-edge should be equal to the distance a, as determined by the formula on page 266. The other case may also be verified in a similar way by using a flat plate of uniform thickness and material. J. J.

STRENGTH OF COLD-ROLLED SHAFTING

H. B. H.—I wish to obtain some data on the strength of cold-rolled shafting when the outer shell of refined metal produced by the cold-rolling process has been removed.

A.—Comparatively little data on the strength of cold-rolled and cold-drawn shafting having the outer shell of metal removed are available. Obviously, the refining effect of the cold-rolling or drawing process cannot penetrate deeply, and it is fair to assume that the core would not have physical characteristics much different from those of the same grade of steel, hot-rolled. The cold-rolling and cold-drawing processes refine and strengthen the outer shell of metal the same as wire is refined and strengthened by being drawn. This outer shell has a tensile strength of perhaps one and one-half or two times that of the core, and being on the outside, it increases the bending strength of the shaft out of all proportion to the amount of the drawn and refined metal.

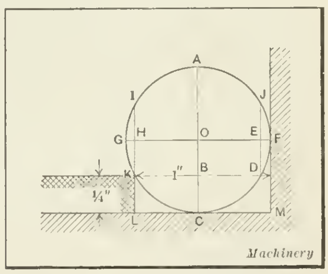
ADDITION AND SUBTRACTION WITH LOGARITHMS

G. T. V.—I claim that addition and subtraction cannot be performed with logarithms, but a friend tells me I am wrong; which of us is right?

A.—Ordinary logarithms cannot be used for addition and subtraction, but tables of what are called Gaussian logarithms have been constructed for this purpose; they depend on the following principle: $\log (a + b) = \log a \left(\frac{b}{a} + 1\right) = \log a + \log \left(\frac{b}{a} + 1\right)$; and $\log (a - b) = \log b \left(\frac{a}{b} - 1\right) = \log b + \log \left(\frac{a}{b} - 1\right)$. In these expressions, a is always supposed to be greater than b. The table gives the logarithms of the fractions as arguments and the logarithms of the quantities in parentheses as functions, the interpolation being performed exactly as in the case of ordinary logarithms. These tables are very useful in connection with certain calculations, but they do not seem to be much used in this country. J. J.

PROBLEM IN MENSURATION

J. W.—Referring to the illustration, please show how to find the diameter of the circle from the dimensions given. I should like a formula that will solve any similar case.



Problem in Mensuration

A.—Draw the horizontal and vertical diameters GF and AC; also draw the chord KD parallel to GF, and through K and D, draw chords KI and DJ parallel to AC. AC bisects KD in B, and GF bisects IK in H and JD in E. Let $BD = c$, $CB = h$, $LM = l$, and $OA = r$; then, $c^2 = AB \times BC = (2r - h)\,h = 2rh - h^2$; or $c = \sqrt{2rh - h^2}$. Also, $LM = EH + EF = c + r = \sqrt{2rh - h^2} + r = l$. Transposing r to the right-hand member and squaring both sides, $2rh - h^2 = l^2 - 2rl + r^2$. Transposing and collecting terms, $r^2 - 2(l + h)r + l^2 + h^2 = 0$. This last is an affected quadratic equation, which may be solved by the usual rule, and gives $r = l + h \pm \sqrt{2lh}$. Substituting the given values for l and h, $r = 1 + \frac{1}{4} \pm \sqrt{2 \times 1 \times \frac{1}{4}} = 1\frac{1}{4} \pm \frac{1}{2}\sqrt{2} = 1.95711$, or $0.54289 +$. The smaller value is evidently the one desired in this case; hence, d = the diameter sought $= 2 \times 0.54289 = 1.08578 -$ inch. J. J.

FIXING SHAFT, BEARING AND PULLEY BORE DIMENSIONS

L. C.—Owing to differences of opinion of three mechanics, a matter was brought to my attention which I wish to submit as follows: A 7/8-inch cold-rolled steel shaft running at 1500 R. P. M. is fitted in cast-iron bearings, and has mounted upon it a solid hub cast-iron pulley, secured by two set-screws. A suggests that the dimensions be fixed thus:

Shaft 7/8 inch = 0.875 inch;
Bearings 7/8 inch + 0.005 inch = 0.880 inch;
Pulley 7/8 inch + 0.002 inch = 0.877 inch.

B suggests the following instead:

Shaft 7/8 inch — 0.002 inch = 0.873 inch;
Bearings 7/8 inch + 0.003 inch = 0.878 inch;
Pulley (reamed) 7/8 inch = 0.875 inch.

C would give the bearings the standard dimensions:

Shaft 7/8 inch — 0.005 inch = 0.870 inch;
Bearings 7/8 inch = 0.875 inch;
Pulley 7/8 inch — 0.003 inch = 0.872 inch.

It was agreed by all that an allowance of 0.005 inch should be permitted between the shaft and bearing and an allowance of 0.002 inch between the shaft and pulley, but no agreement could be reached as to which should have the basic diameter of 7/8 inch.

A.—There is no absolute fixed rule governing this case. Common practice in the past has been to make the pulley hub hole the standard or nominal size and the shaft to fit, but there has been a change in late years, due to the more general use of cold-drawn shafting. The tendency now is to make the shaft the fixed or nominal size and bore the pulley and bearings to fit. The suggestion of A agrees with this practice.

DEPTH OF FLOTATION

W. J. B.—A cylindrical tank that is 7 feet in diameter and 30 feet long is sunk in water to within 1 foot of the top; what is the pressure tending to raise the tank? The weight of the tank is 4 tons.

A.—The pressure tending to raise a body that is submerged or partly submerged is always equal to the weight of the liquid displaced. Assuming that the axis of the tank is horizontal, the volume of water displaced is the same as that of a solid having a base ACB and an altitude of 30 feet, the length of the tank. First calculate the area of the segment ADB and subtract this from the area of the circle $ACBD$; the remainder will be the area of the segment ACB. The radius $OA = 7 \div 2 = 3.5$ feet; the height of the segment is $ED = 1$

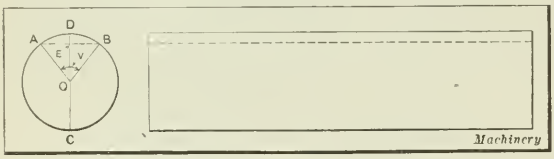


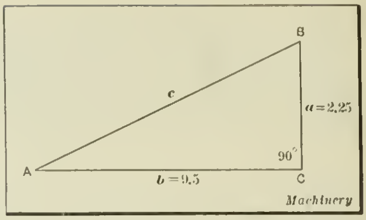
Diagram Illustrating Depth of Flotation

foot; hence, $OE = 3.5 - 1 = 2.5$ feet, and $\cos AOD = 2.5 \div 3.5 = 0.7142857$. The angle corresponding to this cosine is 44 deg., 24 min., 55 sec., and AOB = 88 deg., 49 min., 50 sec. = 1.5503857 radian. The area of the segment ADB is $\frac{1}{2} r^2(V - \sin V) = \frac{1}{2} r^2(1.5503857 - 0.9997917) = 3.3724$ square feet, V being the central angle AOB. Area of $ACB = \pi \times 3.5^2 - 3.3724 = 35.1122$ square feet. Taking the weight of a cubic foot of water as 62.5 pounds, the weight of the water displaced is $35.1122 \times 30 \times 62.5 = 65{,}835$ pounds, say 33 tons. As the tank weighs only 4 tons, an additional weight of $33 - 4 = 29$ tons must be placed on the tank in order to sink it to the required depth. J. J.

ACCURACY IN CALCULATION

F. E. K.—In a right triangle, one of the legs is 2.25 inches and the other is 9.5 inches. I calculated the hypotenuse in three different ways and got three different results; thus: $\tan A = 2.25 \div 9.5 = 0.23684 = \tan 13$ deg., 19 min.; $c = a \div \sin A = 2.25 \div \sin$ 13 deg., 19 min. $= 2.25 \div 0.23033 = 9.76859$. $c = b \div \cos A = 9.5 \div 0.97311 = 9.76251$. $c = \sqrt{2.25^2 + 9.5^2} = 9.76281$. I obtained the sine, cosine, and tangent from MACHINERY's Reference Book No. 55; if this is correct, why don't I get the same answer each time?

A.—There are a number of reasons why the first two results do not agree with the third. In the first place, a table of trigonometric functions will give only as many significant figures correct in the final result as there are significant figures in the functions, and frequently the last figure may be one or even two units too large or too small. As the table used gives the functions correct to five significant figures, you cannot expect to get the hypotenuse correct to more than five significant figures; *i. e.*, if you obtained for a result 9.7628, the result may be considered correct. In the second place, you have expressed the angle only to minutes and have neglected the seconds; the angle the tangent of which is 0.23684 is 13 deg., 19 min., 28 sec., and the sine of this angle is 0.230465, these values being as close as can be obtained with a five-place table. Using this value for the sine, $c = 2.25 \div 0.230465 = 9.76287$, or 9.7629 to five figures. Observe that this is one unit too large in the last place. Using a seven-place table, and calculating the tangent to seven figures also, $\tan A = 0.2368421$, from which A = 13 deg., 19 min., 28.311 sec.; the sine of this angle is 0.2304664; whence, $c = 2.25 \div 0.2304664 = 9.762811$, which agrees with your third result to six significant figures. The seventh figure, however, should be 2 instead of 1. J. J.



Triangle, One Side of which is being found

LAYING OUT A KITE-SHAPED TRACK

J. G. J.—We wish to lay out a kite-shaped race track; the circular part is to be one-half mile in length, and the two straight parts are to be one-quarter mile each; what should be the length of the radius?

A.—Referring to the illustration, $BA = BC = \frac{1}{4}$ mile; arc AD = arc $DC = \frac{1}{4}$ mile; A is the point of tangency, and OA is the radius sought. Since OA is perpendicular to AB, angle $AOD = \frac{\pi}{2} + \phi$. $\tan \phi = r \div \frac{1}{4} = 4r$; arc $AD = \left(\frac{\pi}{2} + \phi\right) r = \frac{1}{4}$. From these two equations, $r = OA = \frac{\tan \phi}{4} = \frac{1}{2\pi + 4\phi}$, or $\tan \phi = \frac{4}{2\pi + 4\phi}$. To find an approximate value of ϕ, substitute for $\tan \phi$ the first two terms of the tangent series, obtaining $\tan \phi = \phi + \frac{\phi^3}{3} = \frac{4}{2\pi + 4\phi}$. Clearing of fractions, the equation becomes $4\phi^4 + 2\pi\phi^3 + 12\phi^2 + 6\pi\phi - 12 = 0$. Solving this equation by Horner's method, $\phi = 0.4605$ radian = 26.4 degrees, nearly. This value is probably a little large, as only two terms of the tangent series were used; if a closer value is desired, a table may be constructed as follows:

ϕ Deg.	Min.	$\frac{\tan \phi}{4}$		$\frac{1}{2\pi + 4\phi}$		
26	10	0.1228346	—	0.1233051	=	—0.0004705
26	15	0.1232863	—	0.1232167	=	+ 0.0000696
26	20	0.1237387	—	0.1231285	=	+ 0.0006102

The values in the second and third columns are approximate values of r, and are found by substituting in the forms at the head of the columns the value corresponding to ϕ in the first column. Inspection of the table shows that the difference becomes zero somewhere between ϕ = 26 degrees, 10 minutes, and ϕ = 26 degrees, 15 minutes; by interpolation, ϕ is found to be 26 degrees, 14.35545 minutes = 26 degrees, 14 minutes, 21.33 seconds. Substituting this value in either of the expressions for r, r = 0.1232281 mile = 650.6442 feet. It may be remarked that problems of a

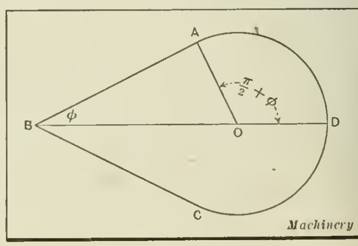


Diagram for laying out Kite-shaped Track

nature similar to this frequently arise in practice; the calculation is exceedingly laborious, and the method just explained is the only one known to the writer by which all such problems may be successfully attacked. J. J.

PERPETUAL MOTION MACHINE

J. E. B.—I send you herewith a circular describing a perpetual motion machine. Will you please explain why this machine will not work?

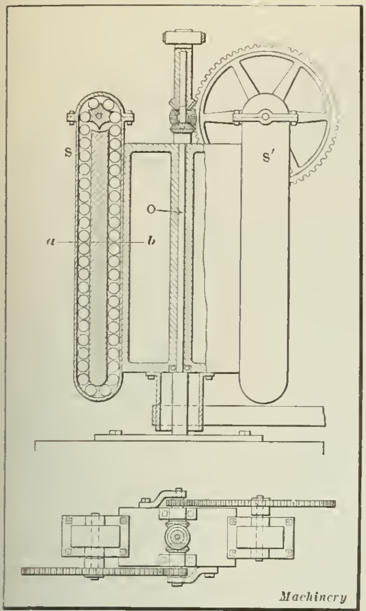


Fig. 1. Part Sectional and Top Views of Perpetual Motion Machine

A.—Referring to the illustrations, Fig. 1 represents a half sectional view and a top view of the machine. From a very meager description, we understand that the machine is supposed to work as follows: The casings S and S' are filled with two columns of balls, the balls touching one another and the tubes containing them having a square cross-section. The casings are half full of mercury, say to the line ab. The whole apparatus is to be set spinning about the spindle O, with the result that the centrifugal force will cause the mercury in the outer column of the casings to rise higher than in the inner column. Since the balls are lighter than the mercury, those in the outer column will rise (and those in the inner column will fall) with the mercury; this will cause the various gears to turn and keep up the motion indefinitely. Suppose the vessel V, Fig. 2, is partly filled with a liquid, and is rotated about the axis Y′–Y through the center of the cross-section of the vessel. The surface of the liquid will no longer be flat, but curved, and a vertical section through its center, as ACB, will be a parabola, the surface being a paraboloid of revolution. The depth DC will depend entirely on the speed, in revolutions per minute, and for some particular speed, it will be DC, and the curve will be as shown in Fig. 2. If, now, another vessel V', say a tube, is partly filled with a liquid and rotated about the axis Y′–Y, and with the same speed, the surface mn will be a part of the same paraboloid ACB. Here V' corresponds to one of the casings in Fig. 1. It should be noted, however, that for any particular speed, the surface has its own special shape, and it will not be altered as long as the speed is not changed; if it decreases, the points C and n rise, while A and m fall, and *vice versa*. Referring again to Fig. 2, let P be the position of a particle of the liquid; the centrifugal force may be represented by the horizontal line PF and the weight by the vertical line PG; completing the parallelogram, the diagonal PN is the resultant, and, according to Pascal's law, must be perpendicular to the surface of the liquid. Since the centrifugal force changes with the speed and the weight of the particle does not change, the position of the point P is determined by the speed only. In Fig. 1, the mercury in the outer tube will rise higher than in the inner tube, but whether this will cause the balls in the outer tube to rise also will depend on the amount of friction in the gearing, the mercury, etc. Even if they did move, the system would immediately put itself in static equilibrium, and the friction would cause the rotative speed to decrease. The machine cannot start itself, and it cannot increase its speed of rotation, nor even keep it up, after it has once been started. J. J.

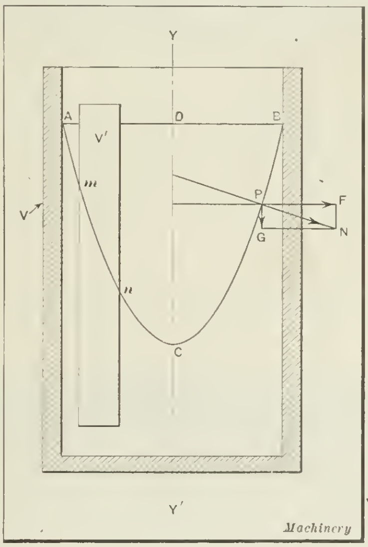


Fig. 2. Cross-section of a Vessel, showing Form assumed by Surface of Liquid when Vessel is rotated

UNIT OF ENERGY

R. S. P.—In a recent article in a technical journal, I notice that the kinetic energy of a shell is given as a certain number of foot-tons; should it not have been foot-tons per second? If not, what becomes of the time element in the velocity?

A.—The unit of energy is always the same as the unit of work; it is the unit of power that contains the time element. The time element in the velocity is cancelled by the time element in the acceleration, as will be readily seen if, instead of taking the unit of time as one second, we take it as t seconds. The formula, kinetic energy $= \frac{1}{2}mv^2 = \frac{wv^2}{2g}$, then becomes $\frac{w\left(\frac{v}{t}\right)^2}{2\frac{g}{t^2}} = \frac{wv^2}{2g}$. In this last expression, the unit of time is one second, as before. Or, since $\frac{v^2}{2g} = h$, $\frac{wv^2}{2g} = w\left(\frac{v^2}{2g}\right) = wh$; here h is the distance that a body would fall in attaining the velocity v. If h is expressed in feet and w in tons, the product is foot-tons, and the unit of time is not involved. J. J.

PRESSURE ON A SCALE BAR

R. J. T.—I enclose a sketch showing a scale bar. Desiring a formula for finding the pressure at W for any position of the scale block w, I derived the following, and wish to know if it is correct: $WL = wl + w_1l_1$, $l = \frac{w_1l_1 - WL}{w}$. Also, do you know of any literature containing formulas of this nature?

A.—The formula is not correct, for the reason that you have made a mistake in finding the value of l; it should be $l = \frac{WL - w_1l_1}{w}$. Furthermore, if you wish exact results, you must take into account the weight and center of gravity of that part of the bar that extends to the right of the pin, which should preferably be a knife-edge instead of a pin. Calling this weight w_2, and the distance from the center of the pin to the center of gravity l_2, $WL + w_2l_2 = wl + w_1l_1$, or $l = \frac{WL + w_2l_2 - w_1l_1}{w}$. Problems of this kind are treated in mechanics under the head of moments and couples; any good elementary work treating on statics should give you the information. "Mechanics for Beginners," by J. B. Lock, is a good book, but is rather difficult for a beginner. J. J.

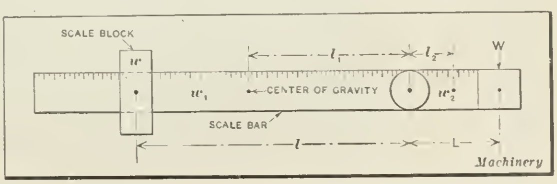
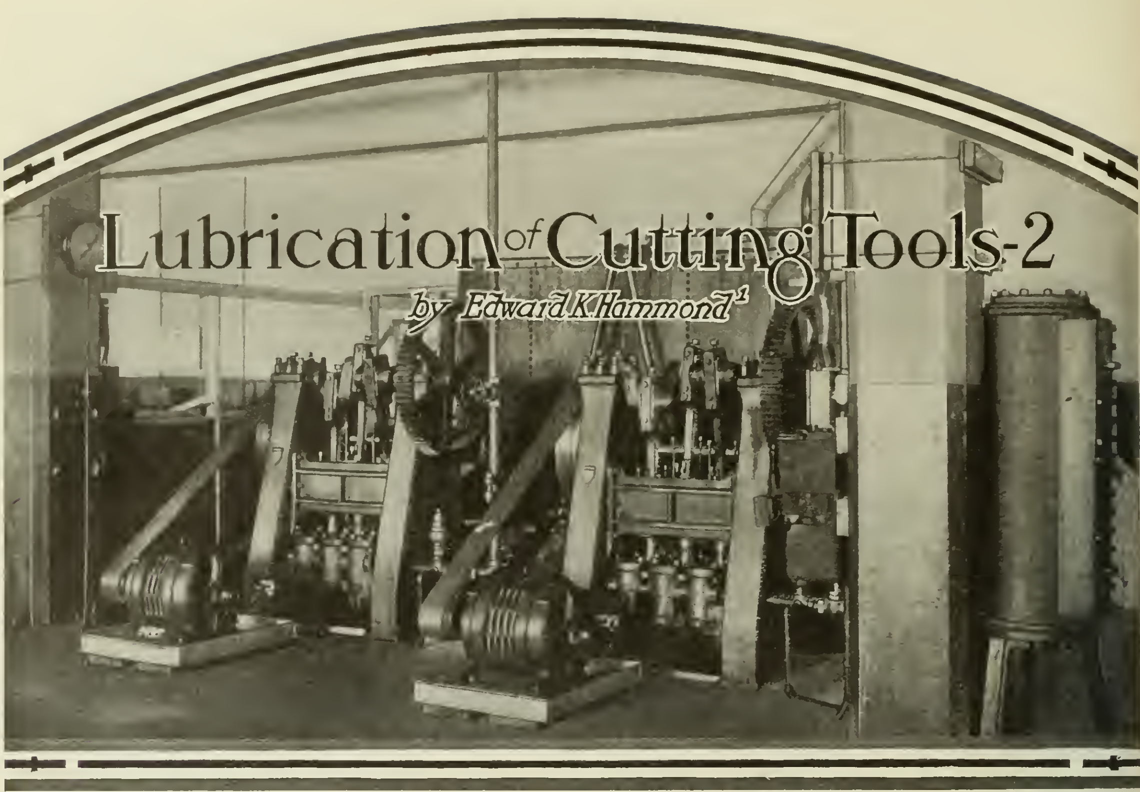


Diagram illustrating Pressure on Scale Bar

Lubrication of Cutting Tools-2

by Edward K Hammond[1]



AFTER spending much time and care in developing equipment and an organization to secure efficient production, many manufacturers are losing much of the benefit of this work through the use of unsuitable oils or cutting compounds. It is known that the purity of an oil or compound delivered to metal-cutting tools is a most important factor in determining the amount and quality of service that will be obtained from the tools. When great care is not taken, in filtering, to remove such impurities as oxide or scale and particles of metal from the oil, the fluid frequently becomes heavily charged with these impurities and trouble is experienced through rapid wear of bearings and slides of machine tools, rapid destruction of the cutting edge of tools, and inferior finish on the work. The following analysis of cutting costs shows what an important effect the purity of oil or cutting compound may have on the cost of production.

Analysis of Cutting Cost

Cutting costs can be classified under the following heads:

Labor: (1) Operation of machine tools; (2) time occupied in changing dull tools; (3) time occupied in resharpening tools.

Power required to drive machines.

Cost of steel for cutting tools.

The cost of labor for operating machine tools will naturally vary according to the location of the factory and the skill required for conducting the various machining operations. This labor cost per unit of work produced is naturally cut down by any increase effected in the rate of production, and one important way of obtaining higher production is to increase the life of cutting tools so that delays occasioned by shutting down machines for changing tools is reduced as far as possible. The use of good cutting lubricants may be responsible for an increase in production of as much as 35 or 40 per cent.

The time required in changing dull tools will vary according to the complexity of the machine and tools; and in addition to the direct cost, there is an indirect cost through loss of production while the machine and its operator are idle. Even under the best conditions, the cost of resharpening tools is a factor of some importance. As the use of pure oil of suitable quality is the means of increasing the life of cutting tools, it will be evident that this reduces the cost of changing and resharpening tools.

The power required to drive the machines is reduced by increasing the speed at which they are driven, but it is only possible to take advantage of this condition when the cutting tools are kept sharp, which, in turn, requires the use of a suitable lubricant, kept in good condition through proper filtration. The

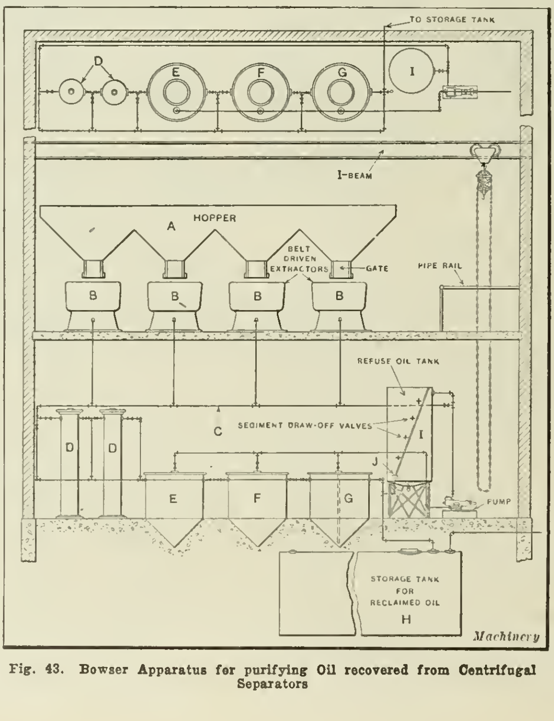


Fig. 43. Bowser Apparatus for purifying Oil recovered from Centrifugal Separators

[1] Associate Editor of MACHINERY.

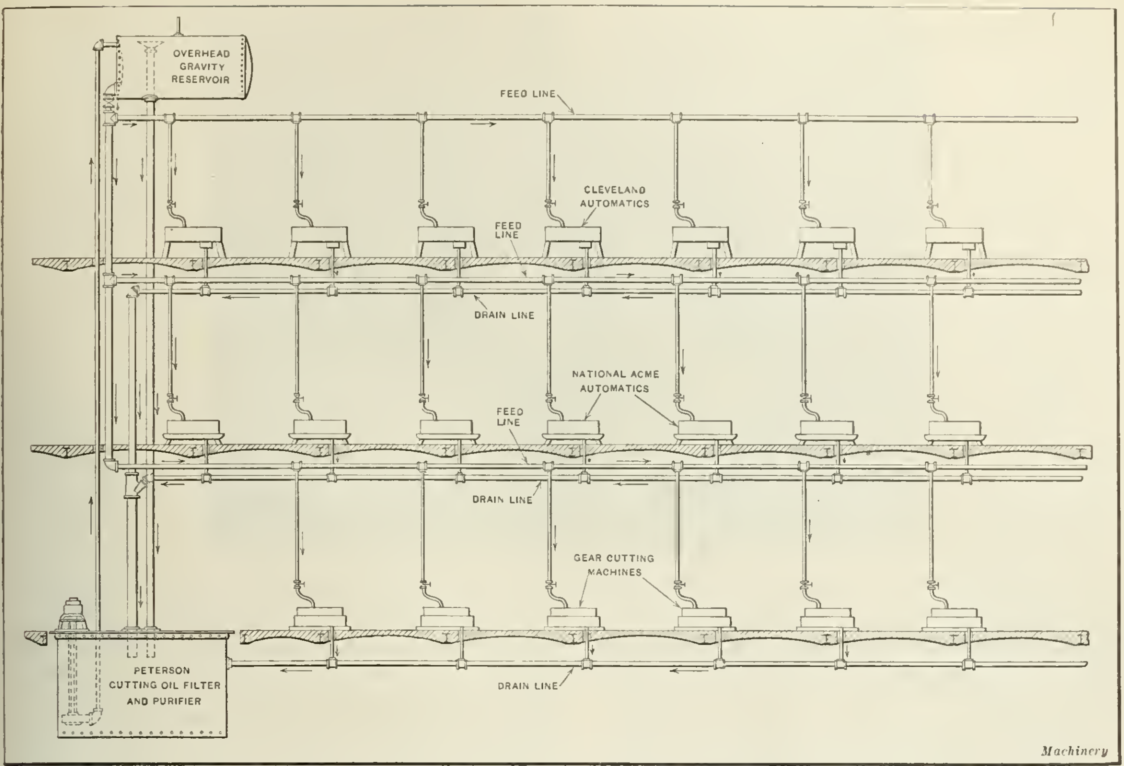


Fig. 44. Arrangement of Complete Central Station and Piping for Distribution and Purification of Oils and Cutting Compounds—the Richardson-Phenix Co., who built this Equipment, now favors Delivery of Fluid to Machines direct from Pump, instead of using Gravity Tank System illustrated, but there are still many Advocates of the Gravity Tank

saving of power effected through the use of good cutting lubricants is dealt with in detail later. The cost of steel for cutting tools is directly controlled by the amount of service obtained between grindings, which depends largely on the quality of oil or cutting compound, as previously explained.

Filtration of Oil Recovered by Centrifugal Separators

Fig. 43 shows an apparatus for the purification of oil recovered from centrifugal chip separators, which was designed and built by S. F. Bowser & Co., Inc., Fort Wayne, Ind., for installation in the plant of the Timken Roller Bearing Co, Canton, Ohio. It will be seen that hopper *A* is furnished with chutes for delivering chips into the baskets of separators *B*, the hopper being so arranged that chips may be delivered to it by a container carried on a trolley. The separators are placed on the second floor of the building in order to facilitate shoveling the cleaned chips into a car for shipment. Oil from the separators is carried down into header *C*, which delivers it into heating cylinders *D*, which are connected in series; in each case the pipe leading into the cylinder extends down to a point close to the bottom and the oil flows up through the cylinder and out by way of a pipe near the top. Each cylinder is furnished with a steam coil, so that the temperature of the oil is raised to about 170 degrees F. It will be noted that a by-pass is provided to allow one or both of the cylinders to be cut out of the system if necessary.

The heated oil next flows through tanks *E*, *F* and *G*, which are connected in series, the oil being delivered into each tank through a pipe extending down almost to the apex of the conical bottom and escaping through a pipe near the top of the tank. Tanks *E* and *F* provide for the settling out of chips and other foreign matter held in suspension in the oil, while tank *G* is furnished with a steam coil to provide for raising the temperature of the oil to 200 degrees F. in order to sterilize it. The rate of flow is so adjusted that the oil is held in tank *G* for fifteen minutes, which is regarded as sufficient

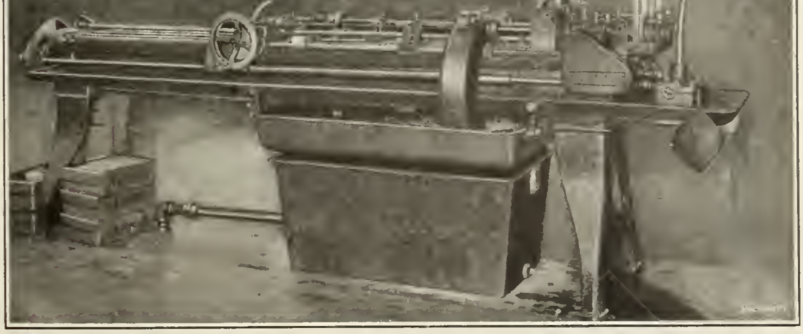


Fig. 45. Arrangement of Piping that delivers Lard Oil to Rifle-barrel Drilling Machine and carries away Oil to Drains in Floor that return it to Filter

time to effect complete sterilization. Clean oil from the tanks flows into storage tank *H*, from which it is pumped back to the machines. Refuse oil from the conical bottoms of tanks *E*, *F* and *G* is pumped into tank *I*, in which it is allowed to stand for a sufficient length of time to allow impurities to settle to the bottom. It is then possible to draw off the better grade of oil through cocks which deliver it into funnel *J*, carried on a pipe connection to the header leading to storage tank *H*. About 75 per cent of the oil recovered from tank *I* is suitable for use on metal-cutting tools, and the remainder of the oil is used on machinery which is of such a character that a poor grade of lubricant can be employed with satisfactory results.

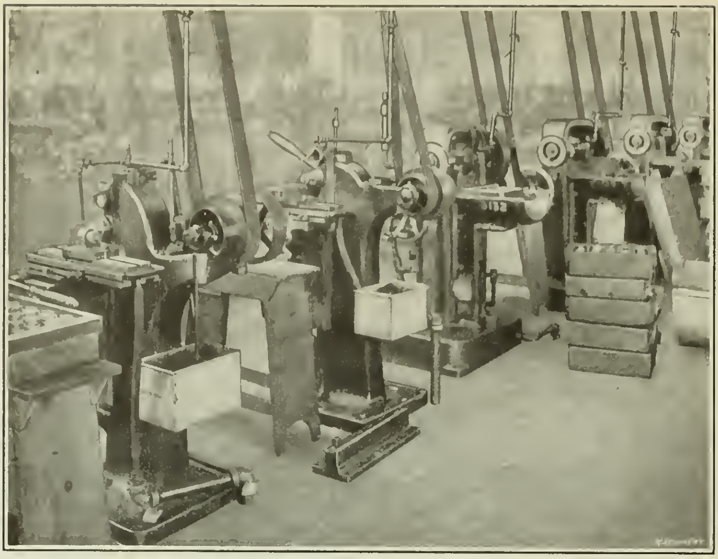


Fig. 46. Battery of Hand Milling Machines supplied with Cutting Compound through Pipes from Central Distributing Station; Compound is returned to Filter through Drain Pipes

Practice of Nash Motors Co. in Purifying Cutting Oil

The Nash Motors Co., successor to the Thomas B. Jeffery Co., Kenosha, Wis., is using an interesting equipment for the purification of oil recovered by the use of centrifugal chip separators. The oil from the chip separators passes into a settling tank in which coarse dirt and chips are precipitated. From the settling tank the oil runs by gravity through a pipe into a storage tank, from which it is pumped into four settling tanks. These tanks are provided with steam coils, which raise the temperature of the oil to about 240 degrees F., at which it is held for one hour, after which the oil is allowed to stand for from twelve to twenty-four hours to allow all impurities to settle to the bottom.

The centrifugal chip separators are driven by steam turbines, which pass exhaust steam into the chip baskets to facilitate the separation of oil, and in so doing the oil becomes mixed with water that must be removed before it is returned to the machine tools. This is done by passing the oil into a battery of three centrifugal cream separators, from which the pure oil is collected in steel barrels. These barrels are carried through the shop on trucks and the oil is pumped into tanks on the machines by means of hand pumps on the barrels.

Oil carried away by chips and recovered through the use of centrifugal separators usually contains many impurities such as particles of iron oxide, fine chips, etc., which makes careful filtration a matter of great importance. In place of the methods of filtration that have been described in the foregoing, some manufacturers have found that it is better practice to use horizontal filter presses for cleaning oil recovered by centrifugal chip separators. In these presses the fluid to be purified is passed through a series of porous diaphragms, supported in a horizontal frame; and to increase the rate of filtration, pressure is applied to the fluid by a plunger operated by a capstan wheel and screw or other suitable means. Experience has shown that if finely ground Fuller's earth, kieselguhr, or similar mineral matter is added, this material will build up on the diaphragms of the filter and form a porous structure that constitutes a highly efficient filtering medium. Oil purified in this way is often superior in quality to the original oil shipped from the refining plant.

Importance of Filtering Oil or Cutting Compound

Where it is not the practice to filter the oil or cutting compound used on machine tools, impurities carried in suspension

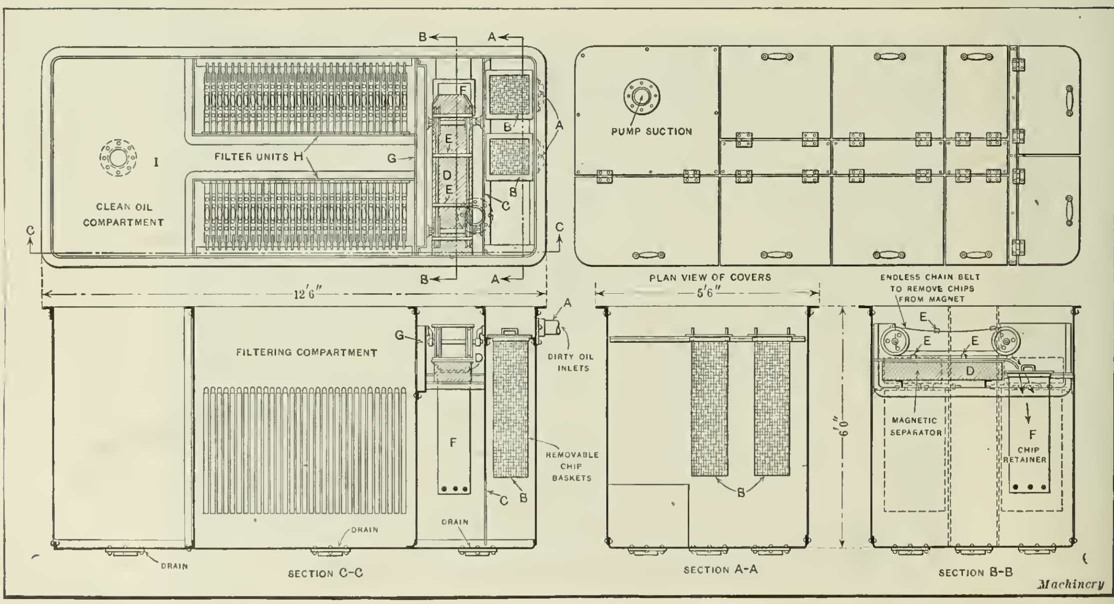


Fig. 47. Peterson Filter and Purifier built by Richardson-Phenix Co., showing Arrangement of Chip Baskets, Baffle Plates, Magnetic Separator and Filtering Units

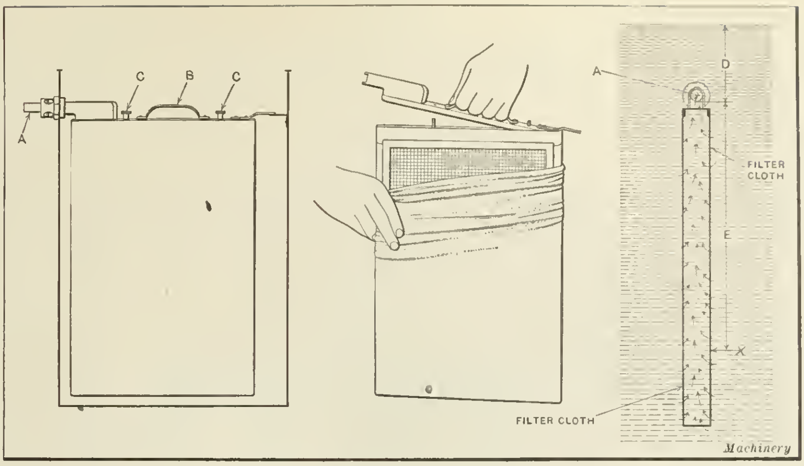


Fig. 48. Close View of Filtering Unit, showing Method of removing Cloth Bag for cleaning, and Diagram showing that Mean Effective Pressure is the Same all over Surface of Filtering Unit

by the oil are likely to cause trouble in a number of ways. One of the commonest of these is the damage done to machine-tool slides and bearings through particles of oxide scale and small metal chips. In some cases these impurities exert a harmful effect upon the finish produced by the tools. They also cause trouble through scoring the cylinders of pumps used for circulating oil on individual machines or for distributing it from a central station to all the machines in the factory.

Particles of metal suspended in the oil delivered to cutting tools will sometimes cause the most unexpected difficulties, of which the following is a typical example. In a certain shop it was the practice to manufacture a brass product on automatic screw machines, and when the demand for these brass parts had been temporarily filled, the machines were switched over for operation on a product made from steel bars. In the latter case high-speed steel cutting tools were used. When changing over the machines, all chips were removed from the pans, but the same cutting oil was used on both steel and brass products; and the oil recovered from either the brass or steel chips sent to the centrifugal separator was returned to the reservoirs in the automatic screw machines.

Occasionally it was found that the high-speed steel tools that had formerly been giving satisfactory service in producing the steel product would suddenly commence to tear the metal and produce an unsatisfactory finish. A careful investigation showed that this trouble was caused by small particles of brass carried by the oil, which had been used on the tools for machining the brass product. These particles of brass tended to pack on the cutting edge of the high-speed tools, and the high temperature of these tools resulted in partly fusing the brass, with the result that it eventually covered the cutting edge and made the tool dull. To the naked eye nothing was visible, but when examined under a strong magnifying glass the accumulation of brass on the tools was seen to be very pronounced. After an effective filtering system was installed these particles of brass were removed from the oil and no further trouble of this kind was experienced.

Central Distributing Station for Oils and Cutting Compounds

The importance of delivering clean oil to metal-cutting tools has long been recognized, but recently the development of means for oil purification has been carried further than was possible with the form of strainers and distributing equipment furnished on individual machine tools. Many large manufacturing plants are now being furnished with central distributing stations from which cutting oils and compounds are delivered to all machines in the factory by a permanent pipe system, and similar systems of drain pipes carry the lubricant back to the central station where it is purified for subsequent use. Such an arrangement is shown diagrammatically in Fig. 44; and Figs. 45 and 46 show the piping that carries the lubricant to a rifle-barrel drilling machine and several hand milling machines. Figs. 45 and 46 also show drain pipes that carry away the fluid. Not only does this provide better facilities for the purification of used oil, but it also saves labor costs in handling oil and assists in maintaining sanitary conditions in the factory.

The Richardson-Phenix Co. of Milwaukee, Wis., specializes in the construction of systems for the distribution of oil or cutting compound from a central station to all the machines

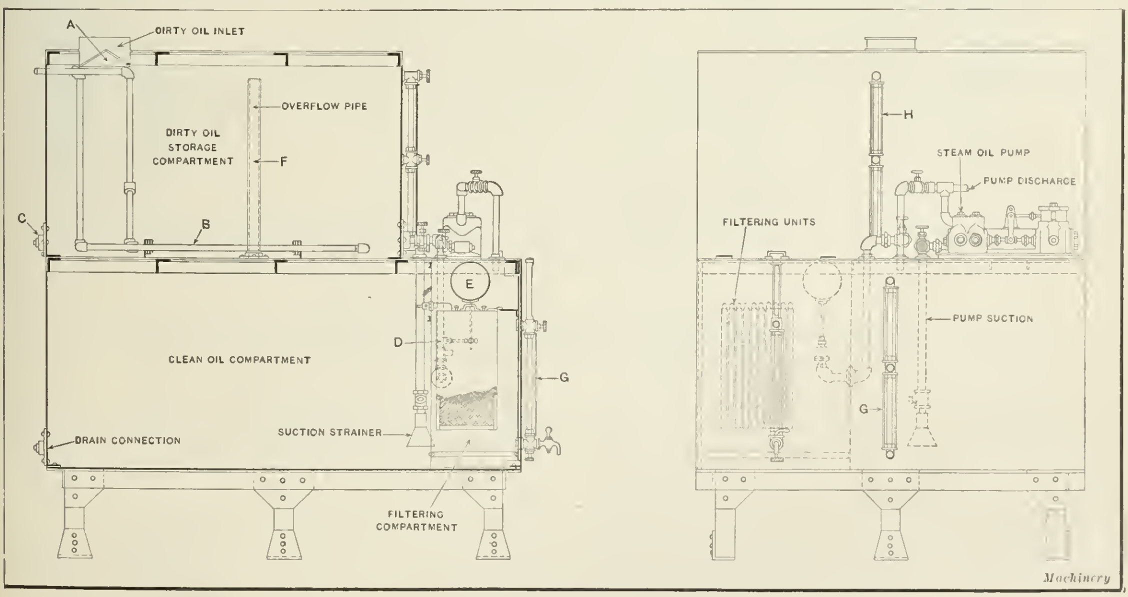


Fig. 49. Richardson-Phenix "Batch" Filter

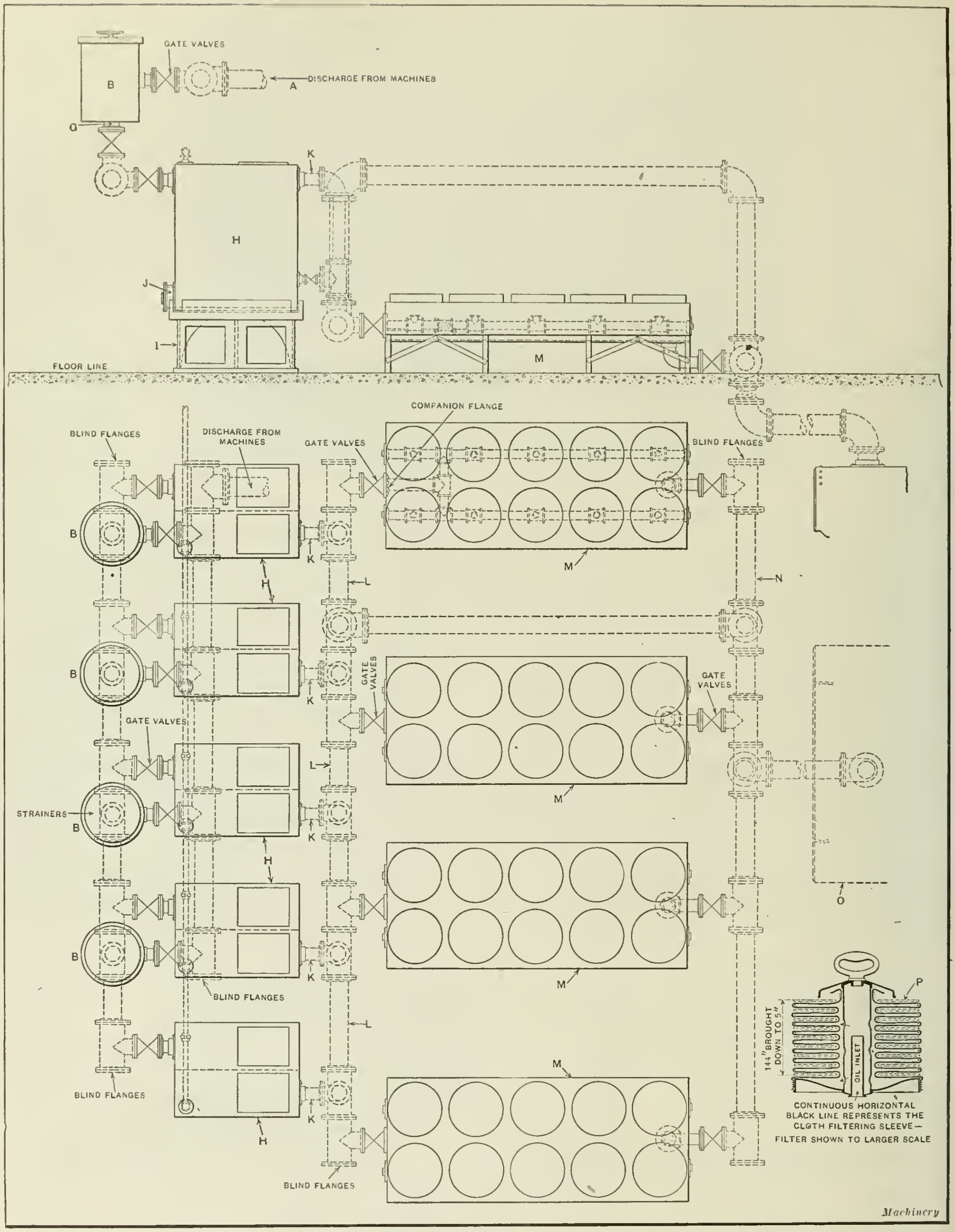


Fig. 50. Oil Reclaiming System built for Remington Arms & Ammunition Co. by S. F. Bowser & Co., Inc.

in the factory, the collecting and returning of this oil to the central station and its purification. This company's system of purification provides for passing the oil through a series of apparatus for the removal of foreign matter carried by the oil; in all cases the equipment is built to meet the special requirements of the plant in which it is to be used, and the means provided for purifying the lubricant will naturally vary in different cases. Fig. 47 shows one of the more complete equipments, from which a good idea may be obtained of the way in which the Richardson-Phenix system is applied. Used oil enters inlets *A* and passes down through strainer baskets *B*, which remove the coarse chips and other impurities. The fluid then flows under baffle plate *C* and up across the top of magnetic separator *D*, where the iron or steel chips are removed. Scrapers *E*, operated by an endless chain belt, travel across the face of this magnet and scrape off the chips into retainer *F*, which is provided with screened holes in the bottom to allow the oil to drain out. Reference to the cross-sectional view on line B–B will show that this chip retainer can be slid to the right and lifted from the tank to empty the

chips. After passing over the magnetic separator D, the lubricant flows across dam G into the filtering compartment, from which it passes through cloth-covered filtering units H, where the most finely divided particles of foreign matter are removed; the clean oil is collected in compartment I, from which it is drawn off through the pump suction pipe.

It will be noticed that a large number of filtering units H are employed in the system shown in Fig. 47, and the number of these units determines the filtering capacity; as it is possible to provide tanks with the desired number of units, the system is readily adapted to the capacity requirement of the factory in which it is to be used. Fig. 48 shows detail views of one of these filtering units and also the means provided for cleaning it. It will be seen that it consists of a cage covered with galvanized wire mesh over which a cloth bag is tightly stretched so that it is free from folds, which retard filtration. Oil passes into these filtering units from the outside and clean oil escapes through discharge pipe A. These discharge pipes fit into automatic valves, and when it is required to remove a unit from the tank it is merely necessary to take hold of handle B and slide the unit to the right, withdrawing discharge pipe A from the valve, which then closes automatically. In many cases the only cleaning required is to brush off any dirt which has collected on the cloth. When it is desired to substitute a fresh bag on the unit, thumb-nuts C are removed and the top of the filtering unit is lifted off, as shown at the center of Fig. 48; this releases the top edge of the cloth bag, which may be drawn down as shown in this view. Attention is called to the fact that the edges of the filtering units are made perfectly smooth so the bags will slide easily over them.

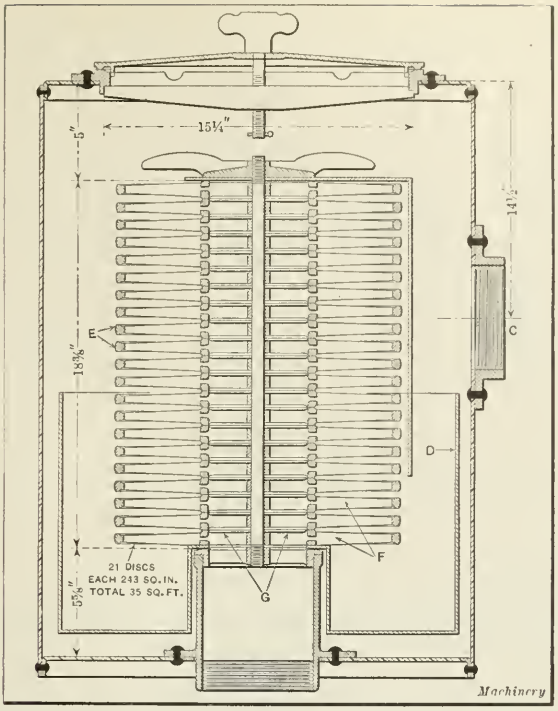


Fig. 51. Detail of Strainer Box used in Oil Reclaiming System shown in Fig. 50

An important consideration of passing oil or cutting compound through this form of filter is that the net pressure on the filter cloth is equal to head D, regardless of where point X is assumed; thus every square inch of surface at any point X is subjected to the same degree of pressure tending to force the fluid out through discharge pipe A. It will be evident that filtering cannot begin until the level of the oil has reached discharge pipe A, thus insuring a uniform effective pressure over the entire surface of the filtering unit. This effective head D is usually maintained at about three inches; and although the capacity of the filters could be greatly increased by carrying a head of two or three feet,

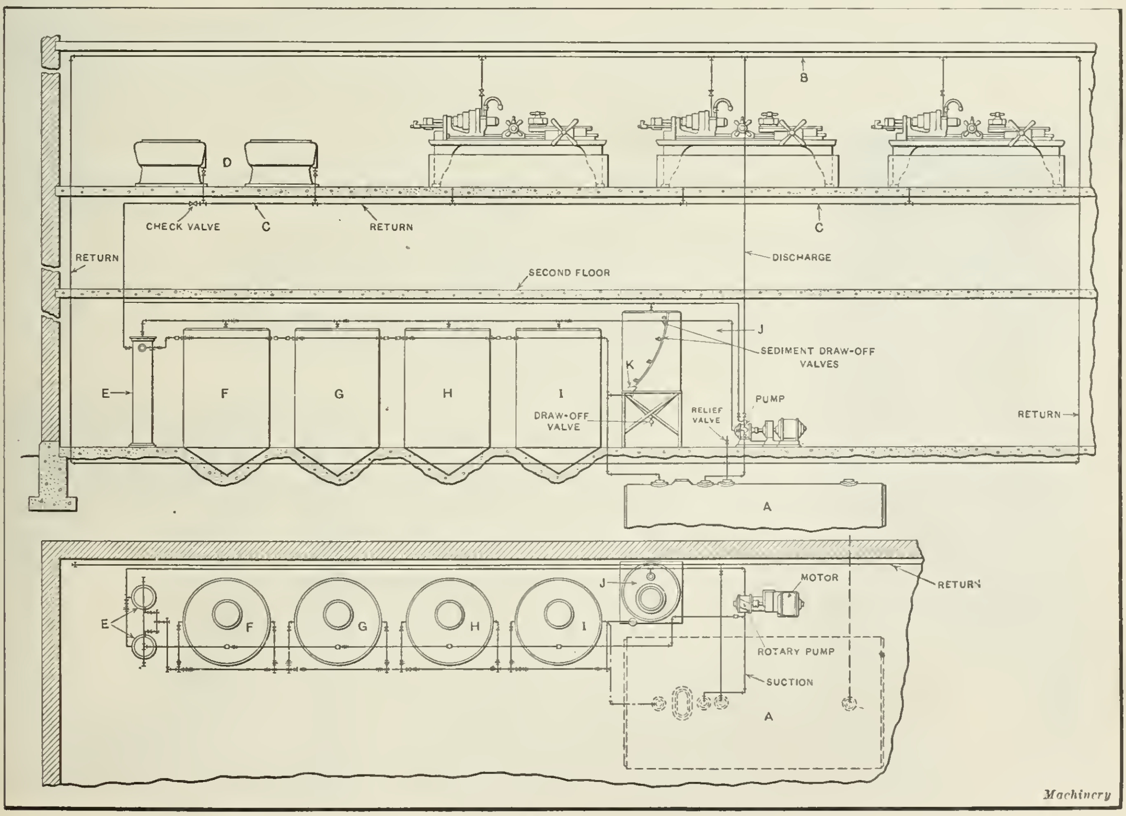


Fig. 52. Oil Reclaiming System in which Oil is heated to facilitate Sedimentation

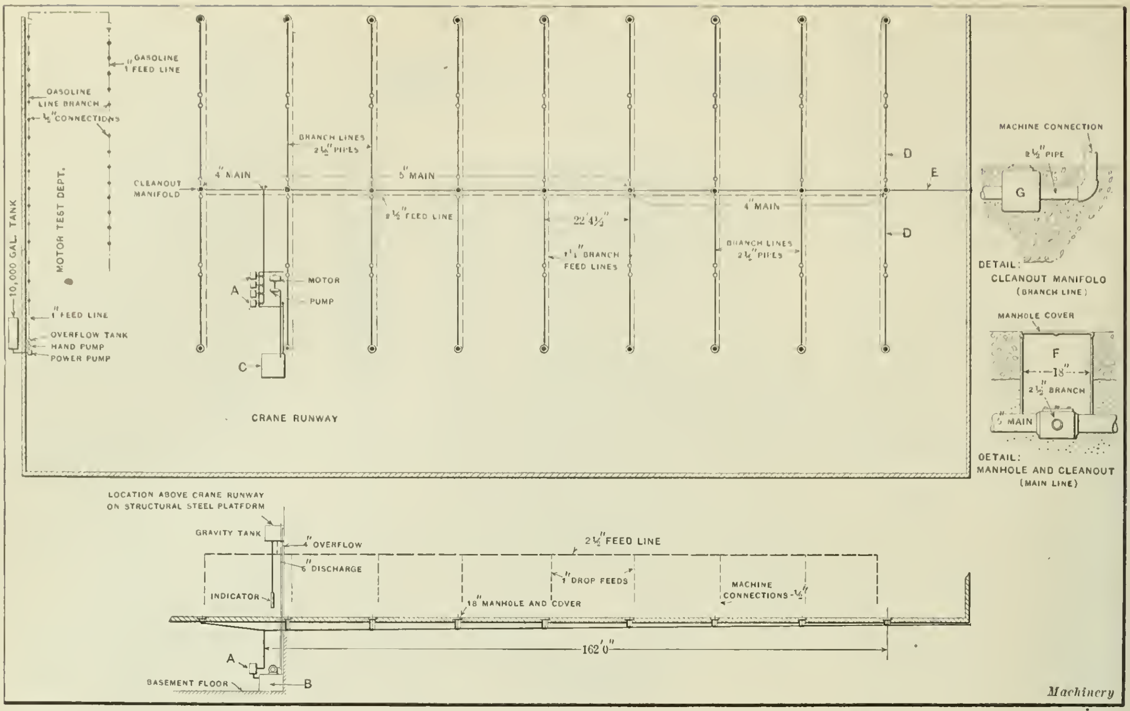


Fig. 53. Bowser Equipment for purifying Emulsions made from Soluble Oil and Water

the pressure developed would be likely to force fine particles of dirt through the filter, thus lowering its efficiency. An important advantage of having the filtering units held in a vertical position, with the oil passing from the outside to the inside, is that slime and sediment held by the cloth tend to drop off and settle at the bottom of the tank.

Equipment for Conducting "Batch" Filtration

A different arrangement of Richardson-Phenix filter tank

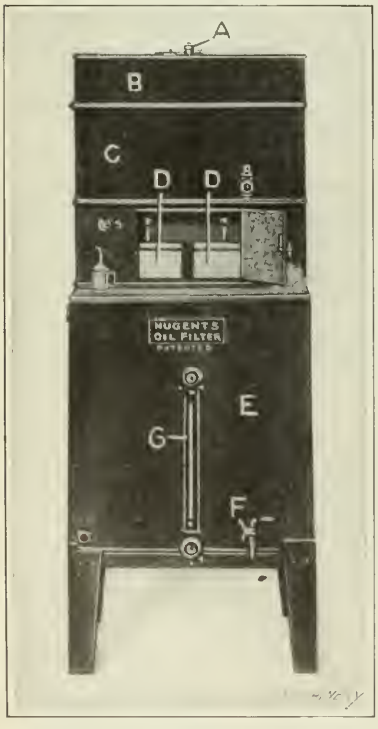


Fig. 54. Oil Filter made by William W. Nugent & Co.

and sterilizer is illustrated in Fig. 49. A quantity of used oil from the machines is run into the "dirty oil storage compartment" through removable strainer *A* that catches all coarse chips and dirt. While held in the dirty oil compartment a portion of the foreign matter in suspension in the oil settles to the bottom and may be flushed out from time to time through draw-off *C*. Oil flows through a float-controlled valve *D* into the filtering compartment, which is equipped with cloth-covered filtering units like those previously described. Control of the rate at which oil flows into the filtering compartment is obtained by regulating the position of float governor *E* on the stem of valve *D*. In this way a head of oil of from one to six inches above the filtering units may be maintained, and this controls the rate at which filtration takes place. To secure the best results, the float valve should be adjusted so that the filter handles the oil as slowly as possible and still maintains the desired capacity.

When it is necessary to sterilize the oil, steam is turned into coil *B* in the dirty oil compartment, and after passing through the filtering units into the "clean oil compartment," the oil is pumped back into the upper compartment. This circulation of the oil is continued until the temperature of all the oil has been raised to 140 degrees F., and it is held at this temperature for twenty minutes.

It will be seen that there is an overflow pipe *F* in the upper compartment, and if the level of the oil reaches the top of this pipe, it runs over into the lower compartment. This is merely a safeguard against the overflow of oil onto the floor. In practice, float-valve *D* is regulated so that the filters will carry away the oil as fast as required. At the front of the filter there are gage glasses *G* and *H* which show the level of oil in the lower and upper chambers. These glasses are protected by white enameled sheet metal reflectors. This system is known as "batch" filtration and sterilization because all the dirty oil is drawn from the machines and a new lot of clean oil substituted, the batch of dirty oil being taken to the filter and put into condition to be used subsequently.

Bowser System of Oil Purification

In the systems built by S. F. Bowser & Co., Inc., Fort Wayne, Ind., for the filtration

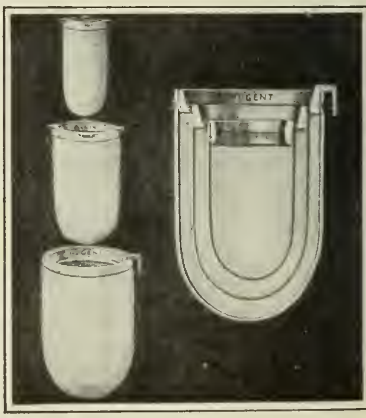


Fig. 55. Detail of Filtering Bag used in Equipment shown in Fig. 54

and sterilization of oils and cutting compounds used on machine tools, the principles employed are somewhat different from those that have already been described. In the type of equipment generally used, dirty oil returned from machines is first run into large settling tanks, where its temperature is raised by heat supplied from steam coils. This serves to make the oil more fluid and facilitates the settling out of impurities; in addition, the temperature may be raised sufficiently to provide for sterilizing the oil before it is passed on through the filtering units.

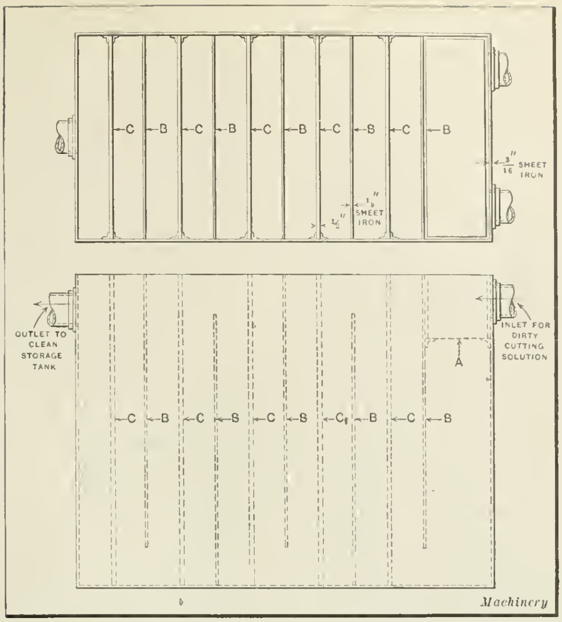


Fig. 56. Filter designed by Marlin Arms Corporation for purifying Cutting Compound used in its Factory

Probably the best way to describe the manner in which a Bowser system is operated will be to describe in detail one or two typical installations. In all cases the systems are designed and built to meet existing requirements in the factory, but there are certain established principles on which all of these operate, and the examples selected are typical of this firm's practice. Fig. 50 illustrates an oil reclaiming system built for the Remington Arms & Ammunition Co., Bridgeport, Conn., which has a capacity for handling 24,000 gallons per hour. Dirty oil enters through pipe *A* and is passed through strainer boxes *B*, in which most of the coarse dirt is removed. A cross-sectional view of one of these strainer boxes is shown in Fig. 51, and it will be well to explain how this operates. The oil to be purified enters the strainer box at *C*, and passes down through a chip basket *D*, which collects the larger chips and coarse dirt that have passed through the strainers in the machine-tool oil pans. At the center of the chip basket will be seen twenty-one disks *E*, which consist of iron frames covered with 1/16-inch wire mesh. It will be apparent from the illustration that these disks are so arranged that oil which enters the strainer box passes through the wire mesh into channels *F* leading to a central duct *G*. The purpose of the multiple disk construction is to provide a maximum straining surface so that oil may be passed through the box as rapidly as possible. From duct *G* the oil passes on to subsequent parts of the system through which it passes during the process of purification. In order to clean one of these boxes, the cover is removed to enable the set of disks and the chip basket to be lifted out. It will be seen that the disks are clamped together by a central rod, and that a shield is provided at the front of opening *C* to prevent excessive pressure from driving dirt through the filtering screen at this point.

In Fig. 50, connection *G* leads from the lower end of the central duct in the strainer boxes through which oil is discharged into magnetic separating tanks *H*. The design of these tanks is quite different from the settling tanks commonly used in Bowser oil reclaiming systems. Instead of being furnished with steam coils for heating the oil to facilitate sedimentation, these tanks are provided with electromagnets mounted in the cast-iron bases *I*, which cause the chips to be quickly drawn to the bottom of the tanks. As a result, the oil can be handled in this system much more rapidly than where it is necessary to wait for impurities to settle to the bottom of the tanks. Unless special provision were made for overcoming trouble from chips becoming magnetized and sticking to the bottom of the tanks, it would be exceedingly difficult to clean out the accumulation of chips. This is provided for by making the bottom of the tanks of brass, which is non-magnetic, so that when the current is turned off from the electromagnet, the chips may be easily raked out through two clean-out doors *J* in each tank.

From magnetic separating tanks *H*, the oil passes through pipes *K* into header *L*, which is connected with a battery of four filter tanks. The Bowser filters consist of cloth sleeves held by clamps at top and bottom to metal frames. The oil is delivered to the filters by pipes communicating with header *L*. The only outlet is through the cloth sleeve of the filter units and in flowing through this cloth, fine particles of metal and other foreign matter carried by the oil are removed. The filter sleeves can be removed from the metal frames and washed when necessary. The clean oil escapes into filter tanks *M*, which are connected with header *N* that carries it to storage tank *O*, from which it is pumped back to the machines. A filter of the type used in tanks *M* is shown in detail at *P*.

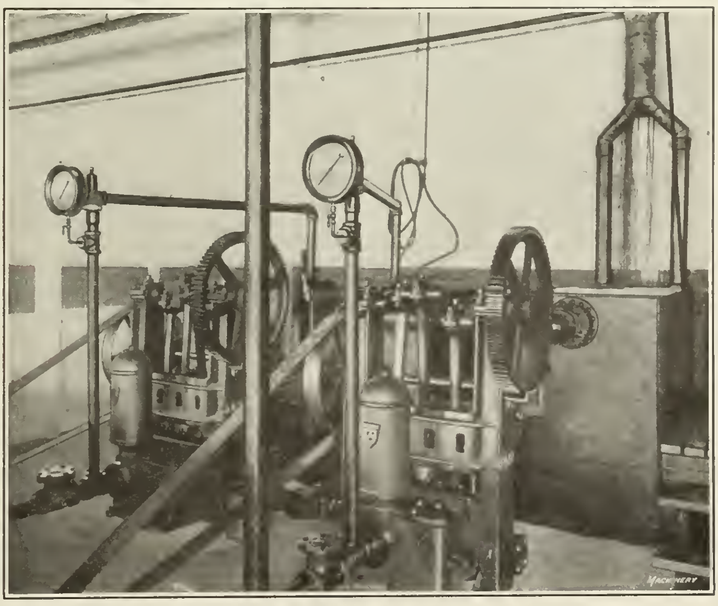


Fig. 57. Filter shown in Fig. 56; also Pumps, Pressure Gages, Storage Tank, etc.

Use of Heat to Facilitate Sedimentation

In the preliminary statement that was made concerning the principles governing the operation of Bowser oil reclaiming systems, the fact was mentioned that a practice is often made of running the dirty oil into settling tanks in which the temperature of the oil is raised by steam coils in order to facilitate the settling out of impurities held in suspension, and also to provide for sterilizing the oil. A good arrangement of such a system is illustrated in Fig. 52. In this system oil is pumped from storage tank *A* to headers *B*,

from which connections are carried down to the machine tools. Drain pipes from chip pans on the machines carry the used oil to return pipes *C*, which deliver it back to the settling tanks and thence to storage tank *A*. In a previous section of this article, attention was called to the importance of recovering oil from chips, and at *D* in the present illustration is shown the manner in which oil from the centrifugal separators is delivered into return pipes *C*.

The first step in purifying the oil consists of passing it through two heaters *E*. These are merely vertical cylinders connected in series. The oil is delivered at the bottom of the first cylinder and flows up over the steam coil and thence into the second cylinder, where it passes over another steam coil, the temperature of the oil being raised in this way to about 170 degrees F. From heaters *E* the oil is delivered into tanks *F*, *G*, *H* and *I*, which are connected in series by pipes that carry the oil down into each tank to a point close to the conical bottom and allow it to escape into the next tank through a pipe placed close to the top. This affords the most favorable condition for allowing impurities in the oil to settle to the bottom of the tank. Tanks *F* and *G* are settling tanks, that is to say, their function is to allow the bulk of chips and other suspended impurities to settle out from the heated oil. Tanks *H* and *I* are sterilizing tanks and are arranged with steam coils that provide for raising the temperature of the oil to about 200 degrees F. The rate at which the oil flows through the tanks is so adjusted that it takes about thirty minutes for it to flow through all four tanks; in other words, it takes fifteen minutes to flow through tanks *F* and *G*, in which sedimentation takes place, and fifteen minutes to pass through sterilizing tanks *H* and *I*. From tank *I* the oil is carried down into storage tank *A*, from which it can be withdrawn for subsequent use.

Oil that collects in the conical bottoms of the settling tanks is of poor quality, owing to the fact that it contains practically all of the suspended matter originally carried by the entire volume of oil passed through these tanks. This oil requires further treatment before it is fit to be delivered to the cutting tools, and this treatment is obtained by pumping it into cylindrical tank *J*, in which it is allowed to stand for a sufficient length of time to allow the impurities to settle to the bottom. It will be seen that there are four draw-off cocks on tank *J*, and after the oil has been allowed to stand for a sufficient length of time to insure that the impurities have settled, the upper cocks are opened one at a time, to allow it to flow into funnel *K*, which is carried at the top of a pipe connecting with the pipe line leading to storage tank *A*. The oil which is recovered in this way will ordinarily amount to about 75 per cent of the oil pumped into tank *J*, although the quantity will vary according to the quality of the oil and the service in which it has been used. The poorest grade of oil drawn off from the lowest cock is unsuitable for the lubrication of cutting tools, and this is usually employed for oiling conveyor chains, and other classes of service where a poor grade of lubricant may be used.

Fig. 58. Coolant applied to Eight Cutters on Multiple Gear-cutting Machine

Fig. 59. Delivery of Cutting Solution to Multiple Nut-tapping Machine

Purification of Soluble Oil Compounds

The purification of emulsions made by the mixture of so-called "soluble" oils with water does not generally require as careful attention as the more viscous oils used on cutting tools when both lubricating and cooling are necessary. This is due to several causes, among which is the fact that emulsions are more fluid than oils and so do not tend to hold such a large quantity of chips and particles of scale in suspension. Another important consideration which simplifies the purification of cutting emulsions is that they are usually employed on those classes of work where it is merely necessary to cool the tools, and as no lubricating action is necessary the presence of fine chips and dirt is not a serious detriment.

Because of these considerations, a much more simple equipment is often employed for the purification of emulsions, and Fig. 53 shows an outfit built by S. F. Bowser & Co., Inc., for this class of service, the system illustrated being used in the plant of the Pittsburg Model Engine Co., Pittsburg, Pa. This illustration shows a plan view of the drain pipes into which the fluid is delivered from pans on machine tools, the fluid being carried to a battery of four strainer boxes *A* of the type described in detail in connection with Fig. 51. After passing through these boxes, the purified emulsion goes to drain tank *B*, from which it is pumped back to gravity tank *C* that delivers it to all of the machines in the factory.

At each intersection of the cross drain pipes *D* on the main header *E*, there is a "cross" which is provided with a cover that may be taken off to facilitate clearing away any stoppage that may occur in the drain pipes. When large chips find their way into the pipe line it is possible for an accumulation of these to gather and cause the pipe to be blocked up; and if trouble of this sort occurs, it is merely necessary to remove the cover from the "cross" and push through a piece of wire to carry the chips and dirt that are giving trouble to the next "cross" so that they may be lifted out. This arrangement is shown in detail at *F*, which also illustrates the manhole provided in the floor to give access to the piping. In this detail illustration it will be seen that the piping is located at a considerable depth below the surface of the concrete floor, this being necessary in order to give the piping the required pitch to cause the compound to run off with the desired rapidity. At *G* is shown the type of box with a removable cover that is provided at the end of each cross drain pipe.

Nugent Oil Filters

William W. Nugent & Co., Chicago, Ill., manufacture oil filters of the type shown in Fig. 54. This type is made in three sizes, having capacities for handling four, six and twelve gallons per hour. Such filters could be used to advantage in filtering oil recovered from centrifugal separators or for reclaiming dirty oil taken from the pans of machine tools. Oil enters the filter at *A* and passes through a wire mesh strainer in upper compartment *B*, that removes the coarse material from the oil. It then flows into a settling tank *C* in which a further purification is effected. From tank *C* the oil flows

through pipes that discharge into filter bags D, each pipe being provided with a shut-off cock. There are three bags in each set, which are made of cloth of different degrees of fineness; and these bags are supported on metal frames in such a way that the bags in any one set do not come into contact with each other. This arrangement is shown in detail in Fig. 55. The filtered oil is collected in storage tank E, from which it is drawn off through cock F; and a gage glass G shows the level of oil in the tank.

The Nugent filters are also made in larger sizes capable of handling the oil or cutting compound used in large shops. These large filters are equipped with any required number of filter bags to provide for taking care of the volume of oil to be purified.

Simple Filter for Cutting Compounds

In the plant of the Marlin Arms Corporation, New Haven, Conn., a Richardson-Phenix filter is used for the purification of lard oil supplied to rifle-barrel drilling machines and certain other machines in the factory. For the purification of soluble cutting compounds used on milling machines, drill presses, and some other classes of machine tools, a simple filter was designed and built in the Marlin factory. As shown in Figs. 56 and 57, this filter consists of a sheet-metal tank with a chip basket A through which the compound flows to remove coarse chips. Five baffle plates B cause the fluid to follow a winding course in order to facilitate the settling of small chips and other impurities held in suspension. Between each of these baffles there is a wire screen C held between angle-irons so that it may be lifted out for cleaning. It was the original plan to have each of these screens covered with muslin to provide a filtering medium, but subsequent experience has shown that the fluid passes through more rapidly if only the last two screens are covered with muslin, and this is sufficient to insure the removal of all the suspended impurities. Placed beside the filter tank there is a storage tank for clean cutting compound, as may be seen in Fig. 57.

Improvement in Efficiency through Filtration

Any manufacturer who contemplates the installation of equipment for filtering oil or cutting compound will naturally ask the question, "How will the use of such an outfit be valuable in handling my work?" This can best be answered by citing one or two typical experiences of manufacturers who have found that trouble from rapid tool wear or poor finish is due to suspended impurities carried by the tool lubricant, and who have overcome such difficulties through the installation of an efficient system of filtration.

In the plant of the Boss Nut Co., Chicago, Ill., dissatisfaction was felt with the method of lubricating dies and cutting tools. This plant has an equipment of six punch presses of from two to five tons each, and one twenty-ton press; also six nut tappers, having six spindles each. The plant manufactures square and hexagon nuts, which are stamped out of 5/16- to ½-inch metal.

The former method of lubrication was by means of a gravity tank on each press, the lubricant being fed through a ¼-inch pipe to the die, from which it dripped off into a pan underneath the press. The stampings from the presses fell into iron pails with perforated bottoms, so that the lubricant would drip off from the finished product. These pails, after standing in the pans for a certain period, were lifted out, the drippings remaining in the pans. In lifting out the pails, a certain amount of cutting compound adhered to the bottom, etc., and later dripped onto the floor around each machine. While this loss of lubricant was not great, in dollars and cents, the task of keeping the floors clean, so that the men could do their work properly, took the time of one or two men about two hours each day; besides, it required two or three men to lift the pails filled with punchings from the presses.

Small rotary pumps were used to deliver the used lubricant from the drip pans to the gravity tank; and as the fluid was used over and over again without treatment, it always contained a great deal of scale and other foreign matter. Besides, at the speed at which the machines worked, a considerable portion of the cutting compound at each machine was lost by drippage and by adhering to the finished product. It required the time of two men at least two hours each day to mix and deliver new cutting compound to the various machines; and when this lubricant became so dirty as to render it unfit for use, it was thrown away. In adding or renewing the cutting compound, the time of the operator and the machine itself was also lost, with the result that the machines were operating at a low efficiency. By the installation of a Richardson-Phenix filtering system, all these faults were overcome, and the output was increased upward of 20 per cent. This system was installed in the following manner:

Trenches were cut in the floor, under the presses, of sufficient size and pitch so that the cutting compound would drip from the machine into these trenches, which are connected by a pipe line to a centrally located cutting oil filter. The trenches are covered with grating made of ⅛- by ⅜-inch flat iron spaced ¼ inch apart. These gratings are removable, so that they can be easily cleaned; and the kegs into which the finished product drops stand on top of the gratings, so that all the drippings flow back to the filter. One of these kegs can be easily and quickly slipped out from under a press and another one inserted. This permits handling the finished product as it comes from the presses, and as one man is now able to do this work, it saves the labor of two men.

Another advantage is that the men operating the presses do not have to stop their machines to fill the gravity tank, nor do they have to pay any attention to whether the pipe leading from the oil tank is full of dirt and grease, but can concentrate all their attention on production. This is also true of the nut-tapping machines. Under the old system it often happened that the operator actually had to wait for compound to be mixed or carried to his machine. The advantage of using a clean compound on drills and taps is self-evident, and while data are not available to show exactly how much longer a tap will last when properly lubricated, this company is quite certain that it is getting longer service from the same taps than it ever got before.

Cutting compound is a mechanical mixture and not a chemical compound; therefore, rapid circulation through a central system tends to keep the compound thoroughly mixed. For this reason, this system was so designed that all the compound in the system is circulated ten times per hour, *i.e.*, the system contains 300 gallons of cutting compound, and there is circulated in the various machines 3000 gallons per hour. Hooded drains from the machines should not be used, because if the oil in the compound tends to separate and float on top it will adhere to the hood, and only the water will be returned to the filter. It was found that a large amount of lubricant discharging into the drain lines acts as an air-rejector, which fills the drain lines with air pockets and holds back the flow; therefore all air traps should be carefully avoided and the drain line into the filter should be located below the top level of the compound in the filtering compartment. On this class of work there is considerable advantage in using long sweep fittings or bends.

The advantages which this company secured from the installation of a cutting oil system are as follows: The record for the month of December, before the new lubricating system was installed, was 4,200,000 nuts. After the system was installed, production for the month of January was 5,300,000 nuts, or an increase in production of 25 per cent; and in February 5,500,000 nuts were produced. This increase was made with the same tools and machines and the same number of men. The non-productive work of cleaning up, etc., was eliminated, and the men who formerly did this worked on production.

In another plant where the item of tool up-keep was heavy, it was found that the tools lasted from 33 to 250 per cent longer when supplied with filtered lubricant. In still another plant, the drills had a tendency to become slightly tapered and wedge in the hole; this was found to be caused by the use of dirty cutting compound, and the trouble was eliminated when the fluid was filtered. With such tools as self-opening dies, this factory found that sediment in the cutting lubricant sometimes clogged the mechanism so that it was impossible to operate it.

HEAT-TREATMENT OF STEEL—2[1]

PHOTOMICROGRAPH STUDY—CHANGES PRODUCED BY ANNEALING—DETERMINATION OF TEMPERATURES

BY MARTIN SYTE

HAVING observed the effect of heat-treatment on the properties of steel, in the December number, it is well to consider some of the causes underlying these results. For instance, why should the steel become hard and brittle and much stronger after hardening? Why should a hardened piece lose its strength and hardness, but gain in ductility, when reheated or drawn? In some cases these changes are very difficult to account for, as the exact cause of the hardening of steel is not known, although there are several theories. These theories will not be discussed here, but some of the points that are thoroughly understood will be considered.

If a piece of 0.10 per cent carbon steel is heated from atmospheric temperature up to about 930 degrees C. (1706 degrees F.), there will be three points at which, instead of rising, the temperature of the piece pauses or may even stop. An experiment will show that 0.25 per cent carbon steel also has three critical points. The two lower points are at practically the same temperature as those of the 0.10 per cent carbon steel, but the upper point will be at a lower temperature than the highest point of the 0.10 per cent steel. If this experiment is repeated with 0.50 per cent carbon steel, only two points will be found. The first will be at practically the same temperature as that of the 0.10 and 0.25 per cent carbon steels, but the second point will be much lower than their second point. In the case of 0.85 and 1.50 per cent carbon steels, just one point will be found, but this will coincide with the first point of the lower carbon steels.

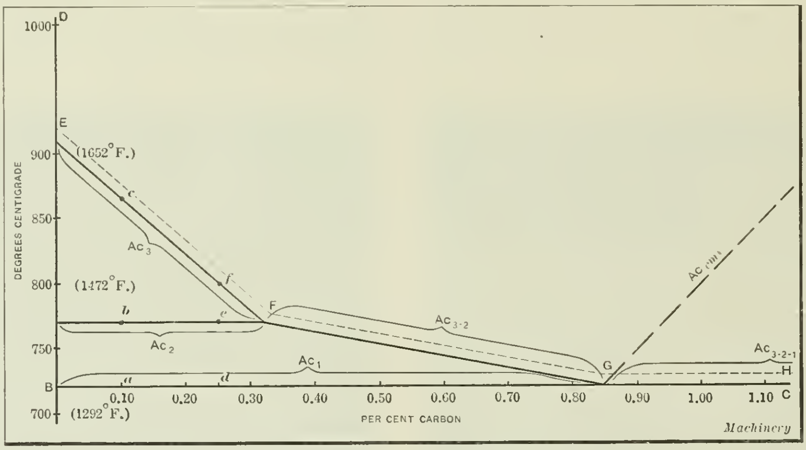


Fig. 1. Position of Critical Points in heating Straight Carbon Steel

Fig. 1 shows the location of these points graphically after a diagram by Sauveur. This diagram should be firmly fixed in mind, as it shows the relative location of the critical points of the plain carbon steels. The carbon content of the steel is shown, in per cent, along the lower horizontal line *BC* and the temperatures at which the critical point occurs along the vertical line *BD*. For instance, the points *a*, *b* and *c* are the three critical points for the 0.10 per cent carbon steel and *d*, *e* and *f* for the 0.25 per cent carbon steel. The diagram was obtained by getting the critical points of many carbon steels and then joining these points by lines.

The question naturally arises as to how these points are obtained. For instance, how is it possible to locate the three critical points of the 0.10 per cent carbon steel? There are several methods for doing this, and the ones most commonly employed in practice make use of the thermo-electric pyrometer. As it is practically impossible to use a furnace that will heat the piece at a uniform rate, it is apparent that there may be pauses or retardations in the heating or cooling that are not caused by any properties of the steel under test. In order to eliminate such pauses from the test, the temperature of the steel should be compared with the temperature of a body that has no transformation points within the temperature range covered by the experiment. If this so-called neutral body is put in the same furnace as the test piece, both bodies will be about equally affected by any irregularities in the heating of the furnace. In other words, they will be heated together, and when the temperature of one varies, the temperature of the other will vary also, so that there will never be a very marked difference in their temperatures; but when a critical point of the steel is reached, there will suddenly be a great difference in their temperatures, as the neutral body will be unaffected (possessing no critical points), while the steel will cease to rise in temperature. By using a double pyrometer to measure the difference between the two bodies, it is always possible to detect when a critical point has been reached; and a second pyrometer will show at just what temperature this point occurs. By this means the critical points of any steel can be found.

The critical points that occur in the heating of a steel also occur in the cooling, but at a lower temperature. If the point occurs in heating, it is called an *Ac* point; and in cooling, an *Ar* point. The point Ar_1 that occurs in cooling is called the "recalescence point," due to the fact that the steel actually gives off heat, or recalesces, at this point. Many writers use the term recalescence point very loosely, but it should be borne in mind that the only correct recalescence point is the Ar_1 point. The importance of knowing the location of these critical points lies in the fact that the correct hardening temperature is just above the upper critical point for any steel; or along the dotted line *EFGH*. Theoretically, it is just at the upper critical point, but it is safer to go a little higher.

Changes that Occur at Critical Temperatures

In studying the changes that take place at the critical temperatures, the range of temperature from the lowest critical point to the highest point of any steel may be called its "critical range." If any piece of steel is heated just below the foot of the range, that is, Ac_1 or Ac_{3-2-1}, and quenched in water, it will be found that there are practically no changes in its properties. If the steel is heated to this point or a little above and then quenched, it will be found that the piece has been made stronger, harder and less ductile; that is, its tensile strength, elastic limit, and hardness have been increased while its elongation and reduction of area have been decreased. If the steel is hardened at successively higher temperatures, it will be found that it is made stronger and harder but less ductile, in each case, until the top of the critical range is reached, when the maximum degree of strength and hardness and the minimum of ductility are obtained. If the steel is heated considerably above the top of the range, there is no gain in hardness or strength; the only effect is that the grain is made coarser. In other words, steel can be hardened somewhat by heating it above its first critical point and quenching, but the full hardness or strength is not obtained until the steel is heated above the upper critical point. This fact is true of all straight carbon steels.

[1] The first installment of this article appeared in the December, 1916, number of MACHINERY.

To determine the reason for this fact, it is necessary to study the steel in the normal state. Normalized steel consists of pearlite and ferrite in the case of hypo-eutectoid steel, pearlite alone in the case of eutectoid, and pearlite and cementite in the case of hyper-eutectoid. When a piece of any of these types of steel is heated to a temperature below the first critical point, no change takes place in the microstructure, and hence there is no change in the physical properties. But if it is heated to the point Ac_1, there is a very marked change in the properties. This is due to the marked change in the microstructure, for just as soon as the point Ac_1 is passed, the pearlite, instead of remaining as a mechanical mixture of alternate layers of cementite and ferrite, becomes a solid solution. As this change of the pearlite has increased the strength of the metal, it follows that the solid solution of the pearlite constituents must be stronger than pearlite in the normalized state.

As the name implies, a solid solution has all the characteristics of a liquid as regards the intimate mingling of its constituents. In fact, in a solid solution it is impossible to distinguish, with the highest power of the microscope, one constituent from another. Hence, while before the pearlite became a solid solution, the plates of carbide (cementite) could be distinguished from those of ferrite, after it was converted into a solid solution neither could be distinguished, because they were so intimately mingled. In fact, in a solid solution each crystal contains a portion of each ingredient, and it is impossible, by any physical means, to separate the matter contained in the crystal.

As the temperature of the steel is raised above the foot of the critical range, some of the free ferrite begins to enter this solid solution and more and more of it enters the solution as the temperature is increased. In fact, when the top of the critical range is reached, all the free ferrite has entered the solid solution, and if the steel is then quenched, it will be in the strongest possible state. If the steel contained no free ferrite or free cementite, that is, if it were a eutectoid steel, all the pearlite would go into solution as soon as the foot of the range was passed (just as it did in the hypo-eutectoid steel), and the whole steel would then be in the state of a solid solution. If it were a hyper-eutectoid steel, the pearlite would go into solid solution as soon as the foot of the range, Ac_{3-2-1}, was crossed, but the excess cementite would not go into solid solution until the dotted line Ac_{cm} was reached.

To summarize, no matter whether the steel is hypo-eutectoid, eutectoid or hyper-eutectoid, when heated the pearlite goes into solid solution at the foot of the range, Ac_1 or Ac_{3-2-1}. If there is any free constituent, as ferrite or cementite, it will be gradually absorbed into the solid solution as the steel is heated to the top of the range (Ac_3 or Ac_{3-2-1} in the case of hypo-eutectoid steel; Ac_{3-2-1}, which is both top and bottom of range, for eutectoid steel; and Ac_{cm} for hyper-eutectoid steel), and by the time the top of this range is reached, all the pearlite will be absorbed. In other words, no matter what kind of steel we have, it will be in the state of a solid solution as soon as it is heated to the top of its critical range.

If the steel is quenched or cooled with extreme rapidity, it will be retained, or locked, in this state, so that when it is cold it is still a solid solution; it is then called austenite. But in practice it is impossible, as a rule, to quench or cool the steel quickly enough to retain it in this perfect solid-solution state, and some of the constituents separate out of this solid solution. If the steel is cooled in liquid air, which is very cold, perfect austenite may be obtained in some cases. If the steel is cooled in water, such a close approximation to the solid solution cannot be obtained, and if cooled in kerosene, the approximation will be found to be even more imperfect. With heavy oil or air cooling, a still more imperfect solid solution is obtained.

By looking at a specimen of hardened steel under the microscope, it is possible to determine just how close it is to the solid solution. The perfect solid solution is called austenite, the first stage in its decomposition is martensite, then come troostite, sorbite, and pearlite. Each of these states has its characteristic appearance under the microscope.

It has been shown that by heating steel to the top of its critical range the steel is put in the solid-solution state, and by quenching in mediums of varying effectiveness the steel may be obtained in the cold state as a solid solution, or one of its decomposition products. But it is possible to obtain the exact decomposition product desired by heating to the top of the range, cooling rapidly enough to get austenite or martensite, and then reheating below the range so as to get troostite or sorbite. In other words, it is possible to obtain the steel in the exact state desired by simply hardening it with the proper rapidity, or by hardening and then reheating or drawing the steel. The hardening process converts the steel into a fine-grained solid solution (or to an approximation), and the drawing treatment lets the steel decompose into one of the states that experience has shown is best suited for the work desired.

In the specimens used for determining the chart shown in Fig. 1, the steel was first hardened just above the top of the critical range, which was determined by means of a neutral body and pyrometers. After this steel was hardened it was as close to a solid solution as it was desirable to get this particular steel commercially; it was then in the state of martensite. Some pieces were then drawn at each of the temperatures shown on the chart, and the martensite was decomposed by this drawing into the softer and weaker, but more ductile, decomposition products, troostite and sorbite. It should be mentioned that each of the successive decomposition products of austenite is softer than those preceding it, except martensite, which is harder than austenite.

Changes Produced by Annealing Process

In a good many cases where steel is to be annealed, the only object desired is to soften the steel so that it can be machined or worked more easily. In other cases, it is desirable not only to make the steel softer, but also to refine the grain size and to make the steel soft. In order to anneal steel perfectly for the latter purpose, it should be heated to the top of the critical range, held there until every part has been thoroughly heated to this temperature, and then very slowly cooled, preferably in the furnace. This will not only wipe out any coarse structure and make the steel fine grained, but it will leave the steel as soft as possible. This is due to the fact that when the steel is heated to the top of the critical range, it goes into the state of a fine-grained solid solution. Then by slow cooling the steel is given no chance to set in this solid-solution state, but forms soft, ductile sorbite or pearlite. If the steel is cooled more rapidly, it will not be given sufficient time to decompose from the solid-solution state, and troostite or sorbite, or a combination, is obtained. If the steel is cooled in the air, it will be still harder, due to the fact that cooling in air is a sort of mild form of hardening. This is shown very clearly in Fig. 1, where the steel has been hardened, then reheated to the top of the range and air cooled. It will be noted that both the tensile strength and the hardness are increased.

The most perfect way to anneal is to heat the steel to the top of its range and harden; this gives a fine-grain hard steel. It should then be reheated to just below the foot of the range and cooled very slowly; this gives the finest grain possible, together with extreme softness, and is a method much used in France. It has been found best to harden hyper-eutectoid steel of 0.85 per cent carbon or more just above the line Ac_{3-2-1}, for if the top of the range Ac_{cm} is passed, all the excess cementite may be in solid solution, but this higher heat will enlarge the grain so much that the advantage gained does not pay. The one exception to this is the case of high-speed steels, which, due to their special ingredients, may be heated above Ac_{cm} and all excess elements changed into solid solution, without dangerously enlarging the grain size.

The literature on hardening is sometimes very inexact and unclear, but if it is remembered that the line *EFGH* shows the proper point for hardening, no confusion should result. In all cases the hardening or correct annealing temperature is the top of the range Ac_3 or Ac_{3-2} in steel under eutectoid carbon content, and Ac_{3-2-1} on all eutectoid and hyper-eutectoid steels with the exception of high-speed tool steels.

Fig. 2. Photomicrograph of Steel correctly hardened

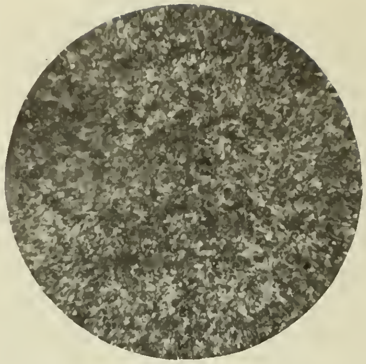


Fig. 3. Steel shown in Fig. 2 magnified to 400 Diameters

A Typical Heating Trouble

In considering the practical operations of hardening, it will be found that the theoretical knowledge gained will stand us in good stead. We may harden a brand of steel for months with complete success and then suddenly have trouble at some inopportune time. The steel may not harden the way it did before, or it may crack in the hardening. The exact cause is sometimes difficult to find, and the man whose practical knowledge is not coupled with an understanding of the why and wherefore of his hardening operations frequently finds himself in trouble.

For instance, a hardener had been getting entirely satisfactory results by hardening arbors in oil. He had hardened thousands of them without experiencing any trouble when suddenly they tested soft after the heat-treatment. The hardener was the center of all the resulting complaints, and naturally he claimed that the analysis of the steel was different from what he had been getting. By using water instead of oil and heating considerably higher, he managed to make a fairly satisfactory job, but still a considerable number cracked in the hardening. The steel manufacturer insisted that the steel was within specifications, and actually showed by analysis that the former pieces that hardened in oil and those which required water quenching were the same steel. The hardener, who merely did this work by rule, was naturally at a loss to overcome this trouble and eventually lost his position. Investigation later showed that the steel in both cases was identical, but that the supplier, having run short of the size bar generally supplied, had obtained permission to supply a smaller one. As very little stock was turned off from this, the decarburized outer skin, or bark, was not completely removed. Therefore, instead of the steel being 0.65 per cent carbon, as specified, the exterior was 0.35 per cent carbon and the interior was 0.65 per cent. It therefore required water and a higher heat to make this low-carbon outside portion hard enough.

If the hardener had only studied the theory a little, he would have known that this higher heat and water quenching was an indication that the carbon was lower. His limited general knowledge kept him from knowing that his first contention that the analysis varied was correct, as far as the outer surface of the bar was concerned, and that the steel manufacturer was also correct as far as the analysis of the interior of the piece was concerned. The solution in this case was very simple, but the writer recalls other cases where a thorough knowledge of both the practical and theoretical side was required before the trouble could be located and remedied.

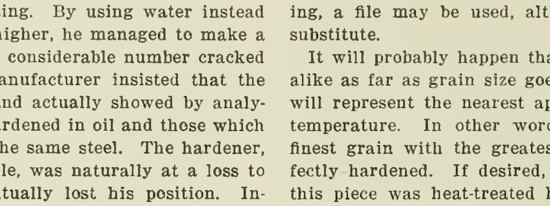


Fig. 4. Cast Steel before it is rolled or heat-treated

Determining Proper Heat-treatment Temperatures

We should keep in touch with the theory as much as possible, even while describing briefly some of the practical points to be observed in the heat-treating of steel. Let us suppose, for instance, that a new type of steel is to be hardened. If the analysis were known, it would help very much in estimating the correct hardening temperature, but it will be assumed that this is not known. If a critical-point outfit can be obtained, the critical points of the steel can be determined; then the critical temperature diagram, Fig. 1, will help us tell the correct temperature to use.

If an outfit of this nature is not at hand, samples of this steel, all cut to approximately the same size and shape, should be hardened in water at different temperatures, starting at 732 degrees C. (1350 degrees F.) and increasing the temperature 15 degrees C. for each sample. The test pieces should then be broken by the same method so that the fractures will be comparative. All soft pieces may be disregarded and only the harder ones examined. Those with the finest grain may be separated from the others and should then be tested to ascertain which is the hardest. Nearly all shops possess either a scleroscope or Brinell hardness tester, but if these are lacking, a file may be used, although in this case it is a poor substitute.

It will probably happen that several pieces will look almost alike as far as grain size goes; in this case the hardest piece will represent the nearest approach to the correct hardening temperature. In other words, the piece that combines the finest grain with the greatest hardness is the one most perfectly hardened. If desired, when the temperature at which this piece was heat-treated has been noted, the test may be repeated by hardening, say, four more pieces at intervals of 5 degrees C. above and below the hardening temperature of the piece chosen by inspection. These pieces should be broken and tested as before, and the one showing the finest grain with the greatest hardness will represent the correct hardening treatment. The second experiment is performed only to locate the temperature a little more accurately than in the first experiment, where 15-degree intervals were used.

If the steel does not show any material increase in hardness at any of the temperatures tried, it is probably a low-carbon steel which, due to its carbon content, cannot be materially hardened. In this case, a file will not do for the hardness test, so a more delicate instrument must be used.

In many cases it will not be necessary to undertake the above experiment, as the manufacturer supplies the information regarding the hardening treatment. Where the chemical analysis is given, by referring to Fig. 1 the hardening temperature may be quite accurately estimated and a trial may be made to confirm it.

If the steel is an alloy steel, it must be borne in mind that in addition to the carbon content the special alloying element may influence the correct hardening temperature; for instance, nickel lowers the hardening point about 20 degrees C. for every per cent of nickel in low-carbon steels containing less than 5 per cent nickel; manganese also lowers it. Vanadium, chromium, and silicon have no marked effect.

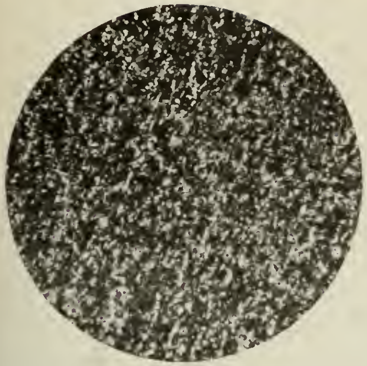


Fig. 5. Steel shown in Fig. 2, hardened at too Low a Temperature

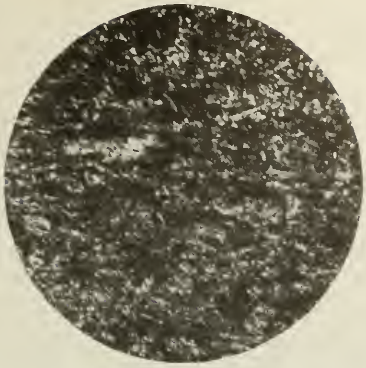


Fig. 6. Steel shown in Fig. 2, when it has been overheated

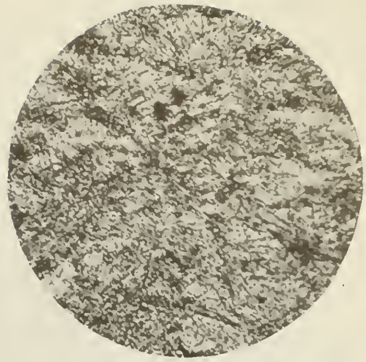


Fig. 7. Steel shown in Fig. 2, when it has been burned

Before proceeding further, we should understand what happened to the steel that was tested for its hardening temperature. Let it be assumed that it was about 0.50 per cent carbon steel. All the test pieces that were heated up to a point below Ac_1, Fig. 1, remained soft on quenching. The first piece heated above Ac_1 and quenched showed an increase in hardness because the pearlite grains had been transformed into austenite and the quenching served to lock them, if not in this state, in an approximation to it which should be hard. As the different pieces were heated to successively higher temperatures through the range, more and more of the excess ferrite entered into the solid solution of austenite, so each of these successive pieces when quenched, therefore, was harder than the previous one. When those pieces that had been heated above the top of the range, where they are converted completely into a solid solution, were quenched, a maximum hardness was obtained. If these pieces were heated much farther above the top of the range and quenched, there would be no gain in hardness; rather the steel would be overheated, which results in a large grain size as already mentioned.

Photomicrographs of Good and Defective Steels

Fig. 2 is a photomicrograph showing the fine grain resulting from hardening a steel at the correct temperature. Fig. 3 shows the same steel magnified still more—to 400 diameters; yet it still appears very fine grained. The actual diameter of the spot of steel shown in Fig. 3 is only 0.008 inch; thus it will be seen that this photomicrograph shows a part of the steel about as big as a pin point. Fig. 4 shows a photomicrograph, of 100 diameters magnification, of cast steel before it was refined by the rolling process and by heat-treatment. The enormous difference in the grain size is apparent and serves to illustrate what changes can be wrought in steel by the correct treatment.

Fig. 5 shows a piece of the same steel as that shown in Fig. 2, which has been hardened at too low a temperature. The steel shown in Fig. 2 had a Brinell hardness of 578, while that shown in Fig. 5 had a Brinell hardness of only 248. To the eye the fracture of both might appear about the same, but the hardness test shows that the second one has not been heated to the top of the range, because it does not possess its maximum hardness. Fig. 6 is a photomicrograph of the same steel when it has been overheated; that is, heated above the top of the critical range farther than is necessary. It shows a coarser grain size, yet it is no harder than the steel shown in Fig. 2. Nothing has been gained, therefore, by overheating; in fact, the coarser grain size is a distinct disadvantage, because the metal is weaker and more brittle. Fig. 7 shows the same steel heated to a temperature of 1000 degrees C. (1832 degrees F.), which is so much too high that it has resulted in burning the metal at some points. This is shown more clearly in the higher magnification, Fig. 8. These illustrations show the importance of finding the correct hardening temperature. If the steel is heated below this temperature to harden, the maximum hardness or strength is not obtained; if it is heated too far above this temperature, it is coarsened and its physical properties are impaired; and if the heating is carried still farther, the steel may be ruined by being burned.

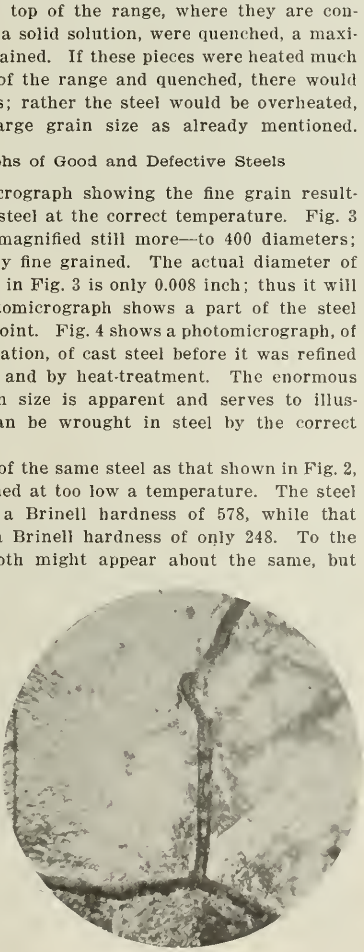


Fig. 8. Higher Magnification of Steel shown in Fig. 7

If the steel with a very coarse grain, as shown in Fig. 6, is not heated to the top of its critical range, this coarse grain will not be entirely eliminated; but if it is heated to the top of the range and quenched, the coarse grain will be refined, unless it has been badly overheated and burned. Fig. 9 shows the same piece of steel as that in Fig. 6 after it has been refined by heating to the correct temperature.

However, if the steel has been previously burned or abused, it may be impossible to restore it to a fine-grained and strong state. For instance, unless the steel is remelted, no amount of heating can repair the cracks produced in the burned steel of Fig. 8. Fig. 10 also shows a case where no hardening temperature can bring the steel into a state of proper hardness, for the edges have been very badly decarburized by the steel mill. This is shown by the fact that the edge A appears lighter than the inner part B, because the former has less carbon bearing or pearlite grains.

It must be borne in mind that the temperatures given in the accompanying table are not to be arbitrarily followed, because other constituents in the steel, such as manganese, affect the correct hardening temperature. They are given to aid the beginner, so that he will know approximately where to start his test for the correct hardening temperature, if he knows the analysis of the steel. It is only possible to obtain the exact temperature by experience.

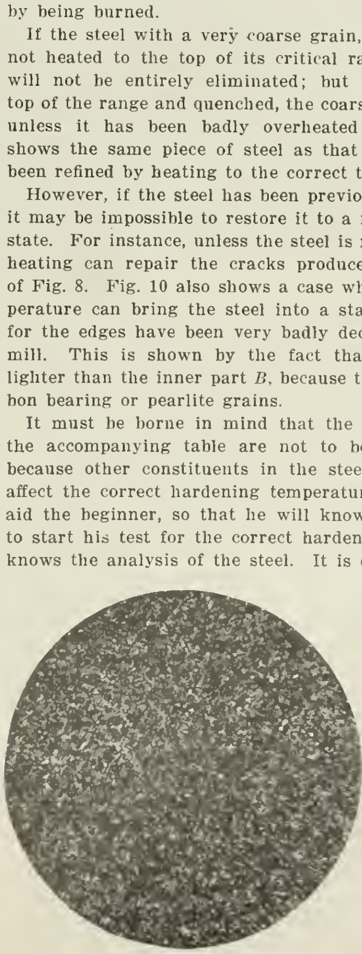


Fig. 9. Steel shown in Fig. 6 heated at Correct Temperature

In practice, after the theoretically correct hardening temperature for a given steel has been obtained, it is advisable to heat slightly above this temperature to allow for any delay in getting the steel into the quenching bath or any other cause that might possibly allow the temperature of the

APPROXIMATE TEMPERATURES FOR HARDENING CARBON STEELS

Carbon, Per Cent	Hardening Temperature	
	Degrees C.	Degrees F.
0.10	885	1627
0.20	865	1589
0.30	845	1553
0.40	825	1517
0.50	805	1481
0.60	790	1454
0.70	780	1436
0.80	770	1418
0.90	760	1400
1.00 to 2.00	760	1400

Machinery

steel to drop below the top of the critical range. If it drops one degree below this temperature, the piece will not possess the maximum hardness, while if it is heated ten degrees above the top of the range and the temperature should fall one or two degrees before the piece is in the quenching bath, the steel will still be above the top of its range and will not lose any of its hardness.

The alloy steels, especially those containing chromium, can be heated farther above the top of their critical range without impairing their physical properties by enlarging the grain than can the plain carbon steels. This fact should not be taken advantage of to "take chances" in the treatment, but should be considered as merely a point in their favor toward obtaining quality.

Time Necessary for Heat-treatment

The next point to be considered is the time required to heat the piece to the correct temperature and the length of time it should be held at this temperature. Generally, the rate of heating a piece to the hardening temperature is given very little attention. The excellent alloy steels of today can be heated quite rapidly without impairing their quality to a marked extent, and this fact is taken advantage of in commercial hardening on a large scale. It must always be borne in mind that when trouble does occur this point should be investigated, for too rapid heating may result in cracking the steel and impairing its qualities. This is especially true in the case of cheap grades of steel that have been hardened and are being rehardened without first being annealed or carefully preheated.

No fixed rule can be given for the rate of heating, as this point can be determined only by intelligent experience. When the piece has been heated to the proper temperature, it should be held at this temperature until sufficient time has been allowed for the complete grain transformation to take place throughout the whole piece. It was believed for some time that when the outside of the piece was of the correct temperature the interior portions were still much below this temperature, but recent experiments have shown that the interior temperature of the piece lags only a very little behind the exterior temperature. This must not be construed as a reason for not giving the piece time to "saturate," for this time must be allowed; its purpose is to give time for changes to be completed in the structure of the steel rather than to effect a complete temperature saturation of the whole piece.

A point of great practical importance and one that must not be overlooked in discussing the heating of the steel for hardening is the pyrometer and its location. A great many hardening furnaces have different temperatures at different parts of their heating ovens. The writer has observed cases where the pyrometer was in the rear of the furnace and read 1420 degrees F. At the same time a piece located near the pyrometer was at a temperature of 1400 degrees F., while a piece in the front of the furnace was at a temperature of only 1380 degrees F. When quenched, a marked variation in the hardness of the two pieces was naturally noted. Wherever possible, the pyrometer should be as close to the piece being hardened as possible. If it is impossible to realize this condition, the hardener should make tests so as to know just what discrepancy exists between the temperature of the pyrometer and the piece; in other words, he should know the temperature conditions that exist in the furnace, so that even if they cannot be corrected they can be intelligently allowed for.

All pyrometer connections must be kept tight and clean and should be soldered wherever practicable. The pyrometer should be checked frequently with a master outfit kept solely for this purpose.

Quenching Mediums

Water quenching gives greater hardness than oil, and cold water and cold brine give still greater hardness. In choosing the quenching medium, we are therefore governed chiefly by the hardness desired and the amount of drastic quenching that the steel will withstand without cracking or severe distortion. A good many concerns use steels entirely unsuited for the purpose intended, and get the necessary hardness by what might be termed "forcing"; that is, the steel is quenched in a very drastic medium, such as ice-cold water, which often results in cracking the steel. By using a better grade of steel or a steel of higher carbon content and quenching it less severely, as, for instance, in oil, the necessary hardness or strength may be obtained with a larger factor of safety against cracking and distortion of the steel. Some steels, however, are made to harden in water and others in oil, and the manufacturers of these steels give instructions to this effect. In the absence of definite information, the beginner can best determine this point for himself.

By removing the steel from the quenching bath before it has become entirely cold, the danger of cracking is greatly reduced, for this allows the steel to be slightly tempered. In some cases, excellent results may be obtained with steel that will crack if quenched entirely in water by placing it in water for a few moments and then removing it quickly and plunging it in oil, where the quenching may be completed. The length of time the work should be held in the water can only be determined by actual trial. Generally, it may be held there until the vibration felt along the handles of the "pick-up" tongs, due to the violent formation of steam around the piece, has almost or entirely ceased.

A very important point in quenching steel is to get the work into the bath as quickly as possible. Just as soon as the furnace door is opened, the inrushing air strikes the piece to be hardened and chills it. As the piece is removed from the furnace, this chilling effect becomes more pronounced. If the piece is one of complicated section, the smaller parts and edges may be materially affected. For this reason, the quenching bath should be located in the most advantageous spot for rapid work.

Pack-hardening and Tempering

Pack-hardening must not be confused with casehardening, where the work is also packed. In casehardening, the object of the packing is to give a pronounced case to certain portions of the steel; while in pack-hardening, the object is to

Fig. 10. Steel badly decarburized at Steel Mill

beat the piece through thoroughly and to prevent the scaling or oxidation of the surface that will result, to a more or less extent, if the piece is heated in the open fire. The parts to be heated, therefore, are packed in metal pots or boxes with charcoal, or some other material that will not have a decarburizing effect upon the steel. The pots are then heated through at the proscribed temperature and held at this heat for the proper length of time, after which the pieces are removed and quenched.

It is very important to know just what temperature exists within the pots and how long they require to become heated through. Preliminary tests should be run with pyrometer ends inserted within the pots and enough data obtained so that an accurate idea exists as to how long each size pot should be heated with a given size load of steel within it. The old method of running wires, through holes drilled in the pot cover, into the interior contents of the pot and withdrawing a wire at given intervals of time and noting its color as compared with that of the furnace walls may also be of value.

The proper tempering, or drawing temperature, as it is also called, depends on the use for which the steel is intended. If it must be intensely hard, it should be drawn, or tempered, at a very low temperature, or the operation may be omitted altogether. If a certain amount of toughness or ductility is desired, the steel must be tempered, unless it is a steel of such analysis, for instance a low-carbon steel, that it possesses enough ductility after being hardened only. Fig. 1 shows that, as we draw or temper a hardened steel, the solid solution (or its approximate state) is decomposed and constituents are formed that make the steel weaker and softer, but more ductile.

By tempering a straight carbon steel at about 400 degrees C. (752 degrees F.) it is changed into the troostitic state, unless it is a steel of such nature, or is hardened in such a way, that it contains some still lower constituent, even after hardening, such as sorbite. Troostite is much softer and less brittle than martensite, and is usually the most common constituent found in commercially hardened and tempered steels. By tempering at 600 degrees C. (1112 degrees F.), which is generally considered annealing, a sorbitic structure that is still more soft and ductile than troostite is obtained.

After a steel has been correctly hardened, it should be drawn, experimentally, at different temperatures and tested to find out how it stands up for the particular application intended. Experience has shown the degree of heat required for tempering for quite a variety of purposes, and these temperatures may be obtained in numerous books on hardening. In practice, there are several methods of tempering hardened steel. The steel may be heated to the hardening temperature. The end desired hard is then plunged into the quenching bath until it is fairly well hardened and is then withdrawn, rubbed bright, and held until the heat of the unquenched part has crept down to the hardened end and heated it to the proper temper color, when the whole piece is plunged into the bath and quenched. In the hands of a skillful and experienced hardener, this method may be entirely satisfactory.

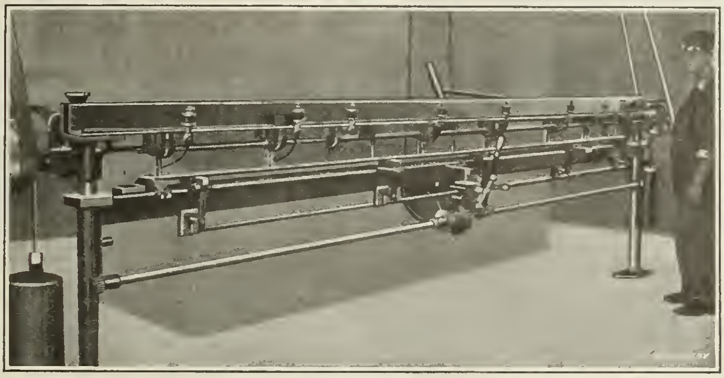
Another way of tempering is to heat the part in a bath of hot oil. Oil can be obtained that will stand a temperature of about 343 degrees C. (650 degrees F.). This is a very accurate way, as the exact temperature of the oil may be obtained by a thermometer and the piece is certain to be tempered uniformly all over. For temperatures between 260 to 583 degrees C. (500 to 1100 degrees F.) a bath composed of equal parts of potassium nitrate and sodium nitrate may be used. Lead and sand baths are also employed for tempering. In every case, however, the same object is accomplished. The solid solution (austenite) or its approximation (martensite or even troostite) formed in hardening is decomposed into a lower constituent or lower combinations, such as martenso-troostite, troostite, troostito-sorbite, or sorbite itself. All of these have more ductility and less hardness than the constituents above them.

Some of the main factors in heat-treating steel and the underlying theory have now been considered. While it has not been possible to give exhaustive attention to every point, an effort has been made to show that there is a reason for each process and also what that reason is. Much progress remains to be made in the investigation of some of the causes of the changes observed in heat-treatment, but if each hardener will study the subject intelligently and forget the rule of thumb or the mysterious formula lent him by some kind acquaintance, he will soon acquire a knowledge that will help him to overcome obstacles and place his work upon a successful scientific basis.

* * *

SPECIAL DRILLING MACHINE FOR T-SECTIONS

The work for which the special drilling machine shown in the accompanying illustration was designed is the drilling of 1¼-inch T-sections, approximately 15 feet long. The largest drill used in this machine is 3/32 inch. Twenty holes can be drilled at one time, and the extreme center distance between the end drills is 14 feet. The two outer sets of 3/32-inch holes are approximately 6 inches from the ends of the work, and there are about ten additional sets of spindles carrying 3/32-inch drills placed at various distances between. The power is transmitted to the two sets of vertical drill spindles by two parallel horizontal shafts, one of which is driven by a flat belt at one end of the machine and the other by a similar belt at the other end. This does away with the use of gears, which are necessary with but one driving pulley. All the drill heads are adjustable longitudinally. The power feed for the table is accomplished through the medium of a round belt in the middle of the machine which runs on a wooden pulley from the lineshaft above. The work-holding clamps bear at several points along the length of the work; yet they are all operated from one position.



Special Drilling Machine for T-sections

One operator can drill these 15-foot T-sections at the rate of fifty per hour, or 900 3/32-inch holes per hour. Each drill is lubricated by an individual oil-cup located at each spindle. The oil feed is positive, so that the operator does not need to pay attention to the matter of lubrication.

The machine was built by the Sellew Machine Tool Co., Pawtucket, R. I., for Cuddy-Gardner Co., Providence, R. I., maker of carpet display racks, of which these T-sections are a part. Though the machine is of skeleton construction, it is sufficiently rigid for the work it is called on to do. V. B.

* * *

The largest and latest Zeppelins, one of which, the L-33, was brought down near London, are 680 feet long and, with their crew of twenty-two officers and men, are estimated to weigh 50 tons. They carry four gondolas, in which are mounted six Mercedes engines, each of 240 horsepower, and can carry about 2000 gallons of gasoline in their tanks. They are armed with seven guns.

MULTIPLE TOOLS FOR THE LATHE

TURNING TOOLS THAT SAVE LABOR AND FACILITATE PRODUCTION

BY HENRY M. WOOD[1]

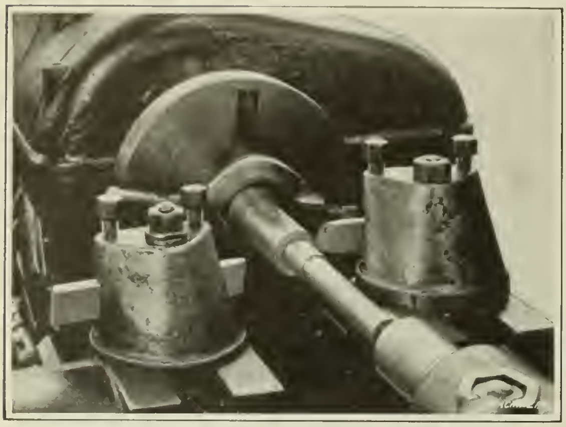


Fig. 1. Shaft Turning with Connected Compound and Plain Rests

In chucking operations, it is common shop practice, whenever the nature of the work permits, to bore with a tool held in the turret on the bed at the same time that a turning cut is being taken with the carriage tool. Such use of multiple cutting tools is generally understood; therefore, although turret operations are strictly instances of the use of multiple cutting tools, this article will be confined to jobs turned between centers or on arbors where multiple tooling is not so generally used.

A large variety of lathe work requires the use of different tools, but the work is of such a nature that two or more tools cannot be cutting simultaneously. This class of work is handled in one of the following ways:

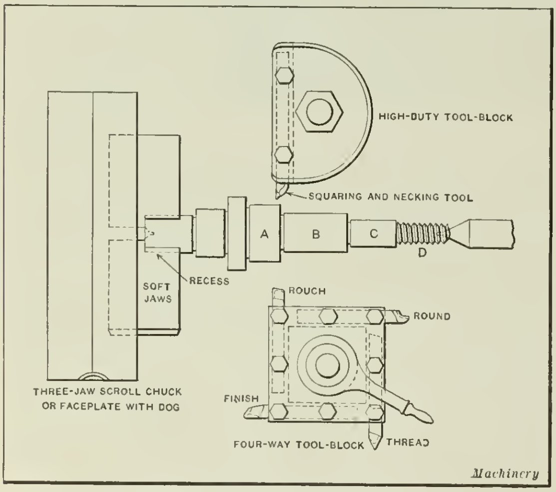


Fig. 2. Lathe Set-up for Operations requiring Five Tools

1. By changing tools in the toolpost. In this case, an engine lathe with one holder for a single tool is used. The piece is kept between centers until it is finished and the tool is changed as often as necessary. For example, after rough-turning, the turning tool is replaced by a squaring and necking tool, a chasing tool, etc. Under this method considerable time is lost by stopping the lathe and changing tools.

2. By changing work for separate operations. The first operation, probably rough-turning, is performed on an entire lot of parts; then the tool is changed and the shoulders are squared and necked (if that is the second operation) on every piece in the lot. Additional tools, if necessary, are used for subsequent operations. This method is usually preferable to the first, because in the case of light shafts or studs, which is the usual class of work turned between centers, the work can be changed more quickly than the tool.

3. By using a front tool for turning and a rear tool for squaring and necking. These tools do not both cut at the same time, but they perform both operations without either the tools or the work having to be changed. Fig. 1 illustrates such a job. The shaft being turned is a typical example of lathe work having different diameters and shoulders. The front tool on the compound rest does the turning. As soon as one of the shoulder positions is reached the rear tool on the plain rest is moved forward to square the shoulder and to neck, at that point, a little below the diameter which has just been turned, to give clearance for the wheel on the last operation of grinding. The compound and plain rests are connected, so that one movement of the cross-feed screw withdraws the front tool and advances the rear tool for performing the squaring operation.

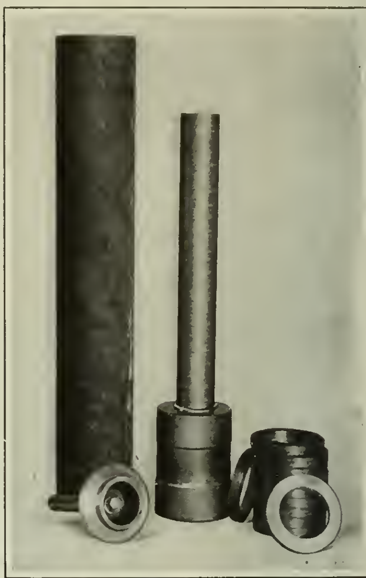


Fig. 3. Special Nuts and Stock from which they are turned

This method is applicable where not more than one turning tool and one squaring tool are required. It saves all the time which, under the former methods, was lost in stopping the lathe to change the tools or work. This equipment is made still more efficient by the addition of multiple stops for length-feed and cross-feed, which locate the carriage and cross-slide positions for both lengths and diameters. As a result, it is not necessary to stop to make any measurements after the stops have been properly set for the first piece of a lot. To obtain a comparison, ten driving shafts, like that shown in

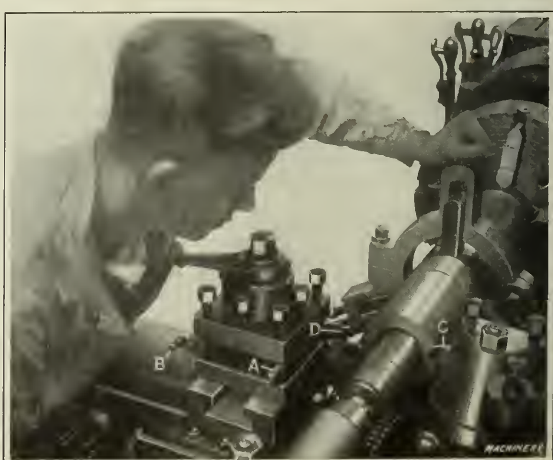


Fig. 4. Facing End of Bar after boring out Nut

[1] Address: Lodge & Shipley Machine Tool Co., Cincinnati, Ohio.

Fig. 1, were turned with this equipment in one hour, fifty-six minutes. Then the same operator turned ten shafts in the same lathe, but without the connected rear rest or the multiple stops; the time required was four hours, three minutes. The turning tool has a straight-line cutting edge, which is

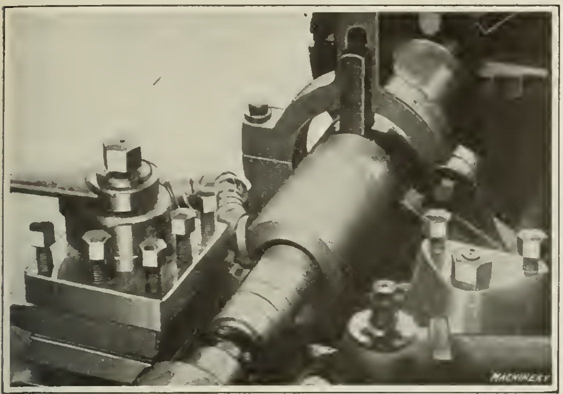


Fig. 5. Boring out Nut

set at right angles to the axis of the work, and a round nose of comparatively small radius of curvature. This leaves a minimum amount of stock to be removed by the squaring and necking tool.

4. By using a four-way (turret) tool-block for turning, rounding, and threading tools in the compound rest; and a single tool-holder for the necking tool in the connected rear plain rest. This equipment is used where one turning tool and one necking tool are not enough for the different operations required on a piece. Fig. 2 is a tooling diagram, in plan view, of a typical lay-out of this sort. If the work is complicated and requires more than five tools, four-way tool-blocks may be used on both the front and the rear rests.

The four-way tool-block made by the Lodge & Shipley Machine Tool Co. fits into the regular T-slot of the compound rest or rear connected plain rest in place of the single high-duty or round toolpost. From one to four tools can be rigidly held in the four-way tool-block, and it can be quickly indexed to

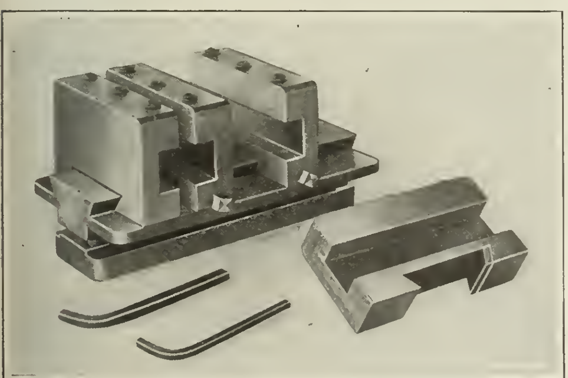


Fig. 6. Gang Tool-block with Adjustable Holders

bring any one of the tools into the working position. Its advantages over the older turret toolpost are that it may be quickly put on or taken off without disturbing the regular compound rest, and also that the angular feed of the compound rest is available for use with any one of the tools. The job illustrated in Figs. 18, 19, and 20 could not be handled in this way with a plain turret toolpost. The four-way tool-block, connected compound and plain rests, multiple stops, pan, pump and tubing form the "manufacturing equipment," and added to the engine lathe make it an efficient machine for rapidly and accurately turning duplicate parts. All the necessary tools are carried on the lathe ready for use in quick succession, and the diameters and shoulders are determined without stopping the lathe.

Manufacturing a Thin Nut

An interesting example of lathe work, which also illustrates the application of the manufacturing lathe just described, is turning washers, collars and thin nuts from bar stock. Fig. 3 shows various stages of the lathe work; the rough stock is shown at the left, the stock after a number of nuts have been turned from it in the center, some of the nuts, which are threaded on the outside, at the right. Instead of cutting the center of the original stock into chips, a core is left nearly as large in external diameter as the hole through the nut. This is not only a saving in material, but also in time, because much less weight of material must be cut up into chips. The tool equipment can be clearly seen by reference to Fig. 4. The sequence of operations is as follows:

1. Grip one end of rough bar stock in four-jaw chuck, and support other end by tailstock center.

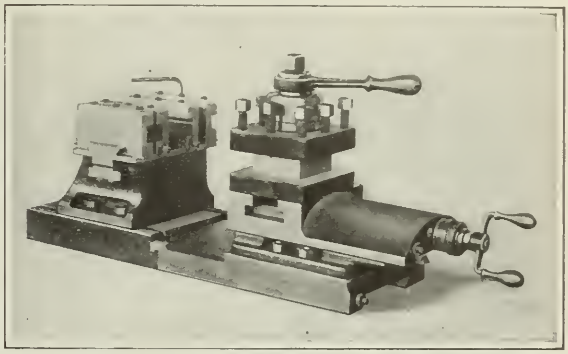


Fig. 7. Connected Compound and Plain Rests with Four-way and Gang Tool-blocks

2. Use turning tool in four-way tool-block on compound rest. Set to proper diameter by cross-feed stop. Turn outside diameter up to chuck jaws. The turning tool is not shown in Fig. 4, as it is on the far side of the four-way tool-block.

3. Adjust steadyrest. Index to next diameter stop, which has been set for full depth of thread. Index four-way tool-block to bring chasing tool *A* into position. Chase thread on outside diameter for a length of about twelve inches, making final cut to proper depth as determined by diameter stop.

4. Start at tailstock end of work, index to next diameter stop, and revolve four-way tool-block so as to use the hooked boring tool *B*. Set to diameter stop and bore to depth a little greater than thickness of one nut, up to length-feed stop. This is the operation illustrated in Fig. 5.

5. Face end, as in Fig. 4, using facing tool *C* in rear connected plain rest. The correct carriage position is determined by length-feed stop.

6. With cutting-off tool *D* in four-way tool-block feed straight in for a depth of about $\frac{1}{8}$ inch. Length-feed stop locates carriage to give correct thickness of nut.

7. Turn back to chasing tool *A* and use it to bevel sides of cut that has just been started.

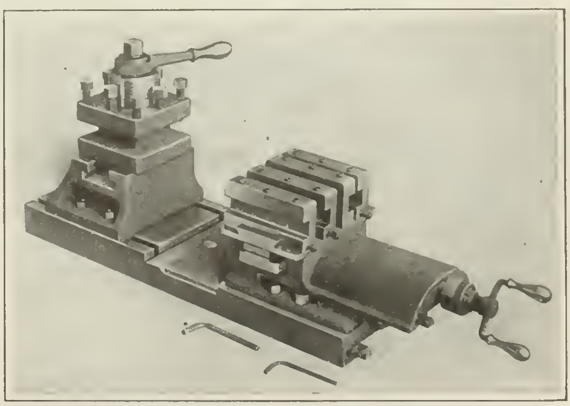


Fig. 8. Same Equipment as in Fig. 7, but with Tool-blocks interchanged

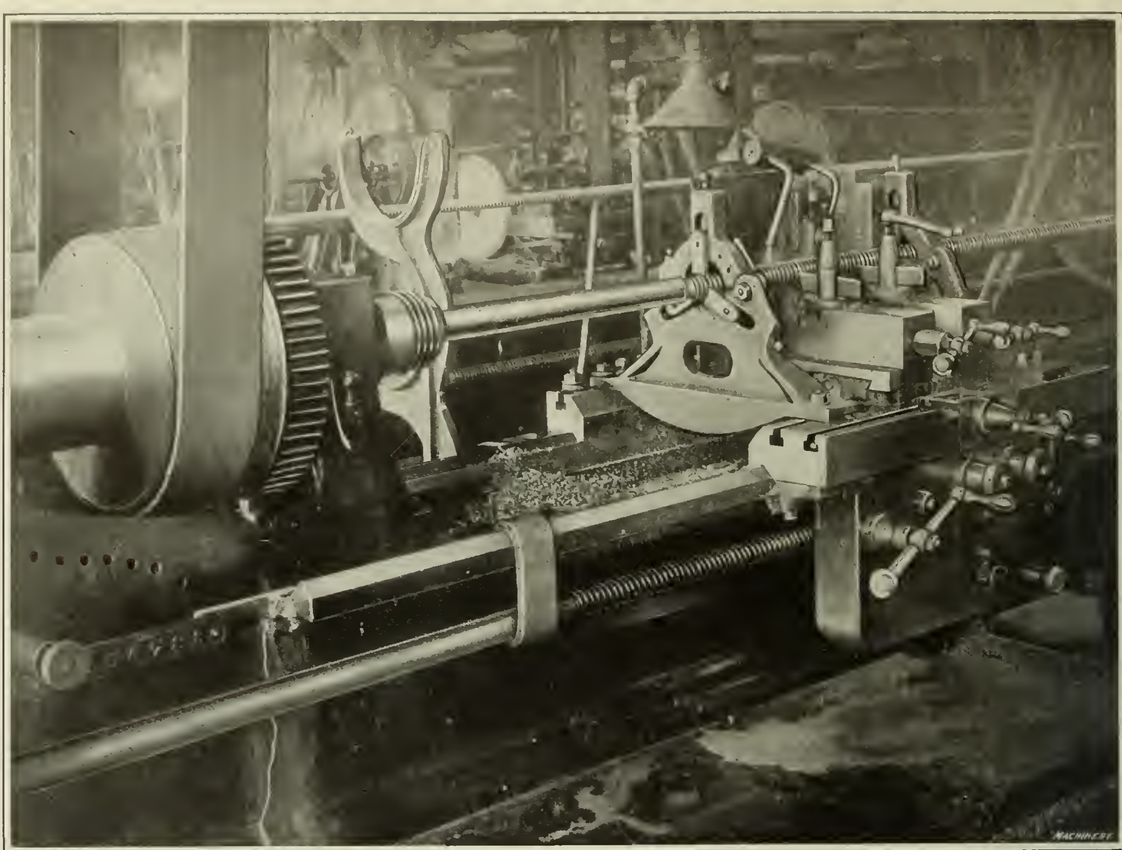


Fig. 9. Chasing Precision Screw in a Lathe with Two Tools

8. Re-index four-way tool-block to cutting-off tool *D* and finish cutting off nut.

For the next nut, start with the fourth operation, and repeat the fifth, sixth, seventh and eighth.

Gang Tools

Frequently, work is of such a nature that multiple tool equipment can be used with several tools cutting simultaneously. The individual tools are held either in adjustable holders or in a fixed block. Among the different ways in which gang tools are used, the following may be mentioned:

1. Dividing a heavy roughing cut between front and rear tools, when turning a rough forging.

2. Roughing with one or two front tools and finishing with a rear tool at one pass of the carriage, as in shaft turning.

3. Turning different diameters simultaneously by several tools arranged in a gang and set at proper distances from each other and from the center of the lathe.

4. Turning the same diameter with two or more tools cutting at different places on the work, so as to reduce the length of carriage travel. For example, if the piece to be turned measures six inches between shoulders, it can be produced with a carriage travel of three inches if two tools are used in a gang, one starting at the center and the other at the end.

5. A combination of the last two methods.

6. Forming, by feeding tools straight in with cross-feed.

The time required for setting up a gang of tools is longer than for single tools. If the piece is slender, gang tools must be ground more frequently than single tools and a somewhat finer feed used to avoid springing the work. For these reasons, it is by no means advisable to use the gang method wherever it will show merely a lower cutting time per piece than the single tool. However, gang tooling is extensively used, and with much success, by a few of the large manufacturers of duplicate parts, and can be profitably extended to quite a variety of work in other shops.

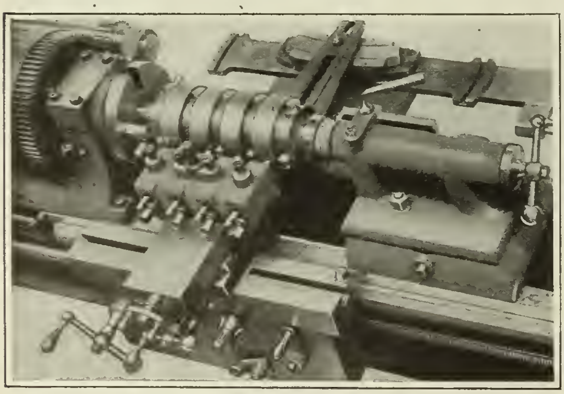


Fig. 10. Turning and crowning Pulleys

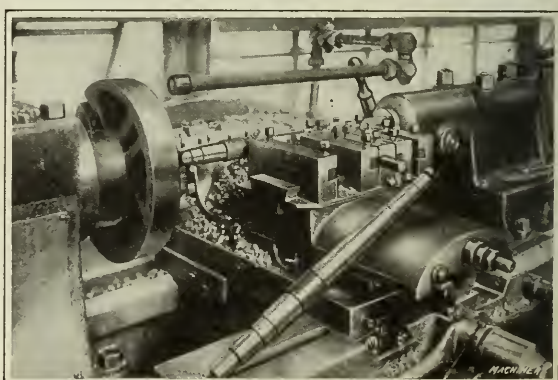


Fig. 11. Turning Armature Shaft with Gang Tools

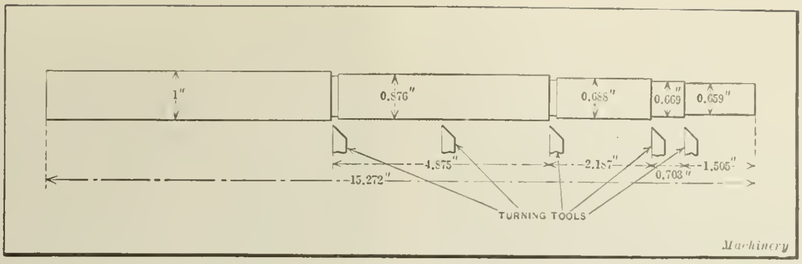


Fig. 12. First Lathe Operations on Armature Shaft

A recently developed gang tool-block is shown in detail in Fig. 6. This has separate holders for four (or more) tools, and these holders are adjustable along the dovetailed upper surface of the base block. The latter fits into the T-slot of either the compound or the plain rest of the lathe. The tool-holders are reversible, as shown by the illustration, so that they may be placed either face to face, back to back, or back to face, to correspond to any reasonable distance between shoulders on the work at hand. Fig. 7 shows one of these gang tool-blocks mounted on the rear connected plain rest of a lathe, and the four-way tool-block on the compound rest. The positions of the gang and the four-way tool-blocks may be transposed, as in Fig. 8. In some cases, for example the armature

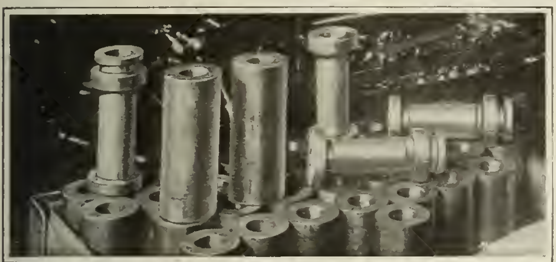


Fig. 13. Double Bevel Pinions after First Lathe Operations have been performed

shaft shown in Fig. 11, gang tool-blocks with adjustable holders are used in both connected compound and plain rests.

The uses of gang tools just outlined can best be illustrated by specific examples. The first two cases, dividing a roughing cut between front and rear tools and roughing and finishing at one pass of the carriage, require independent adjustments for both tools, which is shown in a general way in connection with chasing precision screws, and therefore will not be described separately. Following that are examples showing the adaptability of gang tools held in fixed positions relative to each other for a variety of lathe work, and indicating the great saving which gang tools and the manufacturing lathe effect in turning duplicate parts.

Chasing Precision Screws

Fig. 9 shows a specially arranged carriage with two chasing tools for taking two cuts from a long lead-screw at each pass of the carriage. Each tool is carried in its own holder on a separate cross-slide and each slide has independent in and out adjustment by a cross-feed screw with a micrometer collar. Two special follow-rests are bolted across the front and rear wings of the carriage, one preceding the cutting tools and the other closely following them; a third rest between the two cutting tools supports the work from the rear.

Before starting a chasing cut, both tools are clear of the work. The first tool is fed in to the requisite depth, as read from the micrometer collar, and the power length-feed of the carriage is engaged. When the second tool is nearly up to the starting point of the cut, it is fed in to a little greater depth than the first tool, so that it will take a second chip. A number of cuts must be taken to complete a precision screw, because each cut is necessarily light to prevent distorting or tearing the work. By taking two cuts at each pass of the carriage, much time is saved.

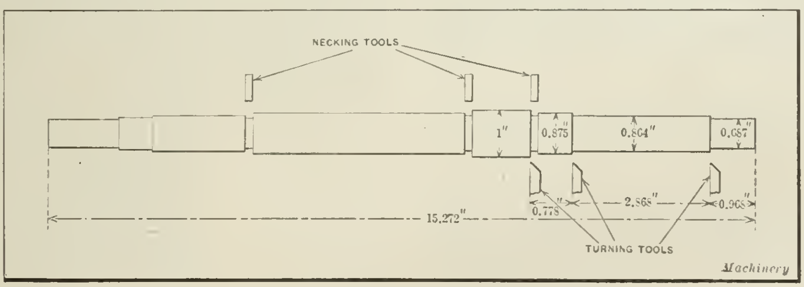


Fig. 14. Second Lathe Operations on Armature Shaft

Turning and Crowning Pulleys

Fig. 10 shows four small pulleys mounted on an arbor and located by spacing collars at definite distances apart, also four tools fixed in a special block on the compound rest. The four cutting tools are placed the same distances apart as the pulleys, so that each tool starts to cut at the edge of one pulley and all feed simultaneously across the faces. A special crowning attachment is fastened to the back of the carriage. This consists of a sliding shoe working in a groove made in the form of an arc of a circle. As the carriage is moved forward by the power length-feed, the cross-slide is automatically moved gradually out and in. This causes the cutting tool to

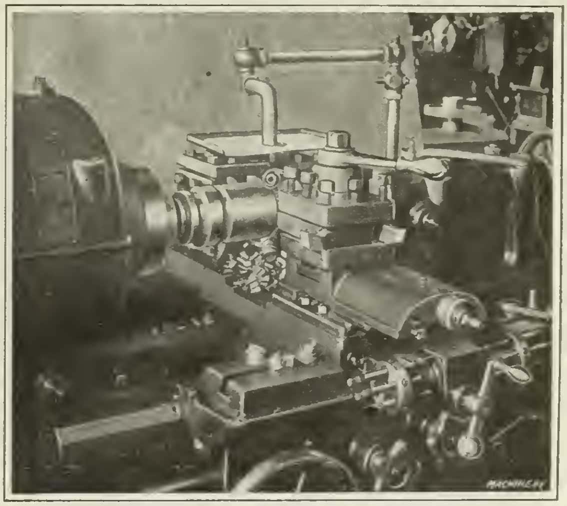


Fig. 15. Turning Double Bevel Pinions in Selective-head Lathe

travel in a circular path and produces the desired crown of the pulley.

In this illustration, the four pulleys are all of the same diameter; therefore, the four cutting tools are all set the same distance from the center. A similar rig is used for turning and crowning cone pulleys. Then the tools are set at different distances from the center, so that the three, four, or five steps of a cone pulley will all be turned simultaneously.

Turning a Small Armature Shaft

The use of the manufacturing lathe with gang tool-blocks and adjustable tool-holders in both the compound and connected

plain rests is admirably illustrated in the case of the small armature shaft, machined as shown in Fig. 11. The shaft is 15.272 inches long over all, and 0.876 inch at the largest turned diameter; the material is 1-inch bar stock of 0.30 carbon "Corona" machinery steel; the speed of the work is 160 feet per minute; and the feed is 0.015 inch per revolution. An allowance of 0.010 to 0.012 inch is left for grinding. The shafts are cut to length, faced, and uniformly centered before being delivered to the lathe. While turning, the work is flooded with a heavy stream of cutting compound. This reduces heating of the work and tools, acts as a lubricant, and permits the use of a much higher cutting speed.

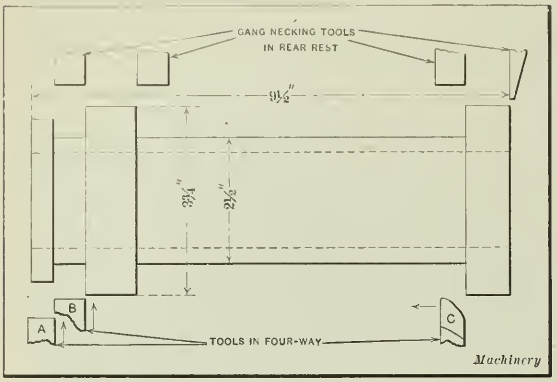


Fig. 16. Tool Diagram for First Lathe Operations on Double Bevel Pinion

For this and for similar pieces turned between centers, two dogs are provided. The operator removes the dog from a finished piece and adjusts it to the next piece to be turned while a piece is being cut. This saves the time that would otherwise be spent in "dogging." Shafts are frequently held in a chuck at the head end, instead of with a dog; the chuck can be set quickly, and it reduces the unsupported length of the work.

The first lathe operation on the armature shaft shown is to turn the diameters on the long end of 0.659 inch, 0.669 inch, 0.688 inch, and 0.876 inch, using a gang tool-block on the compound rest at the front. The arrangement of tools is shown in the diagram Fig. 12. The cut on the large diameter is divided between two tools, so that this length of 4.875 inches is turned with a carriage travel of not more than 2½ inches.

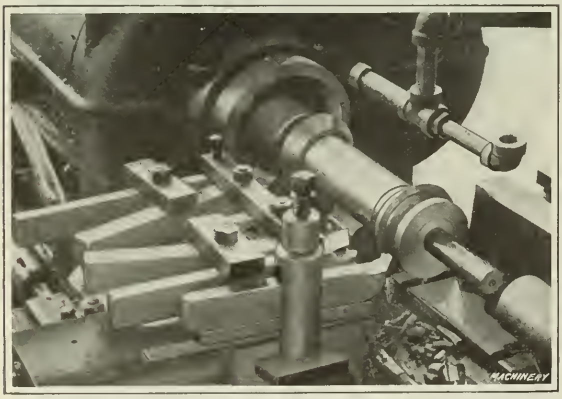


Fig. 17. Tooling for Second Lathe Operations on Double Bevel Pinion

The output on the first operation is 400 pieces in ten hours, or an average time, including handling, of 1½ minute each.

The second operation is to turn the short end diameters of 0.687 inch, 0.864 inch, and 0.875 inch with the gang turning tools carried on the compound rest at the front and also to neck, for grinding with gang tools, on the connected rear plain rest. The output for the second operation is 300 pieces in ten hours, or an average of two minutes each, including handling. Fig. 14 is a diagram of the tool lay-out in the con-

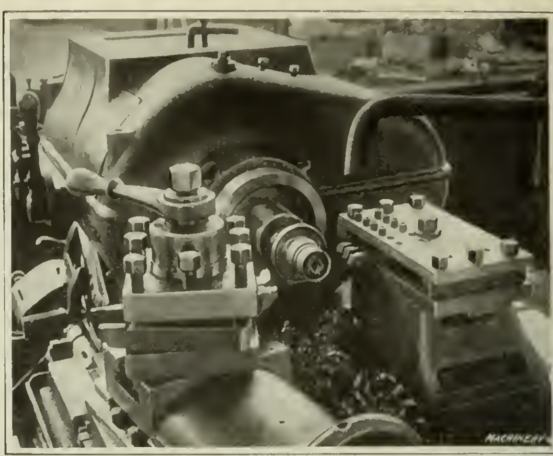


Fig. 18. Manufacturing Lathe Set-up for turning Roller-bearing Cone

nected compound and plain rests for the second operation. Many other shafts and studs that are turned with gang tools in this way are faced in the lathe and are necked at every shoulder. In such cases, it is necessary to use a gang of necking tools for each end instead of on the second operation only. A facing tool is carried in each gang of necking tools so that the ends are faced without making an additional operation.

Turning Double Bevel Pinion

The stock for double bevel pinions as it is delivered to the lathe bored ready for mounting on the arbor, and several of

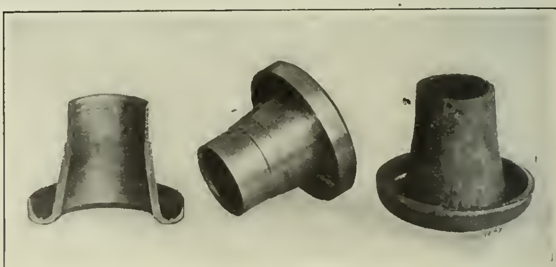


Fig. 19. Cones for Roller Bearings

the pinions after the completion of the first lathe operations, are shown in Fig. 13. A fully equipped selective-head manufacturing lathe is used, having a four-way tool-block on the compound rest and a gang tool-block on the connected rear rest. This piece is handled in two settings.

Details of the tooling for the first setting are given in Fig. 15. The gang tools are fed straight into the work, necking at three places and facing one end. This is shown more plainly by the tool diagram, Fig. 16. The proper depth has been predetermined by the diameter stop. Other cuts at the same setting of the work are taken with tools in the four-way block. The broad turning tool *A*, which turns the reduced diameter

Fig. 20. Last Operation on Roller-bearing Cone

next to the headstock, is fed straight in; then the four-way tool-block is indexed and the next groove is finished with tool *B*. The tool-block is again indexed and the long diameter between the shoulders is turned with tool *C*. The carriage and the cross-slide positions for all of these cuts with both front and rear tools are located by the multiple stops for length and cross feeds, which have previously been set in the proper positions. Six pounds of chips per minute are turned off in this operation.

In the second setting, the work is reversed on the arbor and a group of five gang tools is used in the compound rest only. Feeding straight in with the cross-slide, these tools face the unfinished end of the job, form the bevel surfaces on which the gear teeth are subsequently to be cut, and form the back of the bevel. The set-up for this operation is shown in Fig. 17. The arbor on which the blank is mounted has a journal bearing inside of a bronze bushing in the tail-stock spindle, instead of being merely supported by the tailstock center. This gives a solid support to the end of the arbor against the heavy cuts that are taken with both sets of tools.

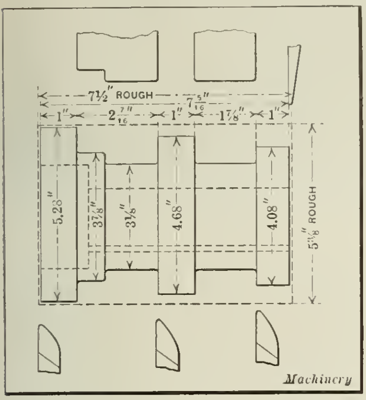


Fig. 21. Tool Diagram for turning and forming Cluster Gear

Handling a Job on an Expanding Arbor

The previous examples have been of work turned between centers. In many cases where the piece is held in a chuck or on a stub arbor, gang tools are just as applicable. Fig. 18 shows a set-up on an 18-inch selective-head manufacturing lathe with a four-way tool-block on the compound rest and a special gang block on the connected rear rest, for turning a cone for a roller bearing. Fig. 19 shows rough and finished cones and a cross-section through a finished cone, which is made from a steel stamping. A novel point in this tooling is the use of the angular travel of the compound rest to turn the conical surface, making the set-up in such a way that the end of the travel of the compound-rest top slide forms a positive stop to locate the large diameter end of the conical surface. The average time for each cone, including handling, is 2¼ minutes each. The sequence of lathe operations is as follows:

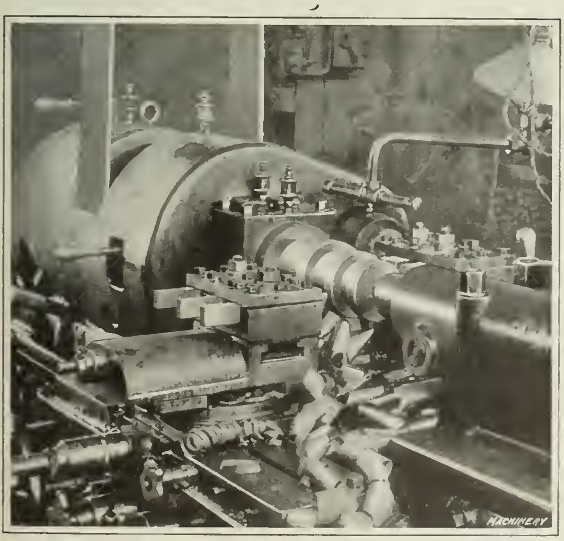


Fig. 22. Turning and forming Cluster Gear

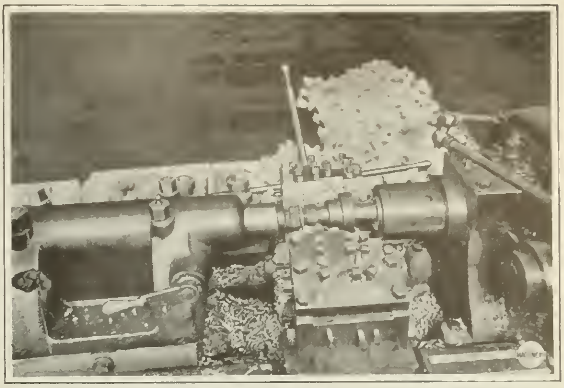


Fig. 23. Forming Three-step Counter Gear with Gang Tools

1. Chuck cone on expanding stub arbor which locates it endways in a fixed position.
2. Feed cross-slide up to first diameter stop; also have compound rest set to correct angle for turning conical part or taper and note reading of graduated dial on compound-rest screw. Do not move compound-rest screw during this operation. Engage power longitudinal feed of carriage to turn large and small outside diameters simultaneously with two tools held in four-way tool-block. The length stop is set to trip the feed automatically at the proper point.
3. Hold carriage in last position against length stop. Set cross-slide to second diameter stop. Turn taper with rear tool of previous operation, using hand angular feed of compound rest and feeding against stop at end of travel of compound-rest top slide.

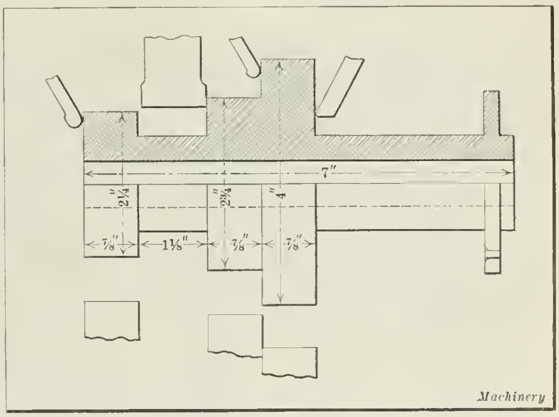


Fig. 24. Diagram of Tooling for Three-step Counter Gear

4. Move cross-slide out, feed compound-rest top slide to its original position, as shown by reading of graduated dial, and face inside of rim. Feed up to next length stop.
5. Locate carriage by length stop and feed cross-slide forward by hand, bringing into action gang of three tools in rear block. These simultaneously neck at both ends of taper portion and face small end of cone.
6. Revolve four-way tool-block to bring other pair of tools into position and set to proper diameter by next cross-feed stop. While one tool is forming inside of cup, the other tool is chamfering small end of piece. Fig. 20 illustrates this operation.

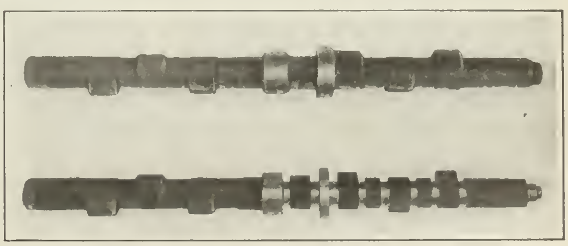


Fig. 25. Cam-shaft before and after First Lathe Operations on One End

Fig. 26. Turning Cam-shaft

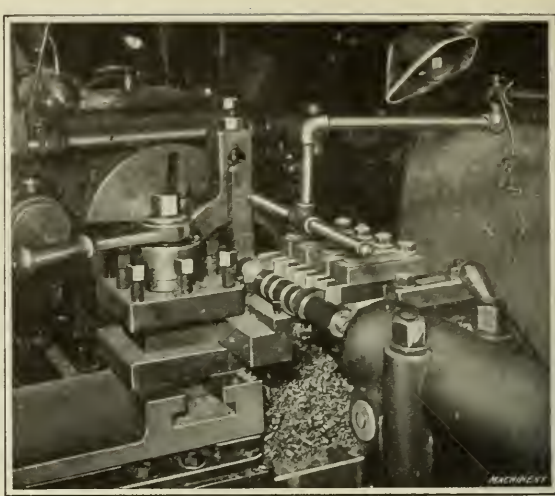


Fig. 27. Details of Tooling for Cam-shaft

Turning a Cluster Gear

The cluster gear illustrated in Fig. 21 is made from a 5⅜-inch chrome nickel-steel bar of 0.25 carbon. As the heavy forming cuts taken on this piece require a stiff, powerful lathe, the job is done in a 24-inch manufacturing lathe, fitted with gang tools in both the compound and connected rear plain rests. Fig. 22 shows the set-up in the lathe. Before delivery to the lathe, the blank is bored, counterbored, faced on the large end, and keyseated. It is mounted on a special arbor with the faced end toward the headstock. This arbor has a shoulder to correspond to the counterbored part of the gear blank; and when the blank is slipped onto the arbor, it is forced up against this shoulder. A key in the arbor engages the keyseat in the blank to give a positive drive. The free end of the arbor is journaled inside a bronze bushing in the tail-stock spindle.

When rough-turning, feed in the cross-slide to the first diameter stop and engage the power length-feed. The three turning tools in the gang on the compound rest rough-turn the outside diameters of the three gears to within 1/32 inch of size. Each tool continues cutting until it has fed across the face of each gear; then the automatic stop trips the length-

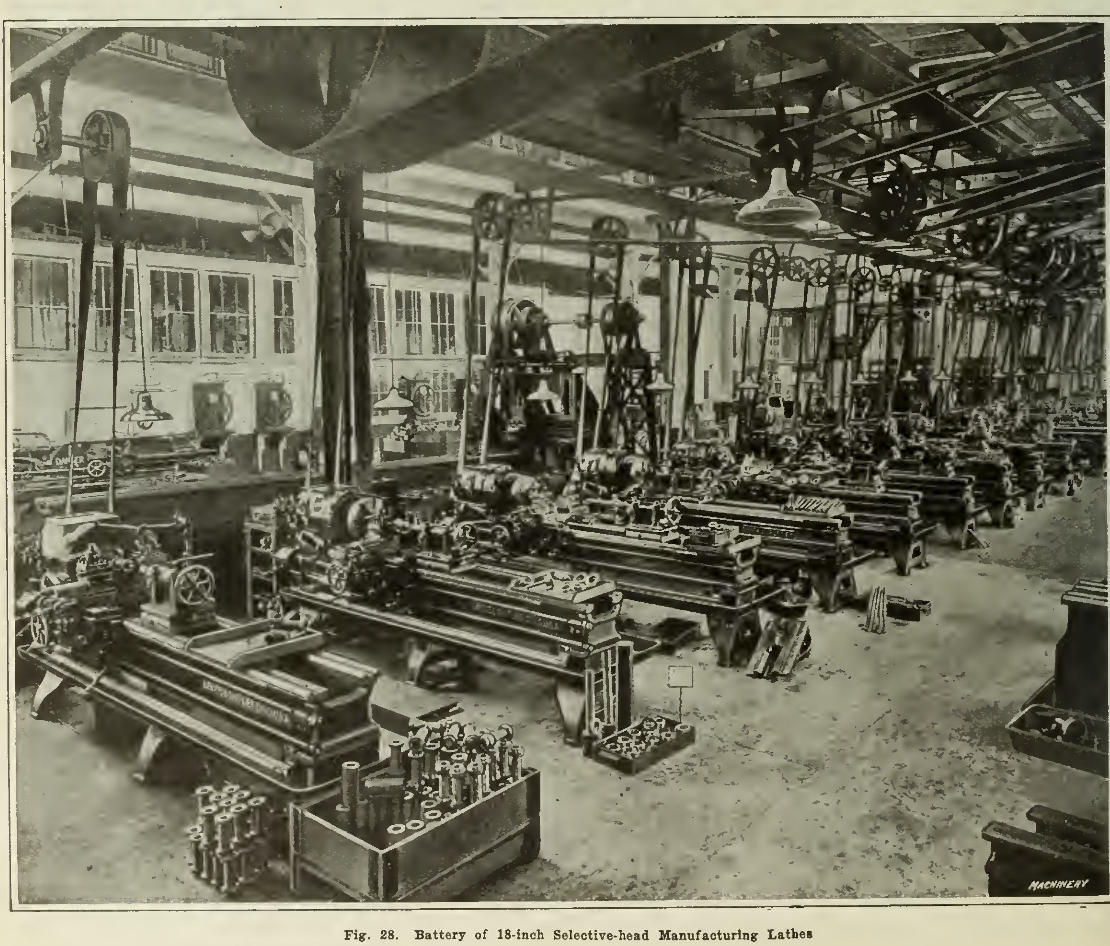


Fig. 28. Battery of 18-inch Selective-head Manufacturing Lathes

feed. In the forming operation, hold the carriage in the position just located by the length-feed stop. With gang forming tools and facing tool in the rear tool-block, rough- and finish-form the recessed diameters between the gears and the faces of the gears themselves, and face the end toward the tailstock, feeding straight into the work with the cross-feed screw up to the diameter stop. When finish-turning, return the carriage to its first position, set to the proper diameter as determined by the next cross-feed stop, and finish-turn the outside diameters with the three tools on the compound rest. This stock, when delivered to the lathe, weighed 38 pounds; after completing the lathe work, the cluster gear blank weighed 18¼ pounds. The total turning time was twelve minutes.

Forming a Counter Gear

The three-step counter gear shown in Fig. 23 is a job similar to the preceding, but it is made from a 3½ per cent nickel-steel drop-forging, instead of from bar stock, and it is machined by forming cuts with gang tools in both front and rear holders, instead of using one gang for turning and one for forming. Because the cross-feed only is used, a large pilot wheel has been substituted for the usual ball-crank on the cross-feed screw. The arrangement of tools, with three straight forming tools in the rear holder and one forming tool and three facing tools in the front holder, is shown in the diagram Fig. 24. These gear blanks are machined all over at one setting. The first operation is to form with the rear tools and the second to form and face with the front tools. The output from this 18-inch lathe is 125 finished gear blanks in ten hours.

Machining a Cam-shaft

Fig. 26 is a general view of an 18-inch selective-head lathe turning a six-cylinder automobile cam-shaft. Fig. 27 shows details of the tool equipment, with gang tools in the four-way tool-block on the compound rest and another gang of tools on the connected rear rest. The cam-shaft before and after this operation is shown in Fig. 25. This is another case where the cross-feed only is used. Each gang of tools is, in turn, fed straight into the work.

Before the cam-shaft is delivered to the lathe, the outside diameters of the pump gear and the center bearing have been turned, so the steadyrest may be used on the center bearing. After placing the shaft between centers and adjusting the steadyrest as shown, the gang of nine tools in the front holder is gradually fed into the work up to the proper depth, as determined by the diameter stop. These tools rough-face one end of the cam-shaft and rough out the spaces between the cams, bearings, and gears. Next, the nine finishing tools in the rear rest are brought forward to finish the places which have just been machined by the front tools. The rear tools are slightly wider than the front and finish the faces up to the diameter stop.

This operation is on one end of the cam-shaft. The other end is handled similarly. The stock left between the cams is turned off and the bearings are finished in subsequent lathe operations. The material is 5 per cent nickel and 0.18 carbon steel drop-forging; the speed of work is 220 revolutions per minute. The time for roughing and finishing one end as shown, including handling, is four minutes.

A Lathe Department for Duplicate Part Work

Fig. 28 shows a row of selective-head manufacturing lathes, such as are used for rapidly and accurately turning duplicate parts as shown by the preceding examples. The lathe in the foreground is turning the double bevel pinions illustrated in Figs. 13 and 15; the next lathe is used for the threaded nut described in connection with Figs. 4 and 5. Groups of these finished parts may be seen at the ends of the lathes. Each of these selective-head lathes has the full manufacturing equipment: connected compound and plain rests with four-way tool-block or gang tool-block on the compound rest and high-duty tool-block or gang tool-block on the plain rest; multiple stops for length and cross feeds to duplicate shoulders and diameters; pan, pump and tubing, so that the work may be flooded with cutting compound.

Noteworthy features of this installation are that the lathes are placed at right angles to the lineshaft and driven, without a countershaft, in groups of four by constant-speed quarter-turn belts from a jack-shaft. This style of drive is possible with the selective head, because there are twelve mechanical spindle-speed changes obtainable through the headstock gearing and the belt is never shifted. This gives a nearly clear ceiling, which keeps down the investment in countershafts and belting and improves the lighting. Having all of the lathes at right angles to the aisles makes it possible to get several more machines into the same floor space without crowding, and greatly facilitates moving material.

* * *

ALCOHOL AS FUEL

It is ten years since Congress passed the denatured alcohol act, permitting anybody to distil industrial alcohol free of government tax. It was then thought that this country would soon be flooded with alcohol in such quantities as to provide a new, cheap fuel, for it was officially stated that alcohol could be made from sugar cane, cornstalks, potatoes, barley, corn, wheat, rye, sugar beets, sweet potatoes, wood pulp, sawdust, apples, the waste of canneries, corncobs, many weeds and a thousand and one waste products of the farms and factories. And the government issued a bulletin—No. 268—describing the tubs, stills, etc., needed, and the best methods of producing alcohol.

The prospect was that every farmer would soon have his little still and turn his waste stuff into industrial alcohol, but the whole scheme was destroyed by the act itself, which required that every still must be registered and conducted under the direct supervision of an internal revenue officer; that no one would be allowed to make less than seven to ten gallons daily, and that no still could be shut down except by the revenue officer. The prospective alcohol industry instantly vanished. No farmer could keep an industrial alcohol plant running all the time, and he was not allowed to use his still occasionally or when he had a lot of refuse stuff to use up. And so alcohol has not yet come into general use as a fuel.

Now, however, a new field seems opening up. Henry Ford asserts that the world's supply of petroleum—and therefore of gasoline—is fast playing out and the day of alcohol fuel for automobiles and tractors is just dawning. He advises breweries, especially those in states that have recently gone dry, to utilize their properties in the making of industrial alcohol instead of the potable kind. But as yet there is not on the market any automobile equipped for the burning of alcohol. Doubtless it will come, for inventors are working hard to produce it, and they generally get what they are after. There are alcohol engines already in experimental operation, but they have not yet been so perfected as to be introduced into commercial use.

If the automobile of the near future can be run with alcohol, which is safer to handle than gasoline, cleaner and of less offensive odor, it will provide an inestimable boon in the way of a new fuel. The source of supply is inexhaustible, the process of distillation simple and cheap, and unless some gigantic corporation gets hold of and controls the industry, alcohol ought to be cheaper than kerosene and much preferable for fuel. It might, in time, be used in stationary engines, in locomotives, in steamships, and in many domestic ways; but, first of all, it would seem that invention must find some way of making it popularly and efficiently available for automobiles.—*Newark Evening News.*

* * *

A central clearing-house has been established by the British Minister of Munitions for the purpose of tracing and registering machinery that is idle or about to become idle. This clearing-house will try to see that contracts are placed with manufacturers having the available equipment; also that engineering contractors who have the facilities for particular purposes will be placed in touch with the Ministry and other government departments that will require their services. This clearing-house will also help contractors who are able to undertake additional or more suitable work, at once or in the future, to maintain continuous employment of their machines and labor.

EXPERIMENT IN IRON ORE SMELTING

In connection with the course of study in electro-metallurgy given at the University of Pittsburg, Pittsburg, Pa., under the direction of Prof. S. L. Goodale, a small furnace has been used for experiments in ore smelting, such as running down iron

Fig. 1. Conducting the Experiment

ore into pig iron and smelting copper ore to matte, etc. Fig. 1 shows the general appearance of the furnace.

Fig. 2 shows the furnace in sectional elevation. A Harbison-Walker 9-inch by 13-inch stove tile was used as the basis in building the furnace. This has a 9-inch diameter circular flue opening, inside of which is the graphite block or blocks for crucible and bottom electric connection. The crucible chamber is about 5 inches in diameter and 5 inches deep; and the lower graphite block rests on an iron plate which is used for one of the electrodes, the lower graphite block serving to keep the bottom connection cool. Layers of granular carbon resistor are set between the two graphite blocks, and a good connection is made between plate and graphite by powdered graphite. Surrounding the tile is a wall of porous insulating brick, 2 inches thick; and a slab of firebrick is used as a cover. The iron and slag are tapped through a small hole, but this feature gave trouble, and in future runs the furnace will be bound solidly together and mounted on trunnions so as to pour out the metal at the end of the run. A 2-inch top electrode of graphite was used. The furnace takes about 30 K. V. A. to work fast enough, and the regulation of the current under the transformer limitations is rather difficult. While these runs are made on a small scale, they serve

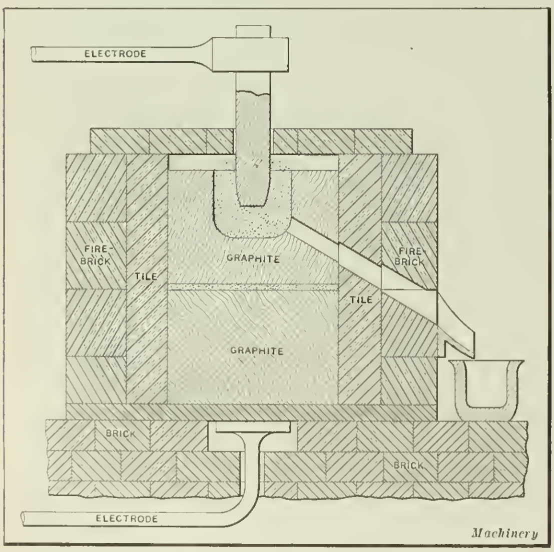


Fig. 2. Construction of Furnace

to give the students practice in manipulation, and illustrate the main principles of the operation as conducted on a commercial scale.

Fig. 3 shows the general lay-out of furnaces and control for the electric smelting work. Current is purchased from the Duquesne Light Co., from one phase of a two-phase supply, being stepped down in a transformer outside the building from 2200 volts. The leads come in through the circuit breaker to a regulating transformer especially designed for this installation. The regulation is such that current can be drawn at any voltage from 5 to 220, in steps of 5 volts each, by the manipulation of six double-throw switches mounted on the transformer. This is a highly satisfactory equipment for its capacity, which is limited to about 600 amperes at voltages of 110 or less, and to 50 K. V. A. at higher voltages, although having a generous overload capacity.

The larger furnace to the left in Fig. 3 is an upright shaft type with a top and a bottom electrode and a lining of chrome brick. The shaft is 26 inches deep and 11 inches diameter, and the 1/4-inch sheet-steel shell has an outside diameter of 30 inches. The loss of heat by radiation from this furnace

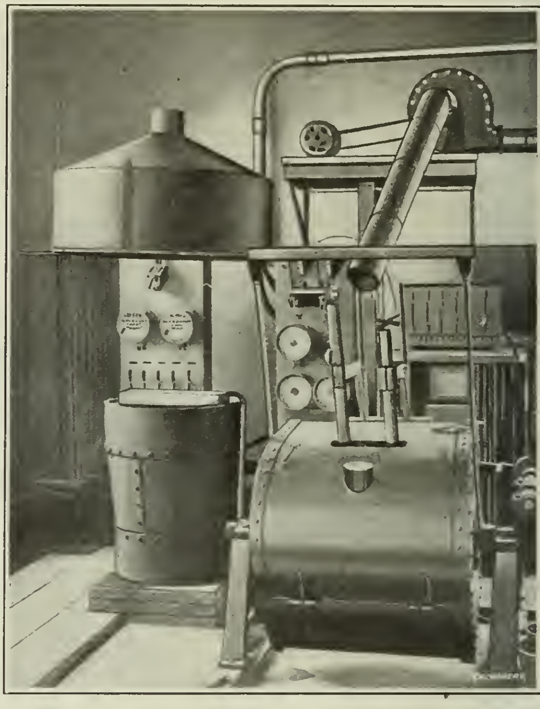


Fig. 3. Furnaces and Switchboard Equipment

is excessive; and it should have been built about 5 to 8 inches larger, with an insulating brick layer just inside the shell. The tilting furnace is strongly built of 1/4-inch steel plate, and is lined with magnesite down to a smelting chamber of about 9 by 18 inches. The over-all length is 37 inches; and the shell might also have been made somewhat larger to permit of a more thorough heat insulation.

The switchboard back of the tilting furnace, on which a large control switch is also to be mounted, holds ammeter, voltmeter and wattmeter, and an integrating wattmeter is to be added. On a shelf directly above this board is a powerful exhaust fan and motor for use when a run is in progress that produces noxious fumes. The intake to this fan is shown just over the tilting furnace, but may also be shifted to the large hood. The switchboard at the left was formerly used in connection with direct-current experiments, and is now used in connection with the water pipe rheostat in the corner, and the alternating current. On arc experiments on a small scale it is far more convenient to use a fairly high voltage with a rheostat in the circuit than to be more economical of power and try to use a low voltage. C. L. L.

LETTERS ON PRACTICAL SUBJECTS

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KEEPING TRACK OF PATTERNS

In the plant where the writer is employed, it is necessary to keep track not only of our own patterns but of many belonging to our customers as well. This is done by means of a card index. A separate card is filled out for each pattern, and these cards are grouped behind a guide card bearing the customer's name. The record is itemized and shows whether the pattern is of wood or metal. Core-boxes are entered in the same manner. The receiving clerk makes a record of the pattern number, also the customer's order number for the castings. The office is then notified of the arrival of the pattern and the date is noted on the card. When patterns are returned with the castings, a record of the fact is made on the card. In order that there may be no slip-up in returning patterns, they are added to the shipping order for the castings. For example, the shipping room's order will read: "Ship to John Smith 100 brass castings No. 208, 1 metal pattern No. 208, 1 metal core-box No. 208." While the shipping clerk will make a part shipment of castings if so instructed, he will hold the final shipment until the foundry delivers the patterns as called for on his order.

Some patterns are left at the plant indefinitely; so when a customer requests the return of his pattern, if there is no order on hand for castings, a regular shipping order is issued, as in the case of castings, and a notice is sent to the foundry to forward the pattern to the shipping room. This shipping date is then entered on the card in the same manner as when patterns are returned with castings. When a pattern cannot be otherwise identified, a rough pencil sketch is made on the card. By this method it is possible to keep a fairly accurate record of the comings and goings of miscellaneous patterns. This simple method has eliminated all trouble in accounting for patterns not owned by the plant, and at the same time it has kept the foundry from being littered up with patterns or castings for which it has no order.

Jersey City, N. J. H. D. MURPHY

FLEXIBLE BLANKING TOOLS

In punch and die work every new piece to be made requires its own blanking die, which is stored away as soon as the order is completed, and after being kept on file for a year or two lands in the scrap heap. This means a waste to the manufacturer; therefore it has been the aim of many engineers and tool designers to develop a more inexpensive and economical die design. The plan of making a die of small blocks that can be used later for other dies is shown in Figs. 1 and 2. In Fig. 1, the die consists of tool-steel blocks A set in a cast-iron die-shoe B. They are held in place by a templet D and by pouring molten lead into the die-shoe. Chunks of rubber C put into the die serve as a knock-out. The punch-blocks E, Fig. 2, are fastened in a cast-iron holder D in the same manner.

Fig. 3 illustrates the die-blocks, and Fig. 4 the punch-blocks, and it will be seen by reference to these illustrations that there is a difference in the shape of these blocks. This difference is

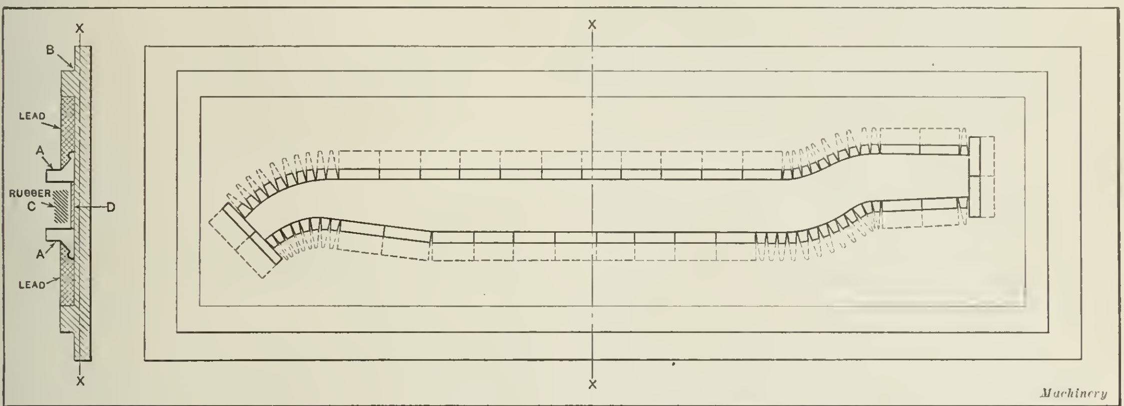


Fig. 1. Flexible Blanking Die

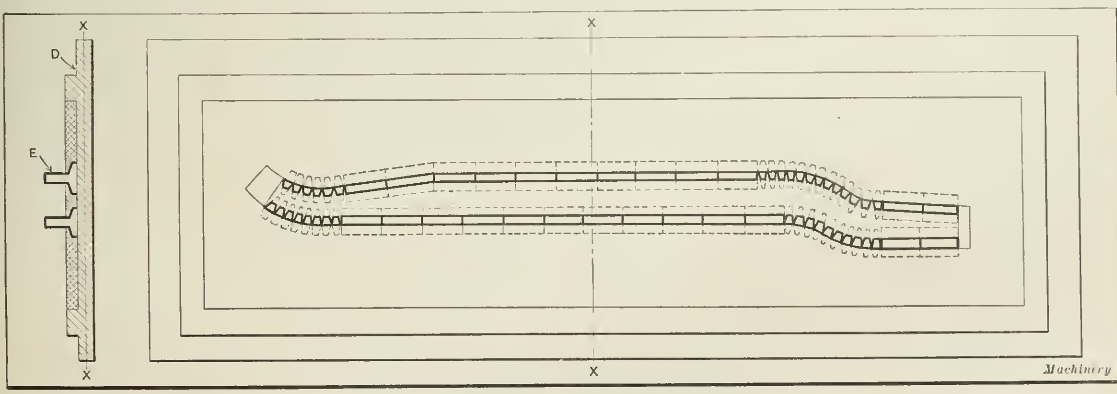


Fig. 2. Flexible Blanking Punch

necessitated by the different blanking stresses and the limited space for the punch-blocks. The blocks are shaped in a milling machine with a form milling cutter, cut to length, hardened and ground, and put in stock for future use. This style of blanking tool has been used for some time by the A. O. Smith Co. for blanking automobile side rails and cross-bars, also for gussets and many other pieces for which dead accuracy in the blank is not required.

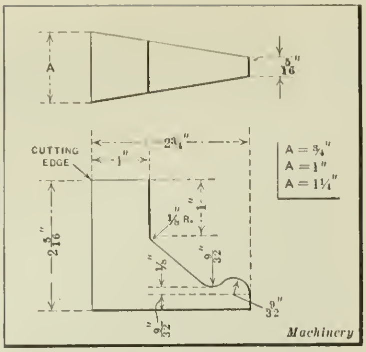


Fig. 3. Die-block used in Die shown in Fig. 1

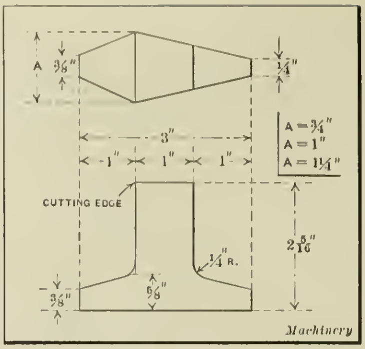


Fig. 4. Punch-block used in Punch shown in Fig. 2

Milwaukee, Wis. P. Baldus

RELATION OF PERIPHERAL SPEEDS TO SPINDLE PULLEYS IN GRINDING

Grinding-machine and grinding-wheel catalogues generally contain a convenient reference table of correct wheel-spindle speeds for peripheral rates of 4000, 5000, 6000 and 6500 feet per minute. These tables, however, are computed for full-size wheels and are not correct for wheels reduced by wear. To compensate for this wheel wear, many grinding machines, whether for cylindrical or wet-tool grinding, snagging, etc., are made with two steps on the pulley. Then a worn wheel may be speeded up to its initial peripheral speed by shifting the spindle belt onto the smaller spindle-pulley step. To insert an auxiliary table of spindle speeds in a general wheel catalogue would be out of the question, as the varied diameters of the smaller spindle pulleys on different makes of grinding machines are legion. To publish an additional table of spindle speeds, even though the machine itself might be specified, might lead to confusion. So it has been left to the operator to shift his belt from the larger spindle pulley to the smaller when he thinks the change should be made. As the cutting action of a wheel often depends to a great extent on its surface speed, the time for making this change should be determined by means of a definite formula rather than by guesswork.

For instance, a 6-inch Norton plain grinding machine with a spindle speed of 1773 revolutions per minute, for a recommended peripheral speed of 6500 feet (as figured for a full-size 14-inch wheel for this size of machine), has two steps on the spindle pulley; the large step is 5.5 inches in diameter and the small step 4 inches. What should be the minimum diameter of the wheel before the belt is shifted to the smaller step in order to obtain an exact peripheral wheel speed of 6500 feet?

As the spindle makes 1773 revolutions per minute when the belt is on the large pulley, its speed with the belt on the smaller is $5.5:4 = x:1773$, or

$$\frac{5.5 \times 1773}{4} = 2437.875$$

revolutions per minute. To obtain the same peripheral speed as when the belt is on the large pulley, the diameters of the grinding wheel should be $14:x = 2437.875:1773$, or

$$\frac{14 \times 1773}{2437.875} = 10.1818$$

inches. Therefore, when the grinding wheel has been worn down to a diameter of 10.1818 inches, or approximately 10 3/16 inches, the spindle belt should be shifted to the smaller step of the spindle pulley to obtain a peripheral speed of 6500 feet per minute. The method used in this example may be reduced to a formula for use with any make of grinding machine having a two-step spindle pulley.

Let D = diameter of wheel, full size;
D' = diameter of wheel, reduced size;
d = diameter of large pulley step;
d' = diameter of small pulley step;
V = revolutions per minute of spindle, using large pulley step;
v = revolutions per minute of spindle, using small pulley step.

Then

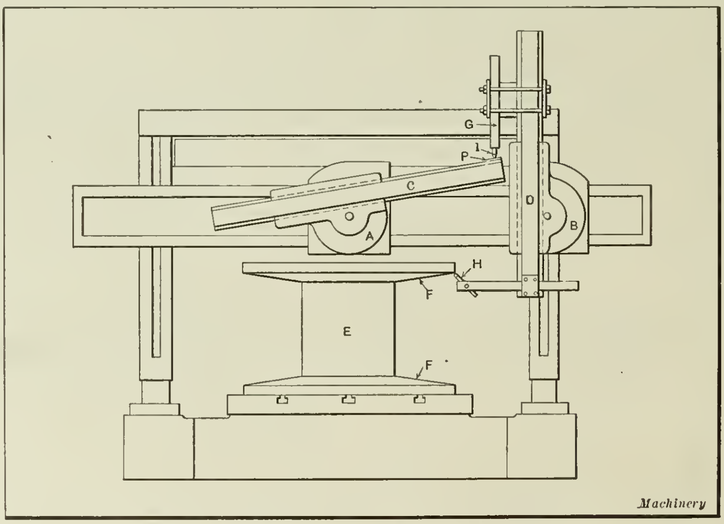
$$\frac{dV}{d'} = v; \text{ and } \frac{DV}{v} = D'$$

Worcester, Mass. Robert J. Spence

FACING ANGLES ON BORING MILL

The writer recently had occasion to machine a cast-steel drum 7 feet in diameter, 5 feet high, weighing 18,000 pounds. Its general shape is shown at *E* in the accompanying illustration. The drums were finished all over and the inside of the flanges *F* were faced at an angle with a rise of 1½ inch to the foot. As it was impracticable to attach the tool for facing these flanges to the boring rams *C* or *D* when inclined to the required angle, the ram *C* of the left-hand saddle *A* was used as a guide for ram *D*, and inclined to the angle it was desired to face. Bar *G* with a point *I* at its lower end, was clamped to the upper end of ram *D*, as shown. The counterweight chain, not shown, was disengaged from saddle *A* but remained connected to saddle *B*. The counterweight, however, was reduced somewhat to permit ram *D* to rest more securely on the end of ram *C* through bar *G*; the vertical feed of ram *D* was disengaged to permit of this. As tool *H* is fed across the flange by the traverse feed of the saddle *B*, the ram *D* feeds down by gravity, following the incline of ram *C*, which is fed in the same direction as the tool *H*. The plate *P*, being free to move on ram *C*, compensates for the slight difference between the traverse feed of saddle *B* and the vertical feed of ram *C*. It was necessary, of course, to reverse the drum in order to machine the flange on the other side.

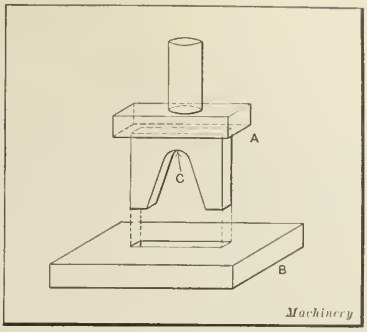
W. Wheatley
Butte, Mont.



Boring Mill arranged to face Flanges of Large Steel Drum

MAKING FERRULES FROM SHEET STEEL OR BRASS

In the manufacture of steel store fixtures, etc., it is necessary to use a number of ferrules for supports at rivets, which hold the two faces, or sides, of a panel together. To use steel tubing for this purpose is expensive because of the waste involved. The accompanying illustration shows a tool for making ferrules from sheet steel or brass, without waste, that is used with success by a concern in the Middle West.



Punch and Die for making Ferrules from Sheet Steel

The tool consists of a punch *A* and a die *B*. The steel is cut into strips that are as wide as the circumference of the ferrule. The slot in the die *B* must be as wide as the ferrule is long, that is, ½ inch wide for a ½-inch ferrule. The radius *C* must be the same as the radius of the ferrule. The metal is placed between the fingers of the punch *A*. Then as the punch travels through the die, it shears the metal from the outer edge; the final cut-off at *C* forms the perfect circle of metal. By the application of a stop on the die, no material is wasted.

Chicago, Ill. J. A. Zeller

CARE OF THE EYES IN MECHANICAL WORK

When one gets a bit of foreign matter "in the eye," as it is called—meaning, merely, between the eyeball and the eyelid—about the easiest thing to extract it with is a long graphite lead-pencil point. This is firm enough to keep the eyelid out of the way, and sufficiently smooth—it is, in fact, slippery—not to scratch either the eyeball or the inner surface of the lid. It should be newly sharpened with a clean knife so as to avoid infection.

New York City. Robert Grimshaw

REMOVING AND APPLYING TIGHT NUTS

In removing stubborn nuts, up to, say, 1¼ inch, it is usually the practice, after all wrench, chisel, and hammer methods have failed, to heat the piece in a forge and then remove the nut. If the job is not portable, a torch must be used. It frequently happens, however, that a job cannot be carried to a forge and a torch may not be available. If a good handful of cotton waste is twisted into a loose rope, saturated with oil, wrapped loosely around the refractory nut, and set afire, it will nearly always expand the nut sufficiently to break the rust joint, and permit the nut to be readily removed. The waste should be permitted to burn to a crisp, and any nut that still remains obstinate may as well be cut off. In places where fire must be handled with care, a piece of tubing may be placed over the burning waste. To allow for air, the diameter of this tube should be about six times the size of the nut to be removed, and it should be not less than three feet in length.

By the application of the expansion principle, nuts may be screwed onto bolts so tightly that they will not work loose. In this case, the bolt should be turned up and fitted to the nut, just so it will "promise" to start but will not enter the nut. It is then placed in position and the nut is heated and turned on. The allowance for a shrink fit, in this case, is small, so there will be time to place the nut before it sets. Even though the bolt is cold, and will cool the nut, the shrinkage allowance will permit the nut to be moved on the bolt when only moderately hot. This makes one of the most dependable lock-nuts. Of course it is very likely that a torch will be required to remove the nut; but if that is not available, a piece of waste saturated with oil may be used in its place.

Plainfield, N. J. J. B. Murphy

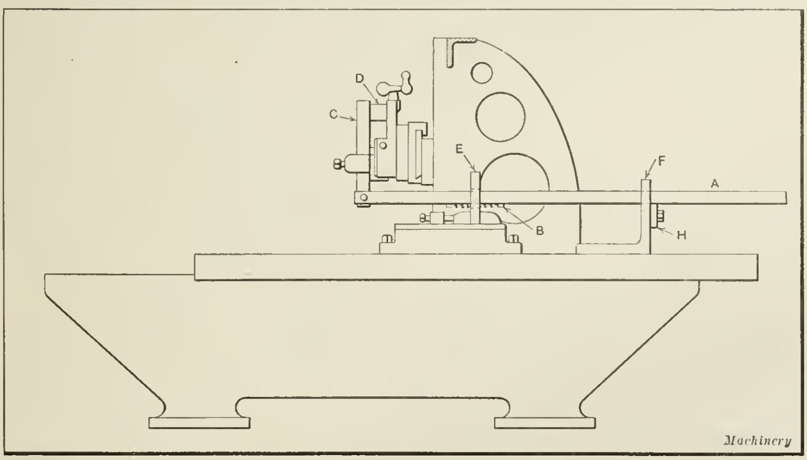
HOLDING STEEL PIECES TOGETHER WHEN SWEATING

If trouble is experienced in holding pieces of steel together when sweating, the pieces should be magnetized after they have been tinned. If they are then placed together in their proper relation, and have a fairly good flat surface, they will not separate unless given quite a jar. If the pieces do not stick after they have been magnetized, one of them should be reversed end for end. The failure to stick is due to the fact that like poles repel and unlike poles attract. In other words, when the steel pieces are magnetized, if they are of any form except circular, a magnetic pole is created at each end of each piece. As a south pole is formed at one end and a north pole at the opposite end, if the two magnetized pieces do not stick together, it is safe to assume that the two north poles of the pieces are together. By turning one of the pieces end for end, the unlike poles are brought together and each will attract the other.

Bridgeport, Conn. James McIntyre

KEYSEATING WITH A SMALL PLANER

The cutting of keyways in milling cutters and work of similar size can be done quickly on a small planer. A cold-rolled round bar *A*, with a slot and hole in the end for attaching it to the toolpost bar *C*, and a slot seven inches from the end in which to place the cutter is the main equipment. The cutter *B* is the width of the slot, four inches in length, and projects far enough out of the bar to give the necessary depth of cut. The action of the toolpost swivel is stopped by a block *D* behind the toolpost bar. A slotted angle-plate *F* at the other end provides for the alignment of the bar, and a cross-bar *H* on the angle permits adjustment for depth. The cutter *E* to be slotted is held in the vise. The pressure for cutting is exerted by hand and is relieved on the back stroke. The alignment of the cutter and the bar is provided for by a ring that slips on the bar and into the work while clamping it in the vise. Fast and accurate work can be obtained in this manner, equaling that done on an ordinary keyseating machine.



Arrangement for keyseating Milling Cutter on Planer

R. M. Blakely
Dayton, Ohio.

QUICK METHOD OF MAKING ELLIPTIC BROACH

Some time ago, a rush order for an elliptic broach, Fig. 1, came into the shop. It was to be made of "Ketos" steel, about 40 inches long, with 107 teeth, a land of 1/16 inch, and a slight taper. First a forging was made and four centers were laid out in each end for the planing operation. The work was then secured to the planer, being supported by a dead center at one end and an index center at the other. After being planed to

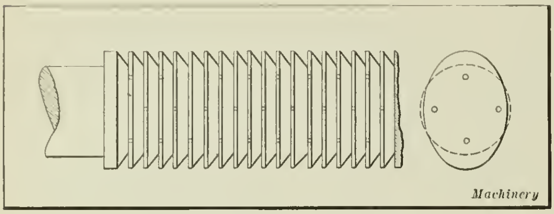


Fig. 1. Elliptic Broach cut on a Lathe

the elliptical form by successive centering and indexing, the piece was filed to gage and the teeth were cut in a milling machine, which was an exceedingly slow operation. The tool cracked while being hardened. As production work was being held up, another broach had to be made as quickly as possible. This one was planed and filed like the first one, but during these operations, a lathe was rigged up with an attachment, Fig. 2, to use in place of the milling machine for milling the teeth. The base of the attachment was a forging having two uprights, which were bored for two shafts, one being for the belt pulley *A* and the other for the cutter *C*. These shafts were 3/4 inch in diameter and cut from cold-rolled screw stock. Two gears 2 1/2 inches in diameter and 24 pitch were taken from a standard lathe, and a 4-inch pulley was used for the belt drive. For overhead power, a 10-inch pulley was put on the main lineshaft and a countershaft from a watch lathe was erected directly over the apron of the lathe, which was connected by belt drive to the pulley on the rigging. The power thus obtained was sufficient to drive the cutter. A roller *B* of the same diameter as the cutter was attached to the slide

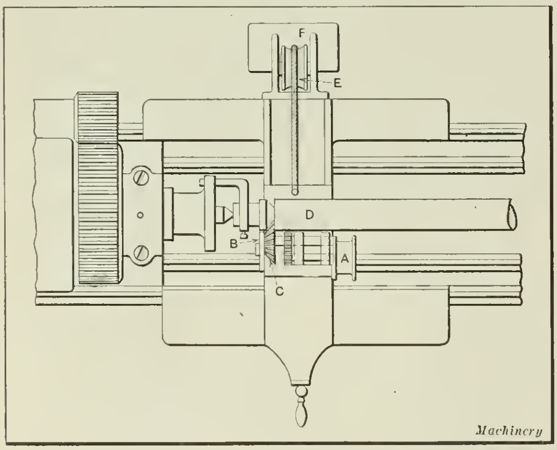


Fig. 2. Attachment for cutting Broach on Lathe

of the lathe and held against the broach. This arm was made adjustable, and allowance was made for the cutter to be fed into the work by the rest screw. This attachment was secured to the compound rest in place of the toolpost. The cross-feed screw was removed and a weight *F* was attached to the slide by means of a cord, which ran over pulley *E* fastened to the way of the lathe. This cord, kept taut by the weight, held the roller *B* and cutter *C* in contact with the revolving work. A bushing with three set-screws, which provided adjustment, was slipped over the broach; this allowed the work to be held by a steadyrest. Another steadyrest was placed on the round part of the broach. In this way chattering was reduced to a minimum.

Two stops were used to locate the carriage for the successive cuts. After one cut was taken, the stop nearest the headstock was taken off and clamped into position ahead of the other. The carriage was then run gently against the stops. By this method, uniform spacing of the teeth was obtained. Very little filing was required to finish the broach milled in the lathe, as compared with the one cut in the milling machine. The time taken for rigging up for the job was five hours, but by using the lathe for cutting the teeth, about forty-five hours was saved.

New Haven, Conn. ERIC LEE

PROBLEM IN ALGEBRA

The following method is offered for solving the simultaneous equations $x^2 + y = 7$ and $x + y^2 = 5$, given by J. G. K. in the November number of MACHINERY. The value of x and y can be easily found by the method of successive approximations, using a table of square roots as follows: Take the greatest value for x, in the second equation that will make the right member positive, for the first approximation, and solve for y. Substitute this root in the first equation and solve for x. Substitute this value in the second equation and solve for y, and so on until the values found are the same for x and y in both equations. These results can then be tabulated as in the accompanying table.

$y^2 = 5 - x$		$x^2 = 7 - y$	
x	y	y	x
2.0000	1.7320	1.7320	2.2952
2.2952	1.64462	1.6446	2.3142
2.3142	1.63884	1.6388	2.31542
2.3154	1.63847	1.6385	2.31549
2.3155	1.6384	1.6384	2.3155

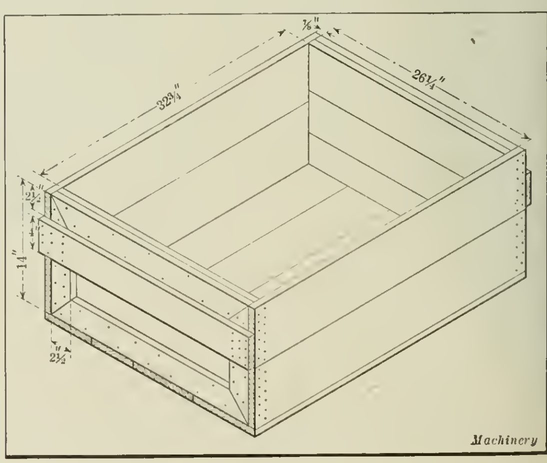
Machinery

The method of successive approximation is not only easier, but has the advantage that the work checks itself (except the last operation).

Cleveland, Ohio. WILLIAM W. JOHNSON

PRESS-ROOM BOXES

In the November number of MACHINERY is described a box truck for transporting work step by step. While this truck has many good features, the following may be of interest. The accompanying illustration shows a box used in a press-room where small sheet-metal and wire parts are made. This box is placed on a platform beside the operator and, when filled, one or more boxes may be placed above it and also filled. When



Box for transporting Work in Press-room

the job is completed or the stack of boxes becomes too high, a transfer truck is run under the platform and the entire load moved where desired. When well made of pine or basswood these boxes will last for a long time. The four-inch strip on each end is a convenient handle, especially when it is desired to move a box that is only partly filled with work.

Beaver Dam, Wis. S. W. Palmer

As far as possible, metal should be used instead of wood, so as to keep the fire risk low.—Editor.

HARDENING PLUG GAGES

The writer has recently had trouble with hardening plug gages. They seemed to stand the file test, but after lapping showed soft spots. The trouble evidently was in the steel, although several brands of carbon tool steel were tried, and all worked out the same. After they were heated to about 1500 degrees F. for two or three hours in a cast-iron box packed with charcoal, the gages were satisfactory. The charcoal, no doubt, had a slight carbonizing effect all over, but to a sufficient depth on the soft spots to render them hard enough for all practical purposes. The plugs were rough-turned to 0.015 inch over size before packing, and quenched from pack heat.

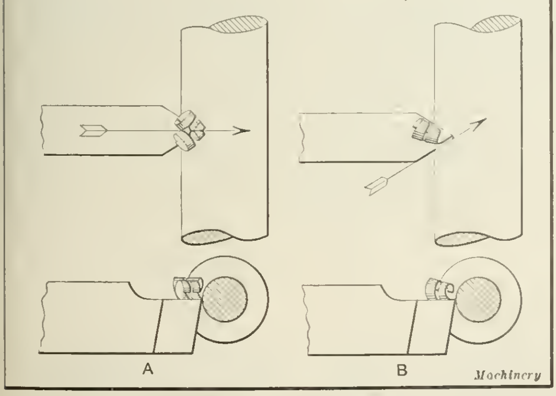
Urbana, Ohio. F. D. Rifner

CUTTING THREADS

In the last few years, modern shop management has awakened shop superintendents and foremen to their full responsibilities. The demand for capable men, the possibility of developing material on hand, and the era of time study investigation and analysis have been so fully advertised and exploited that it seems incredible that shops can be found where the direct antithesis exists. Yet in a recent visit to a factory a glaring illustration of this was found. In a shop where ordinary good practice prevails, men were cutting threads with a 90-degree advance to the center line, whereas an advance along a 60-degree line would do the work in one-fourth the time, avoid a ragged thread, and save both tool and temper.

The accompanying illustration is not a technically correct one, but it illustrates the effect of the chip on the tool to better advantage and may be readily comprehended by the average man and the apprentice. A straight-in advance, as shown at *A*, has a chip on each side and on the point, exerting a pressure in such a way that it will result in breaking down the point. At *B*, the cut is taken the same as any cut in a lathe, and the work is done far more satisfactorily and in less time. Just why machine-shop foremen allow the 90-degree advance to be used is a question. Time and again the writer has observed that this and other practices are permitted, not because of lack of equipment or facilities, but because of indifference. Not only are lathes equipped with compound rests allowed to remain idle while others are being used, but on lathes so equipped the compound rest is not employed.

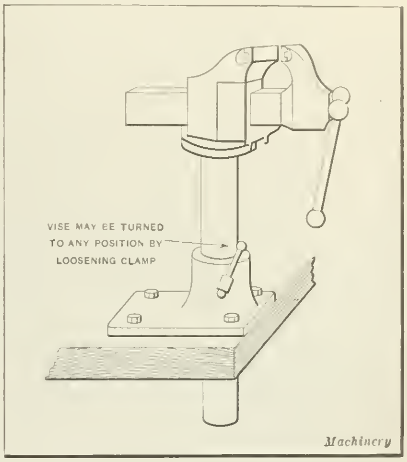
Indianapolis, Ind. F. E. Metzler



Wrong and Right Ways of cutting Threads

VISE ADJUSTABLE FOR HEIGHT

Some progressive vise manufacturer would be taking a step in the right direction, it seems to me, were he to put on the market a vise that could be adjusted to different heights. This would be a marked improvement, and would be appreciated especially by tall men. They are now obliged to bend over at an angle of 45 degrees, more or less, which is an uncomfortable position, to say nothing of the strain on the nerves and the suspender buttons. A few men consider a filing job a snap, and before beginning get the most comfortable stool in the room and place their feet on a box. But most men prefer to tackle a filing job with both feet on the floor, as a standing position gives a freer arm movement and better control over the file.



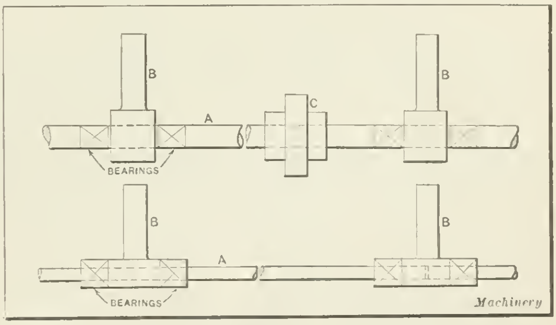
Suggested Design of Adjustable Vise

When the vise is at a convenient height, the operator is able to follow more closely each stroke of the file, without stooping over every few minutes to see if the file is hitting anywhere near the mark. With a vise that can be raised or lowered, as shown in the accompanying illustration, the work may be brought up to a convenient height for close work or lowered for heavy work, for a better leverage, as then one can get the force behind each outward stroke. Such a vise would mean a saving in time and better work. In other words, the vise should fit the man, instead of the man's fitting the vise, as is now the case.

Plainville, Conn. Harry B. Stillman

ORIGINATION VERSUS IMITATION IN DESIGN

The November number of Machinery contains an article entitled "Origination Versus Imitation in Design," but the following is one case where originality in design was a good



Case in which an Original Plan was Economical

dollars and cents quality. This is not a lone instance, but one of a number resulting from many years of experience.

In connection with the design of a certain water-control project, there were available the plans of two similar projects, one of which had copied very closely from the other, both good and bad points. For the new project, it would have been easy to copy from either, but original designs were made. The accompanying illustration shows some of the differences between the new and the older designs. The top view shows

the arrangement, in the older designs, of a shaft *A* with cast-steel props *B*, which are spaced about eight feet apart; the bottom view shows the shaft and props when designed after a careful study of the problem has been made.

It is necessary, in order to facilitate erection, to have the shaft in short lengths. The shaft has no torsional moment except that of overcoming the dead weight of the props when swinging them in position to hold a load and the friction caused by the dead weight of the shaft and props; this is, of course, very small. When the load is applied there is a heavy direct stress on the props. In each case, after the load is brought to bear, there is a heavy load causing bending, similar to that of a beam with the load concentrated at the center and supported at the ends. The condition is not quite so severe as a load concentrated at the center, but the assumption is on the side of safety. In the older design, the bending is taken by the shaft, which is made heavy enough to stand it; so a 4-inch shaft is used. To avoid turning it down, the shaft is made the same diameter throughout. In the later design, the bending is taken by the prop and not by the shaft, so that the shaft is submitted only to the small torsion before mentioned. As a result, a 2¼-inch shaft is sufficient. As there are two of these shafts, each over fifty feet long, there is quite a saving in the amount of steel required for shafts. The 4-inch shaft has a section modulus of 6.3, while the part of the prop taking the bending is 4½ inches in diameter with a 2¼-inch hole in it and has a section modulus of 7.8. And as the strength and stiffness of the parts are a direct function of the section modulus, it can be seen that in the later design strength has not been sacrificed to lightness.

Since the shafts must be coupled in the later designs, they are made in such lengths that the ends come in the center of the props, thus doing away with the separate couplings. As a cast-iron coupling *C* for a 4-inch shaft weighs about 290 pounds, it will be seen that another large saving is effected here. It might also be mentioned that in the later designs the parts are more easily erected, because the props do not have to be moved so far on the shaft, and the lighter weights are more easily handled in an awkward place.

In conclusion, it might be stated that if every pound of metal can be put where it will do the most good, one of the objects that should be uppermost in the mind of every designer has been accomplished; that is, to get out the best plans possible, suited to the requirements, with the least expense.

Albany, N. Y. CHARLES P. WIWEKE

AN EMERGENCY STRAIGHTEDGE

The writer has found the tool points used in the Pratt & Whitney tool-holders for cutting U. S. S. threads to be very useful as a straightedge. As these tool points are lapped on the flat, anyone can make a selection from a bunch of six or seven and find one that checks up with a glass straightedge or test bar. Those of the finer pitch are to be preferred.

Bridgeport, Conn. JAMES MCINTYRE

TOOLS AND BURNISHERS FOR TRUCK AXLE JOURNALS

In the illustrations are shown tools and burnishers used by a large Eastern railroad on truck axle journals of soft steel, containing about 0.40 per cent carbon, 0.55 per cent manganese and 0.05 per cent sulphur and phosphorus.

Fig. 1 shows the journal cutting tools. In order to eliminate all danger of chattering, the straight cutting face of the tool is only 3/16 inch wide. The straight tools are made in pairs, right and left, for use in double-end axle lathes. The offset tools are for use in large gap axle lathes, in which is placed an axle, with both wheels, to have the journal trued. The work speed is from 70 to 90 feet per minute, and the feed of the tools is 1/32 to 1/16 inch. If the journal being trued requires a cut over 1/16 inch deep, it is best to take two cuts, one heavy and the other light, so the burnisher will not have so much to do.

Fig. 2 shows the burnisher. The forks are all made alike so the parts can be made interchangeable when it is desired to have only one fork and several burnishing wheels. An offset fork is not recommended because it will not have a good solid bearing, on account of the tremendous pressure on the fork, but the straight fork will. Therefore it is necessary to move the working part of the roller close to the left side to get the burnisher wheel up in the fillet without having the wheel or axle rub the toolpost or carriage. The inside of the

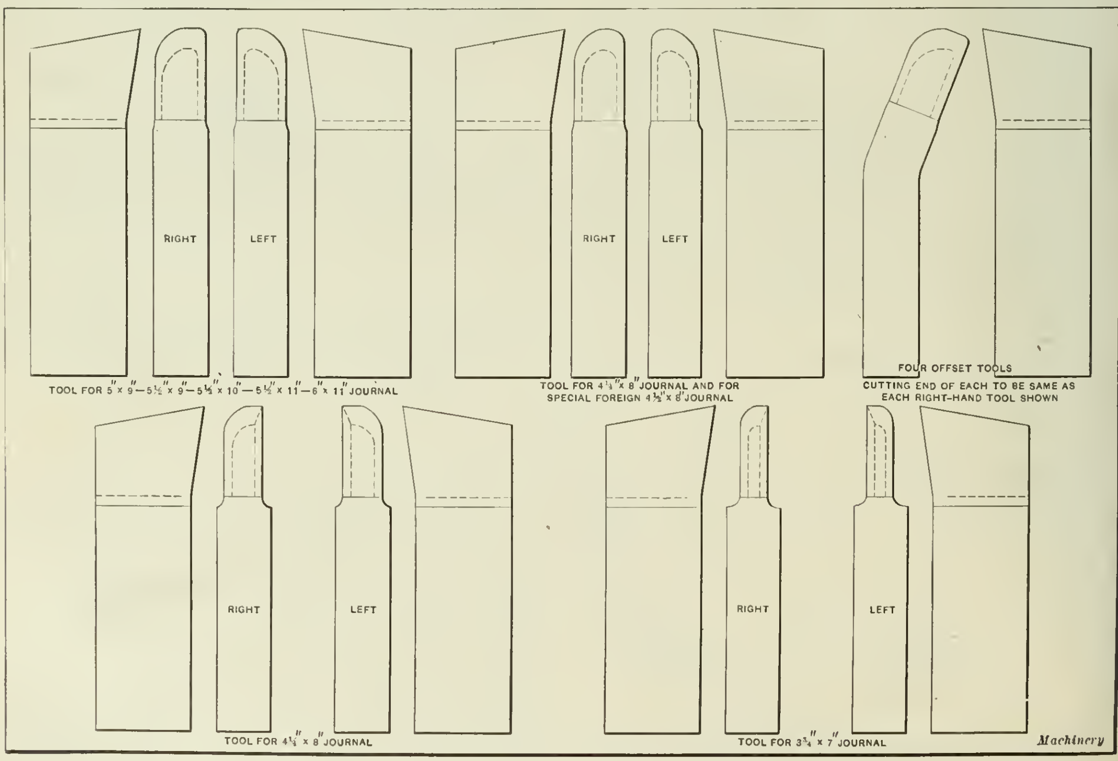


Fig. 1. Turning Tools for Journals and Wheel Seats (One-fourth Size)

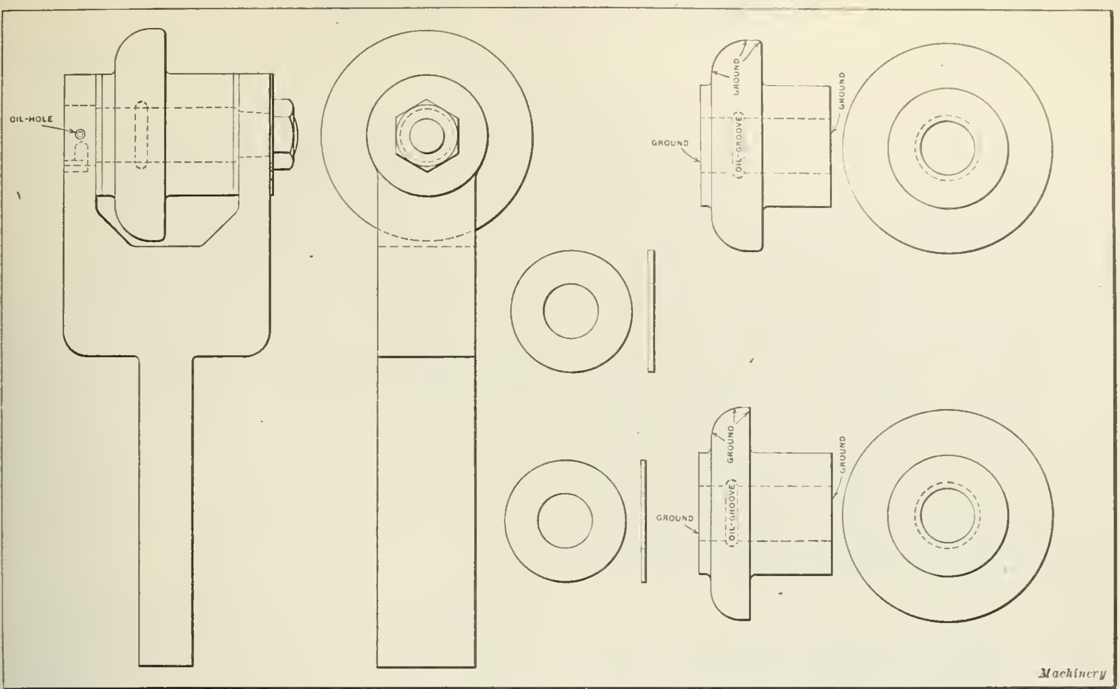


Fig. 2. Burnisher for Truck Axle Journals (One-fourth Size)

fork is finished by draw-filing. Two hardened and ground washers are placed between the fork and the tool, or burnishing wheel, so that there will be no friction. The pin and roller are hardened and ground; the roller is also ground on the inside. In making burnishers for use on gap axle lathes (for mounted axles, of course), the fork can only be used from the side nearest the tailstock of the lathe. In other words, the operator will generally lift and turn the axle after burnishing one end; as a result it will only be necessary to use the tool one way. In this case only one oil-hole is required through the fork, as shown. But when the tool is used in a double-end axle lathe, it will be used right and left, so oil-holes should be drilled from both sides in order that the tool can be oiled while running. The bottom oil-hole should always be kept plugged; also the hole in the center of the pin, which must be drilled in to the required depth to carry the oil in from the other hole. Oil-grooves are cut in the pin (Fig. 3), on the side away from the wear, and oil-retaining grooves are cut inside of the rollers. The burnishers are made of high-grade tool steel. When burnishing, the work speed is from 70 to 90 feet per minute and the feed 1/32 to 1/16 inch. The burnishers must be thoroughly lubricated at the point of contact with the work while in operation. M. K.

"RUSSIAN" METHOD OF MULTIPLICATION

I was recently told of an odd system of multiplication which I believe is known as a "Russian" method; and a description may prove of interest to some readers of MACHINERY. Suppose it is required to multiply 206 by 37: Make up columns and head them "multiplicand" and "multiplier," respectively. Start by dividing the multiplier, *i. e.*, 37, by 2 and disregard the remainder. Write the quotient as the second number in the column headed "multiplier" and then divide the quotient by 2 to obtain the third number in this column. Proceed in the same manner until 1 is obtained as the final quotient.

To obtain figures in the second column in which the multiplicand is the first number, proceed by multiplying the multiplicand by 2 to obtain the second number; then multiply this product by 2 to obtain the third number in this column, and so on until there are the same number of rows in each column.

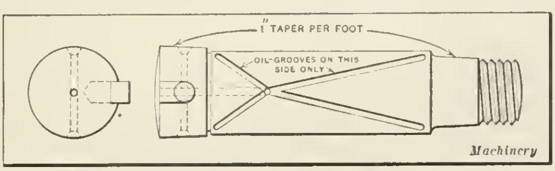


Fig. 3. Detail of Burnishing Roller Pin

Beginning at the top, cancel each corresponding row of figures that is divisible by 2; and add the remaining figures in the "multiplicand" column, which gives the required product of the original multiplicand and multiplier.

The method will be better understood by carrying through the problem as follows:

Multiplier	Multiplicand	
37	206	206
18	412	
9	824	824
4	1648	
2	3296	
1	6592	6592
		7622

As a check on the preceding, we have: $206 \times 37 = 7622$.

Denver, Colo. STANLEY EDWARDS

A PROTECTOR AGAINST BLOTTING

There is nothing that fully expresses the feelings of a draftsman who inadvertently blots or smudges the still wet ink of a carefully made drawing, particularly where the design is of an intricate character or where many parts come together. Of course some draftsmen can, by reason of their steady hands and long training, draw ink lines in the midst of a complicated mass of lines without touching the drawing sheet, but such a process is nerve racking and is not always successful.

The blotting and smudging can easily be avoided by the use of a curved hand rest. This may be made by cutting a barrel stave to a suitable width, preferably about two inches, and to a length of about fourteen inches. It is then sandpapered and its edges smoothed; if desired, it may be shellacked or varnished. In use, the device is placed over the drawing so that the ends of the stave will span the work, thus forming a support for the draftsman's hand. The stave will be above the drawing paper, except at its ends, and will keep the hands away from the sheet and thus prevent blotting and smudging the drawing.

A. P. CONNOR

Washington, D. C.

INTERNAL HELICAL GEARING[1]

NORMAL PITCH AND CIRCULAR PITCH—CURVATURE OF TEETH—INTERFERENCE—PROPORTIONS—STRENGTH—MACHINING

BY REGINALD TRAUTSCHOLD[2]

THE requirements of smoothness and silence in operation, long life, and high efficiency for high-speed parallel gear transmission, which in the case of externally meshing gears are best secured through the gradual engagement of spiral teeth, are likewise met by internal helical gearing. In addition to these decided advantages, internal helical gearing discounts certain of the drawbacks common to internal spur gearing. That is, the relative advantage of cutting the teeth at an angle to the axis of the gear is greater in the case of internal helical gearing than in external helical gearing.

A typical lay-out of internal helical gearing is shown in Fig. 1. From this it is plain that the tooth action is identical with that of externally meshing helical gears and the arrangement of the teeth is similar, with the exception that for internal gearing the spiral angles of both gear and pinion are of the same hand, while for externally meshing gears the hands of the respective spiral angles are opposite—one is right and the other left. This is because, in internal gearing, the direction of rotation of both gear and pinion is the same, while in the more common type of gearing the pinion revolves in one direction and the gear in the opposite.

Peculiarities of Helical Gearing

Helical gearing has two circular pitches, the normal pitch, which is the shortest distance between centers of consecutive teeth measured on the normal pitch curve, and the circular pitch, which is the shortest distance between centers of consecutive teeth measured on the pitch circle in the plane of the gear, that is, in a plane at right angles to the axis of the gear, as in the case of ordinary spur gearing. This double pitch is responsible in large part for the smoothness and silence of operation. Besides, the obliquity of the teeth produces gradual engagement and avoids shock of impact, for the effective pressure angle of the teeth—the pressure angle in the plane of the gear—is greater than the normal pressure angle governing the normal tooth section. For instance, the effective pressure angle of helical gears with a 14½-degree normal profile pressure angle is greater than 14½ degrees, the increase depending upon the angle of spiral, or the angle measuring the obliquity of the teeth. An increased pressure angle always tends toward increased smoothness in operation.

An increased pressure angle also reduces interference; and, as interference is much more marked in internal gearing than in gears meshing externally, the decrease is more marked in internal gearing and discounts in helical gearing that which has proved one of the most serious drawbacks to internal spur gearing of the involute system. Theoretically, at least, the spiral angle of internal helical gearing could be made sufficiently great to avoid all interference, irrespective of the number of teeth in the pinion and the speed ratio of the gears, making the involute system as adaptable as the cycloidal system for internal helical gearing. In practice, however, it is seldom advisable to make the spiral angle greater than about 20 degrees, on account of the axial thrust created by the obliquity of the teeth. With a normal pressure angle of 14½ degrees and a spiral angle of 20 degrees, the effective pressure angle will be 15 degrees, 27 minutes. This increase in pressure angle will not, in itself, be sufficient to avoid interference in gear combinations of usual speed ratios, so that correction for interference by rounding off the corners, as for internal spur gear combinations of the involute system, is still necessary. But the amount to be removed from the corner of the internal helical gear teeth is not as great as in the case of similar internal spur gear teeth.

Normal Pitch Ellipse

The effect of arranging the teeth obliquely across the face of the gear is to increase the pitch diameter, the normal section and pitch remaining the same, owing to the circular pitch being greater than the normal pitch. The normal pitch of a helical gear corresponds to the circular pitch of a spur gear. Referring to Fig. 2, it is evident that the normal pitch curve must be a section of an ellipse (an oblique section of a cylinder being elliptic in outline), the conjugate axis of which is equal to the pitch diameter of the helical gear, and the major axis equal to the pitch diameter divided by the cosine of the spiral angle. Actually, no such normal pitch ellipse exists, for there are not enough teeth in the gear to circumscribe such a curve. Nevertheless, it is a short section of the flattest part of the ellipse, the section straddling the conjugate axis, which controls the proportioning of the teeth. This normal pitch arc, or

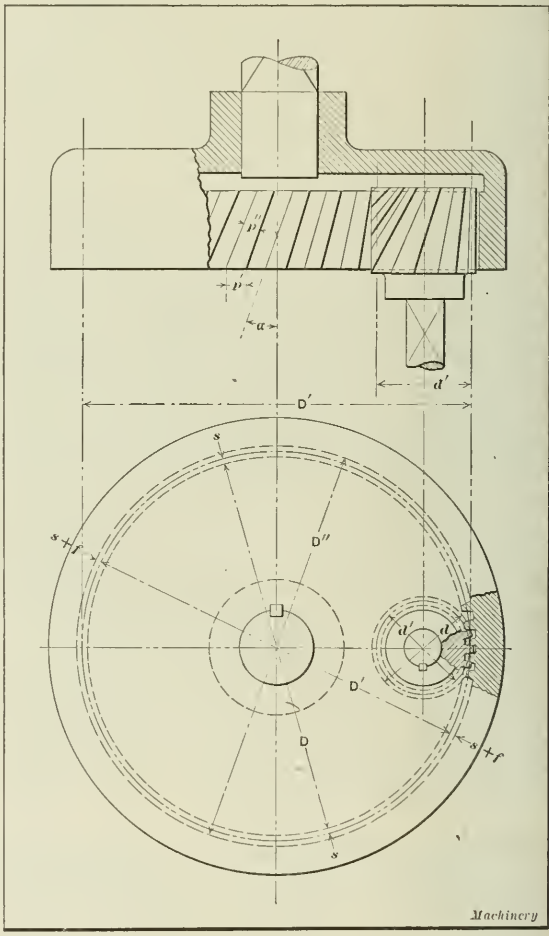


Fig. 1. Lay-out of Internal Helical Gearing with a Speed Ratio of 4:1

curve, is approximately an arc of a radius equal to the major axis of the ellipse minus one-half its conjugate axis. The normal section of a helical gear tooth is controlled then not by the pitch diameter directly, but by a radius equal to the pitch diameter of the gear divided by the cosine of the spiral angle minus one-half the pitch diameter.

Curvature of Helical Gear Teeth

Helical gear teeth, being of constant depth, are also slightly curved in their length. As in the case of the normal pitch curve, a close approximation, as the radius of curvature is practically accurate, for the true curvature is the flat section of an ellipse; see Fig. 3. The conjugate axis of the ellipse is

[1] For previous information on internal gearing, see "Internal Spur Gearing" in the January, 1917, number of MACHINERY.
[2] Address: 39 Charles St., New York City.

again the pitch diameter of the helical gear, but the major axis is equal to the pitch diameter divided by the sine of the spiral angle. The curvature of the tooth, the section of the ellipse straddling the conjugate axis, is then approximately the arc of a radius equal to the difference between the major axis of the ellipse and one-half its conjugate axis. That is, the radius of tooth curvature equals the pitch diameter of the gear divided by the sine of the spiral angle minus one-half the pitch diameter. For external helical gears, the tooth curvature is convex, and for internal helical gears it is concave.

Interference of Internal Helical Gear Teeth

The interference circle, locating the point on the teeth at which interference commences, is not fixed for internal helical gears as it is for internal spur gears. In the latter type of gear, it is located midway between the pitch and base circles for 14½-degree involute teeth. For internal helical gear teeth of normal 14½-degree involute standard, the interference circle is relatively smaller and lies nearer the base circle. Two factors govern the point at which interference commences: the pressure angle and the number of teeth. Both of these factors are dependent on the angle of spiral, the beginning of the point of interference being the same whether the normal section of the tooth is considered or the section in the plane of the gear.

Although the ordinary pressure angle of the normal tooth section of an internal helical gear is 14½ degrees, the normal pitch arc that controls the position of the teeth is greater than the pitch radius of an internal spur gear of the same number of teeth, pitch, and pressure angle. In other words, comparison may be made with an internal spur gear combination of greater speed ratio. The effect is the same as slightly decreasing the curvature of a gear section; the point of interference is brought nearer the top of the tooth for the particular speed ratio. The effective pressure angle, considering the tooth section in the gear plane, is greater than 14½ degrees so that the point at which interference commences must be nearer the top of the tooth. A fixed relationship exists between the increased pressure angle, the normal pitch arc radius, and the number of teeth in the gear and pinion.

With the more advantageous location of the point at which interference commences in internal helical gears of standard normal pitch, there is a corresponding reduction in the amount of the corner of the tooth that has to be removed to avoid interference. The dedendum cutting radius for the normal tooth section is obtained from the normal pitch arc radius. The proportion of this latter radius that is taken is the same as that of the pitch radius of an internal spur gear taken for the dedendum cutting radius of the spur gear, so that the actual dedendum cutting radius for helical internal gears is the larger for a given pitch (normal), and less of the tooth corner is removed. In the plane of the gear, the dedendum cutting radius bears the same relationship to the pitch diameter as in the case of internal spur gears, although the effective pressure angle is greater than the pressure angle would be in the case of the internal spur gear—the circular pitch of the spur gear corresponding to the normal pitch of the helical gear.

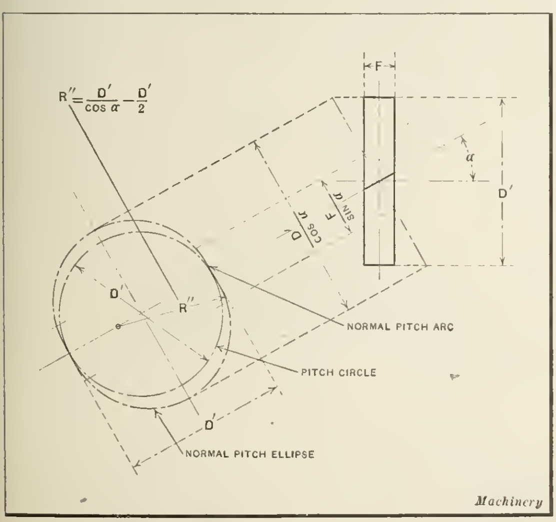


Fig. 2. Normal Pitch Arc Radius of Helical Gears

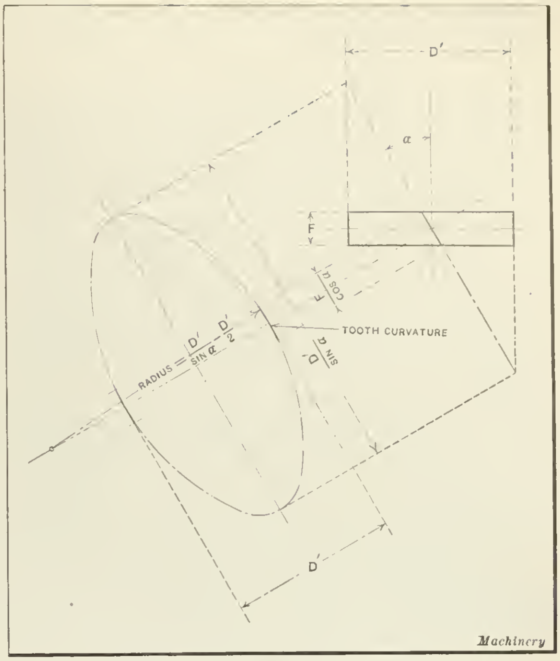


Fig. 3. Tooth Curvature Arc of Helical Gears

Formulas for the calculation of both the dedendum cutting radius (normal) and the effective cutting radius will be derived, as well as for ascertaining the correction arc radius and the effective correction curve radius from which the respective dedendum cutting arcs are struck, but formulas for locating the interference curves will be omitted, as they are of little practical value and are likely to lead to confusion. In laying out internal helical gear teeth, the dedendum cutting arc is made tangent to the tooth profile—the point of tangency being actually on the interference curve—and is struck about a center located on the correction curve.

Proportions of Internal Helical Gear Teeth

Fig. 4 depicts cross-sections of internal helical gear teeth, viewed first on a normal plane and second on the plane of the gear. Although the spiral angle of the gear illustrated is less than 20 degrees, there is quite an appreciable difference in the proportions of the teeth viewed from the different angles. The normal tooth section is similar to that of an internal spur gear of the same pitch and pressure angle but with a considerably greater number of teeth than are actually on the internal helical gear. The effective tooth section, on the other hand, is similar to that of an internal spur gear of the same number of teeth, but of a greater pressure angle and larger pitch.

The relative location of the base-curve arc and the pitch-curve arc is not materially affected in the two views, for the radius of this curve depends on the respective pitch arc radii and on the cosine of the respective pressure angles. As the radius and angle increase, the cosine of the pressure angle decreases, so there is little relative difference in the product of the respective radii and the cosine of their corresponding pressure angles. On the other hand, the relative location of the correction-curve arc, in respect to the pitch-curve arc, is quite appreciably different in the two views. This is due to the fact that the correction-curve arc is controlled by the pitch-curve arcs and the reciprocal of the cosine of the pressure angle. When the pitch-curve radius is the greater (proportionally) and the pressure angle correspondingly increased, the cosine of

the angle is smaller and the increase in the quotient of the pitch-curve radius divided by the cosine of the pressure angle is quite marked.

Strength of Helical Gear Teeth

The effective thickness of helical gear teeth bears the same relationship to the normal thickness of the tooth as does the pitch diameter of helical gears to the major axis of the imaginary normal pitch ellipse; that is, it equals the normal thickness of the tooth divided by the cosine of the spiral angle. Furthermore, more than one set of teeth in a gear combination, the number depending on the angle of spiral and the pitch of the gear, are always in contact and transmitting power at the same time. The result is that the teeth of helical gears are practically indestructible from fracture in operation and a very much finer normal pitch can be employed than could be used with safety in spur gearing transmitting the same amount of power.

Instead of employing a finer pitch, the face of the helical gear could be decreased, but this would necessitate an increase in the spiral angle in order to secure the advantage of the same number of teeth in contact at one time, resulting in increased axial thrust. As axial thrust serves no useful purpose and is difficult to control, unless double helical gears of the herringbone type can be employed, an increased spiral angle should be avoided. The use of a finer pitch on account of the increased effective strength of helical gear teeth is then decidedly preferable to a decrease in the width of the gear for the same reason.

Notation for Internal Helical Gearing

	Gear	Pinion
Angle of spiral	α	α
Number of teeth	N	n
Diametral pitch	p	p
Circular pitch	p'	p'
Normal pitch	p''	p''
Pitch diameter	D'	d'
Normal pitch arc radius	R''	r''
Outside diameter		d
Inside diameter	D	
Dedendum diameter	D''	
Addendum	s	s
Clearance	f	f
Dedendum	$s+f$	$s+f$
Whole depth of tooth	W	W
Thickness of tooth (normal)	t	t
Lead	L	l
Pressure angle	β	β
Effective pressure angle	δ	δ
Base arc radius	B	
Effective base arc radius	B_e	
Correction arc radius	C	
Effective correction arc radius	C_e	
Dedendum cutting radius	b'	
Effective dedendum cutting radius	b_e'	
Addendum cutting radius	c'	
Effective addendum cutting radius	c_e'	

	Pair of Gears
Speed ratio	V
Center distance	X

Formulas for Internal Helical Gearing

$$D' = \frac{2VX}{V-1} = Np'0.3183 \quad (1) \qquad d' = \frac{2X}{V-1} = np'0.3183 \quad (1a)$$

$$N = \frac{3.1416D'}{p'} = nV \quad (2) \qquad n = \frac{3.1416d'}{p'} = \frac{N}{V} \quad (2a)$$

$$\cos\alpha = \frac{p''}{p'} \quad (3) \qquad p' = \frac{p''}{\cos\alpha} \quad (4)$$

$$p'' = p'\cos\alpha = \frac{3.1416}{p} \quad (5) \qquad p = \frac{3.1416}{p''} \quad (6)$$

$$d = d' + p''\,0.6366 \quad (7) \qquad D = D' - p''\,0.6366 \quad (8)$$

$$D'' = D' + p''\,0.7366 \quad (9) \qquad s = p''\,0.3183 \quad (10)$$

$$f = p''\,0.05 \quad (11) \qquad s + f = p''\,0.3683 \quad (12)$$

$$W = p''\,0.6866 \quad (13) \qquad t = p''\,0.5 \quad (14)$$

$$L = 3.1416\,D'\cot\alpha \quad (15) \qquad l = 3.1416d'\cot\alpha \quad (15a)$$

$$R'' = \frac{D'}{\cos\alpha} - \frac{D'}{2} \quad (16) \qquad r'' = \frac{d'}{\cos\alpha} - \frac{d'}{2} \quad (16a)$$

$$B = R''\cos\beta \quad (17) \qquad C = \frac{R''}{\cos\beta} \quad (18)$$

$$b' = 0.25R'' \quad (19) \qquad c' = \sqrt{(0.25R'')^2 + (0.25r'')^2} \quad (20)$$

$$\sin\delta = \frac{\sin\beta}{\cos\alpha} = \frac{0.25038}{\cos\alpha} \quad (21) \qquad B_e = 0.5D'\cos\delta \quad (22)$$

$$C_e = \frac{D'}{2\cos\delta} \quad (23) \qquad b_e' = 0.125D' \quad (24)$$

$$c_e' = \sqrt{(0.125D')^2 + (0.125d')^2} \quad (25)$$

$$V = \frac{N}{n} = \frac{D'}{d'} = \frac{R''}{r''} \quad (A) \qquad X = 0.5\,(D' - d') \quad (B)$$

Example 1.—Required: An internal helical gear combination cut normally with a 4-pitch involute cutter; 76 teeth in gear, 19 teeth in pinion; center distance, 7½ inches. That is,

$$p = 4,\ V = \frac{76}{19} = 4,\ X = 7.5 \text{ inches}$$

$$D' = \frac{2 \times 4 \times 7.5}{4-1} = 20 \text{ inches} \quad (1)$$

$$d' = \frac{2 \times 7.5}{4-1} = 5 \text{ inches} \quad (1a)$$

$$p' = \frac{3.1416 \times 20}{76} = 0.8267 \text{ inch} \quad (4)$$

$$p'' = \frac{3.1416}{4} = 0.7854 \text{ inch} \quad (5)$$

$$\cos\alpha = \frac{0.7854}{0.8267} = 0.95 \quad (3) \qquad \alpha = 18 \text{ degrees, } 11 \text{ minutes}$$

$$d = 5 + 0.7854 \times 0.6366 = 5.5 \text{ inches} \quad (7)$$

$$D = 20 - 0.7854 \times 0.6366 = 19.5 \text{ inches} \quad (8)$$

$$D'' = 20 + 0.7854 \times 0.7366 = 20.5785 \text{ inches} \quad (9)$$

$$s = 0.7854 \times 0.3183 = 0.25 \text{ inch} \quad (10)$$

$$f = 0.7854 \times 0.05 = 0.0393 \text{ inch} \quad (11)$$

$$s + f = 0.7854 \times 0.3683 = 0.2893 \text{ inch} \quad (12)$$

$$W = 0.7854 \times 0.6866 = 0.5393 \text{ inch} \quad (13)$$

$$t = 0.7854 \times 0.5 = 0.3927 \text{ inch} \quad (14)$$

$$L = 3.1416 \times 20 \times 3.0445 = 191.292 \text{ inches} \quad (15)$$

$$l = 3.1416 \times 5 \times 3.0445 = 47.823 \text{ inches} \quad (15a)$$

$$R'' = \frac{20}{0.95} - \frac{20}{2} = 11.0526 \text{ inches} \quad (16)$$

$$r'' = \frac{5}{0.95} - \frac{5}{2} = 2.7632 \text{ inches} \quad (16a)$$

$$B = 11.0526 \times 0.96815 = 10.7006 \text{ inches} \quad (17)$$

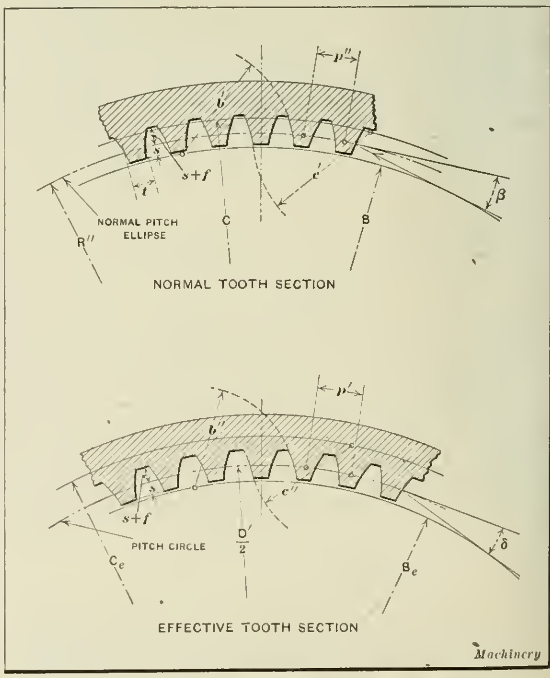


Fig. 4. Internal Helical Gear Tooth Proportions

$$C = \frac{11.0526}{0.96815} = 11.4162 \text{ inches} \quad (18)$$

$$b' = 0.25 \times 11.0526 = 2.7632 \text{ inches} \quad (19)$$

$$c' = \sqrt{(0.25 \times 11.0526)^2 + (0.25 \times 2.7632)^2} = 2.8481 \text{ inches} \quad (20)$$

$$\sin \delta = \frac{0.25038}{0.95} = 0.26356 \quad (21)$$

$$\delta = 15 \text{ degrees, } 17 \text{ minutes}$$

$$B_e = 0.5 \times 20 \times 0.96463 = 9.6463 \text{ inches} \quad (22)$$

$$C_e = \frac{20}{2 \times 0.96463} = 10.3667 \text{ inches} \quad (23)$$

$$b_e' = 0.125 \times 20 = 2.50 \text{ inches} \quad (24)$$

$$c_e' = \sqrt{(0.125 \times 20)^2 + (0.125 \times 5)^2} = 2.5769 \text{ inches} \quad (25)$$

Example 2.—Required: An internal helical gear combination to replace an internal spur gear set of 60 and 15 teeth, respectively, 3 pitch, 7½ inches between centers. The speed ratio is to remain the same and the helical gears are to be cut with the same normal pitch. That is, $p = 3$, $V = \frac{60}{15} = 4$, $X = 7.5$ inches.

$$D' = \frac{2 \times 4 \times 7.5}{4 - 1} = 20 \text{ inches} \quad (1)$$

$$d' = \frac{2 \times 7.5}{4 - 1} = 5 \text{ inches} \quad (1a)$$

$$N = 56 \text{ (Assumed)} \qquad n = 14 \text{ (Assumed)}$$

$$p' = \frac{3.1416 \times 20}{56} = 1.122 \text{ inch} \quad (4)$$

$$p'' = \frac{3.1416}{3} = 1.0472 \text{ inch} \quad (5)$$

$$\cos \alpha = \frac{1.0472}{1.122} = 0.93333 \quad (3)$$

$$\alpha = 21 \text{ degrees, } 2 \text{ minutes}$$

$$d = 5 + 1.0472 \times 0.6366 = 5.6666 \text{ inches} \quad (7)$$

$$D = 20 - 1.0472 \times 0.6366 = 19.3334 \text{ inches} \quad (8)$$

$$D'' = 20 + 1.0472 \times 0.7366 = 20.7714 \text{ inches} \quad (9)$$

$$s = 1.0472 \times 0.3183 = 0.3333 \text{ inch} \quad (10)$$

$$f = 1.0472 \times 0.05 = 0.0524 \text{ inch} \quad (11)$$

$$s + f = 1.0472 \times 0.3683 = 0.3857 \text{ inch} \quad (12)$$

$$W = 1.0472 \times 0.6866 = 0.72 \text{ inch} \quad (13)$$

$$t = 1.0472 \times 0.5 = 0.5236 \text{ inch} \quad (14)$$

$$L = 3.1416 \times 20 \times 2.6006 = 163.4008 \text{ inches} \quad (15)$$

$$l = 3.1416 \times 5 \times 2.6006 = 40.8502 \text{ inches} \quad (15a)$$

$$R'' = \frac{20}{0.9333} - \frac{20}{2} = 11.4287 \text{ inches} \quad (16)$$

$$r'' = \frac{5}{0.9333} - \frac{5}{2} = 2.8573 \text{ inches} \quad (16a)$$

$$B = 11.4287 \times 0.96815 = 11.0647 \text{ inches} \quad (17)$$

$$C = \frac{11.4287}{0.96815} = 11.8046 \text{ inches} \quad (18)$$

$$b' = 0.25 \times 11.4287 = 2.8572 \text{ inches} \quad (19)$$

$$c' = \sqrt{(0.25 \times 11.4287)^2 + (0.25 \times 2.8573)^2} = 2.9449 \text{ inches} \quad (20)$$

$$\sin \delta = \frac{0.25038}{0.9333} = 0.26827 \quad (21)$$

$$\delta = 15 \text{ degrees, } 34 \text{ minutes}$$

$$B_e = 0.5 \times 20 \times 0.96332 = 9.6332 \text{ inches} \quad (22)$$

$$C_e = \frac{20}{2 \times 0.96332} = 10.3807 \text{ inches} \quad (23)$$

$$b_e' = 0.125 \times 20 = 2.5 \text{ inches} \quad (24)$$

$$c_e' = \sqrt{(0.125 \times 20)^2 + (0.125 \times 5)^2} = 2.5769 \text{ inches} \quad (25)$$

Discussion of Formulas

The double pitch peculiarity of helical gears complicates the derivation of convenient formulas for the calculations involved in the design of helical gearing, the pitch diameters and the number of teeth being controlled by the circular pitch and all other diameters affected by the normal pitch, from which the tooth proportions are also figured. The relationship existing between the normal pitch and the measurements figured from it is similar to the relationship of the circular pitch of spur gears to their similar measurements.

As practically any pitch diameter of gear, for a given number of teeth of certain pitch, can be secured by varying the spiral angle of helical gear combinations, it is customary to consider the distance between the pinion and gear shafts as fixed and to proportion the pitch diameters accordingly. In the case of internal helical gearing, twice the center distance divided by the speed ratio minus 1 gives the pitch diameter of the pinion and this multiplied by the speed ratio gives the pitch diameter of the gear.

The pitch circle diameter divided by the number of teeth in an internal helical gear gives its circular pitch, and its normal pitch divided by the circular pitch gives the cosine of the spiral angle. The outside diameter of the pinion, inside diameter of the internal gear, and all tooth proportions are then calculated from the normal pitch by formulas similar to the corresponding formulas for internal spur gearing, the pitch diameter having first been proportioned according to the circular pitch.

The normal pitch arc radius is the approximate radius of the flat section of the imaginary normal pitch ellipse and is found by dividing the pitch diameter of the gear by the cosine of the spiral angle and subtracting from the quotient one-half the pitch diameter. From the normal pitch arc radius are figured the base arc radius, correction arc radius, dedendum cutting radius, and addendum cutting radius for the internal helical gear; all as corresponding dimensions are figured for internal spur gears.

The spiral lead is the distance covered by the thread in one complete revolution of the pitch circle and is equal to the pitch circumference multiplied by the cotangent of the spiral angle.

The sine of the effective pressure angle is found by dividing the sine of the pressure angle (normal) by the cosine of the spiral angle. The cosine of the effective pressure angle is employed for ascertaining the effective base arc radius and the effective correction arc radius in a similar manner to that used in calculating the corresponding dimensions for internal spur gears, the pitch diameter of the internal helical gear being the other governing factor.

The effective dedendum and addendum cutting radii are also customarily figured from the pitch diameters, just as the corresponding normal radii are calculated. A slight inaccuracy exists in such practice, for if the tooth profile curves are arcs of circles in planes normal to the tooth axis they cannot also be arcs of circles in an oblique plane, but must be arcs of ellipses. The error is slight, however, and carries practically little weight, but slight wear being required to rectify any slight interference which may exist.

Machining Internal Helical Gears

Three general methods of cutting internal helical gear teeth may be employed: Using rotary cutters in special milling machines; planing the teeth; and employing end-mill cutters. The milling method is naturally the most rapid and is the one generally employed if the gears are to be made in quantities. In this process, the gear blank is made to revolve during the cutting of the teeth, the plane of the cutting tool—rotary mill—being maintained normal to the plane of the gear. This method is feasible only for gears of comparatively slight obliquity (spiral angle), as the cutter must clear itself as it traverses the face of the gear. The practical spiral angle is also limited and the diameter of the gear must be comparatively large in order to provide accommodation within the confines of the blank for the rotary mill and the spindle of the milling machine. The rotating speed of the gear blank is made proportional to the spiral lead of the gear teeth and the feed accommodated accordingly. The cutter is proportioned to conform to the effective tooth section, so that a special cutter is required for each gear of differing obliquity, if accuracy is essential. When the involute form of tooth can be deviated from, the same cutter may be employed in machining gears of differing spiral angle, provided the cutter used for the mating pinion is proportioned accordingly.

When planing the teeth of internal helical gears the cutting tool may be made to conform to the effective tooth section of the gear and the gear blank revolved during the cutting operation, as in the milling process. In another planing method, the gear blank is held stationary, except for the necessary indexing from tooth to tooth, and the cutter is made to conform to the normal tooth section. The plane of the cutting tool is inclined to the plane of the gear at an angle conforming to the obliquity of the gear teeth and the tool is guided by suitable templets in a path following the slight longitudinal curvature of the teeth; the radius of curvature of the "former" is made proportional to the pitch diameter of the gear divided by the sine of the spiral angle minus one-half the pitch diameter.

Machining helical gear teeth with the Fellows gear shaper constitutes a third planing method. For such process, the pinion cutter is proportioned to conform to the normal tooth section, for if machined in the plane of the axis of the gear the cutter could not properly clear itself. Furthermore, following the tooth space permits the standard pinion cutter to be employed. The gear blank is mounted on the work-spindle inclined at the angle of spiral, so that the normal tooth axis, the obliquity of the gear teeth, coincides with the reciprocating path of the pinion cutter when the cutter is normal to to the tooth space section. The gear blank is revolved slowly in its inclined plane at a speed proportional to the spiral lead of the gear, the cutting pinion tool reciprocating rapidly across the face of the gear. Each tooth space is finished on the completion of each revolution of the pinion cutter.

This method of machining helical gear teeth is exceedingly accurate and efficient, for the teeth are generated by a true involute cutter, just as if the gear and mating pinion were rolled together and the teeth molded. The longitudinal curvature of the tooth is automatically taken care of by the cutter following the cylindrical outline of the gear face. The path of the cutter is a true ellipse in reference to the axis of the gear blank and at the same time is in a plane normal to the tooth section on account of the slow revolution of the gear blank while the cutter traverses the face of the gear.

On the commencement of each cutting stroke and upon the completion of each stroke, the distance from the momentary contact of cutter and gear blank to the center of the work-spindle is at a minimum and at the center of the gear face is at a maximum, giving the true concave curvature of the internal helical gear tooth, the section of an ellipse straddling the normal pitch diameter of the gear and its conjugate axis.

The cutting of internal helical gear teeth with end-mills does not usually prove as satisfactory as milling with rotary cutters, on account of the relatively small tool surface over which the unavoidable tool wear has to be distributed. The method is of interest, however, as by it double helical internal gears of the herringbone variety can be most easily machined. A central groove, or recess, slightly wider than the diameter of the mill at the top of the teeth is cut about the inside of the gear, a shade deeper than the whole depth of the tooth. The oblique teeth on the outer edge of the gear are then cut in a similar manner to that employed for cutting internal helical gear teeth with rotary cutters (the milling method), the end-mill being proportioned to conform to the effective tooth section and the gear blank fed normally to the mill and revolved at the proper speed during the cutting operation. The teeth on the outer half of the gear face, terminating at the central groove, are finished at one setting of the machine, after which the rotation of the gear blank is simply reversed and the other teeth, those extending from the central groove to the inside edge of the gear face, are finished in like manner.

Another advantage secured by the employment of end-mills for machining internal helical gears is the more compact design of gear which can be utilized, as compact, in fact, as for gears with planed teeth. The end-mill and the planing tool require but little clearance between the inner edge of the gear face and the web of the gear blank, while rotary cutters require considerably more space in which to clear themselves.

Internal Helical Gears of Low Ratio

Although it is possible to secure lower speed ratios with internal helical gears having standard 14½-degree involute teeth (normal section) than is possible with internal spur gears with similar tooth profiles (owing to the increase in effective pressure angle due to the spiral angle), it is not always possible to use a speed ratio as large as the minimum limit for the particular degree of helical tooth obliquity. At other times the obliquity of the teeth is limited by the ability of caring for the axial thrust to such an extent that the desired speed ratio cannot be obtained on account of excessive tooth interference. In such cases, the cycloidal system of gear teeth is usually resorted to, as in the case of internal spur gears.

Internal Helical Gears with Cycloidal Teeth

The formulas which have been presented for the solution of internal helical gears of the involute system also apply to similar gears with cycloidal teeth, the formulas for the dedendum and addendum cutting radii and also those for ascertaining the radii of correction arcs being, of course, neglected, as avoidance of interference does not have to be provided for in one instance, and in the other the curve of the tooth profile in cycloidal gearing differs from that in involute gearing.

The diameter of the generating circle for helical gear teeth cut to the cycloidal standard is customarily taken as equal to the radius of the pitch circle of a spur gear of either twelve or fifteen teeth of a circular pitch equal to the normal pitch of the gear to be developed, provided that the gear for which the generating circle is chosen has as many or more teeth.

* * *

ROTARY SHELL PAINTING MACHINE

The accompanying illustration shows a machine for rotating shells while they are being sprayed inside, several of which have been designed and built by the Vermont Farm Machine Co., Bellows Falls, Vt., for its own use. This machine has a capacity for holding four shells at one time. It consists simply of a horizontal shaft carrying four bevel gears which engage with the bevel gears on the four work-holding spindles,

Rotating Machine for painting Interiors of Shells

causing them to rotate. On the end of the shaft is a wooden pulley through which power is transmitted by a small round belt from a motor underneath the machine. The device for holding the shells as they rotate consists of a loose fitting cup, in which the shells are centered, being held by gravity. The machine can be inclined at any desired angle, but 45 degrees seems to be most desirable. In operation, two boys stand in the position indicated. One replaces the completed shells by new ones, while the other sprays the interiors. The machine runs at about 30 revolutions per minute. The two boys can paint about 4000 shells per day of ten hours. V. B.

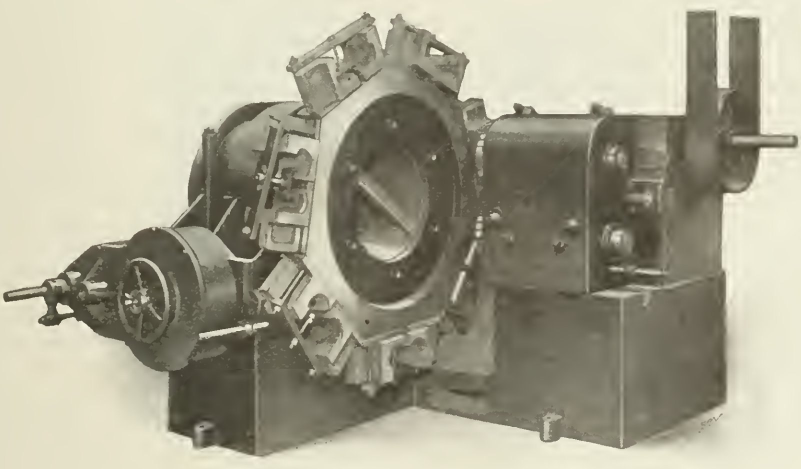
* * *

Clean castings may be made from scrap brass and bronze by placing a handful of plaster-of-paris in the bottom of the crucible before putting in the metal. Of course, all iron should be removed from the scrap by passing it through magnetizing machines, if finely divided, or by hand. As the plaster-of-paris rises through the molten metal, it carries off the free dirt and most of the oxides.

DAVIS MULTIPLE-SPINDLE DUPLEX MILLING MACHINE

A duplex milling machine of the rotary continuous-milling type has been designed by the Davis Mfg. Co., 57th Ave. and Mitchell St., Milwaukee, Wis. This is a special machine intended for milling large quantities of duplicate castings or forgings. The work-holding table revolves in a vertical plane, and the parts to be milled are attached to its periphery. This table has a continuous feeding movement, and as each successive part comes around to the milling position, it passes first between a pair of roughing cutters and then between a pair of finishing cutters.

The machine is driven by a single-belt pulley which may be seen at the right-hand side of the illustration. Motion is transmitted from the belt pulley shaft to a second shaft within the housing through reduction gearing having a ratio of 20 to 1. On the second shaft wide gears having a face width of 10 inches are mounted, and these drive the upper and lower cutter-spindles. The cutter-spindle housings are adjustable parallel to the axis of the work-table spindle, for varying the distance between the milling cutters. This adjustment enables the machine to be used for milling pieces varying from 1 inch to 16½ inches in width.



Davis Duplex Multiple-spindle Milling Machine of Continuous-milling Type

The work-table is bolted to the flange of a large tubular sleeve. The large bearing for this sleeve is formed on a slide or carriage that is given a feeding movement at right angles to the axes of the cutter-spindles and along one extension of the L-shaped base or bed. The particular work-table shown in the illustration is of heptagonal form, there being seven equal sides or faces. This machine is used in the plant of the Davis Mfg. Co. for milling the parallel sides of engine bearings. Another work-table which has been designed for this type of machine is circular in form and has a T-slot extending around the periphery. The fixtures intended for use with the circular table have tongues that fit into the T-slot. The bases, which are bolted against the work-table, are machined to the proper radius on an ordinary boring mill, and when applied to the milling machine table, can be moved around the periphery of the table so that there is a minimum amount of space between them. The design of these jigs can, of course, be modified to suit the different classes of work for which the machine is adapted. Experience has demonstrated, however, that it is economical to have the work-table fitted up for specific operations, one table replacing the other when a change of operations is made. This change of work-tables can be effected much more quickly than by using the same table and replacing one set of jigs or fixtures with another. The circular table is 4 feet, 10 inches in diameter, which is also the width between the faces of the work-table illustrated.

The tubular sleeve or spindle for the work-table is mounted in an exceptionally large bearing and the cutter-spindle housings are rigidly bolted to the bed so that vibration and chatter are eliminated. The work-table is driven through worm-gearing which gives a smooth, powerful drive. The necessary feed changes and the control of the feeding movement are obtained through suitable gearing and friction clutches. This feeding mechanism is enclosed by the casing seen at the left-hand side of the illustration. The slide or carriage for the work-table is adjusted along the bedplate to locate the work in the right position relative to the cutters.

The cutter-spindles have the ordinary conical, bronze, adjustable bearings. The lower spindles are located within sleeves to provide endwise adjustment for taking the finishing cut, and to compensate for the wear of the cutter. The housings which carry the milling cutter spindles are held in position by four bolts located at an angle of 45 degrees. The inner ends of these bolts engage suitable grooves, and, owing to their angular position, each housing is drawn firmly down against the bed and also against the casting containing the driving gears. When this machine is in operation, the continuous feeding movement is so regulated that one man is kept busy removing the finished parts and inserting rough castings.

KANE & ROACH STRAIGHTENING AND SHEARING MACHINES

Kane & Roach, Niagara and Shonnard Sts., Syracuse, N. Y., are the manufacturers of the automatic straightener and shear, and the hot roll straightener described in the following. The straightener and shear is intended for rolling mills, and especially for tool-steel mills. It is designed to straighten flat strips from coils of stock and to cut off automatically any length desired. The dumping table which receives the cut-off stock operates automatically. This No. 1 machine (see Figs. 1 and 2) is designed to handle material varying in width from 3 to 10 inches and in thickness from 1/32 to 1/8 inch. The adjustment on the table can be set to cut practically any required length, and during the shearing operation the rolls stop feeding automatically. The instant the piece of stock is sheared off the table automatically dumps the strip of material and returns to its normal position. After the table returns, the shears stop, open a little, and the rolls start to straighten and feed out a new length of stock. This cycle of operations is repeated as long as there is any material to run through the rolls. The stock passes through the machine at the rate of from 100 to 125 feet per minute, and sometimes the feed is as high as 150 feet per minute. Machines of this type are made in several different sizes and may be used for cutting

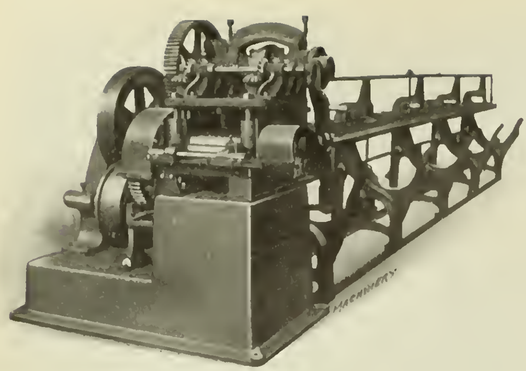


Fig. 1. Kane & Roach Automatic Straightening and Shearing Machine

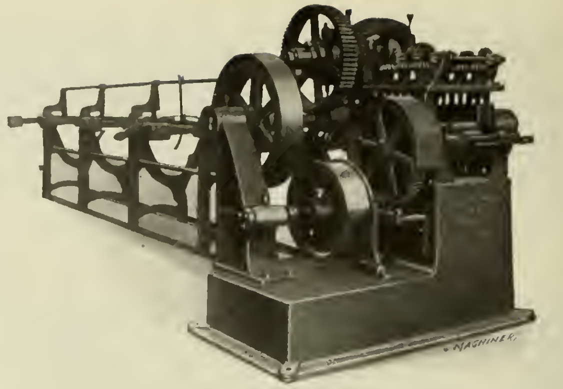


Fig. 2. View showing Driving Mechanism of Kane & Roach Straightener and Shear

and straightening brass, copper, steel, or any kind of material desired.

The straightening machine shown in Fig. 3 has also been brought out by this firm. This machine is intended primarily for straightening round stock while hot and just as it comes from the rolls. Material can also be straightened while cold, although the larger bars should preferably be straightened while hot. The hot bars, after passing through the machine, are given a regular blue finish and the surface is smoothed or polished almost as though the bar had been cold-rolled. When bars are straightened while cold they are also given a good finish and are made true or straight, but the surface does not have as good a finish as that of stock which is straightened while hot. The straightening of a bar is accomplished in one passage through the machine, and the material moves at the rate of 20 to 25 feet per minute.

These machines are made in four or five different sizes. The No. 17 hot roll straightener may be used for stock varying from ½ up to 1½ inch in diameter. The No. 18 size, which is shown in Fig. 3, straightens stock varying from ½ inch to 2½ inches in diameter. The No. 19 size will take stock from 1 inch up to 3¼ inches in diameter; and the capacity of the No. 20 size is for diameters varying from 2 to 5 inches. These machines may be driven either by a belt or motor, the belt drive being shown in the illustration. A different base is used for the motor drive and the motor is geared directly to the machine. The tables at each end of the machine for supporting the stock are about 15 feet long and may be adjusted vertically to suit the diameter of material being straightened. There are also guide boxes and guides between the rolls of different widths and heights to suit the diameter of stock.

The particular machine illustrated in Fig. 3 has what is known as an independent adjustment; that is, each side or each corner can be adjusted independently and can be locked tightly after the adjustment is made. These machines may also have a universal adjustment which is so arranged that all four adjusting screws may be operated by turning one handle from either side of the machine. With this type the rolls are adjusted either toward or away from a common center and are always kept in accurate alignment. The No. 18 machine weighs about 7½ or 8 tons and occupies a lengthwise space of about 36 feet. These machines are designed to enable rolling mills to produce round shafting and round steel bars which are straighter and have a better finish than the round stock that is ordinarily obtained.

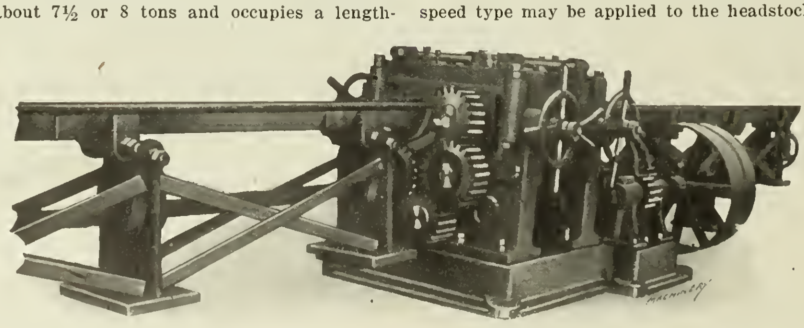


Fig. 3. Kane & Roach No. 18 Hot Roll Straightener

OLIVER MACHINERY CO.'S LATHES

The engine lathes illustrated in Figs. 1 and 2 are recent products of the Oliver Machinery Co., Coldbrook and Clancy Sts., Grand Rapids, Mich. The 26-inch heavy-duty lathe illustrated in Fig. 1 has an all-geared headstock and it may be motor-driven as shown in the illustration or arranged for a single-pulley belt drive. Twelve spindle speeds varying from 8 to 300 revolutions per minute are available. The speed control levers are conveniently located at the front of the headstock and the speed changing mechanism operates on the selective principle. The front spindle bearing is 6½ by 10 inches, and the rear bearing 4½ by 7 inches. The hole through the spindle is large enough to receive a 3-inch bar of stock. The tailstock spindle is 4 inches in diameter and is rigidly held by clamps acting on two sides. The tailstock is adjusted along the bed by means of a crank connected through gearing with the feed rack.

The carriage has a length of 40 inches on the shears and there are two methods of adjusting it by hand. One is by means of the regular handwheel which is used when the carriage is in position for taking a cut, and the other by using a rapid-motion crank which is applied to the extended end of the intermediate gear shaft between the handwheel and rack pinion shaft. The apron is of the double-plate box type with bearings at both ends of each shaft. The apron has a removable front plate which gives access to the internal mechanism without removing the entire apron from the lathe. Both the longitudinal and cross feeds are friction-driven and may be thrown into action by means of the same lever. The arrangement is such, however, that both feeds cannot be engaged at the same time, and means are also provided for locking the feed mechanism against operation when the lead-screw is in use.

The changes for feeding and thread cutting are obtained from the quick-change gear-box below the headstock. Thirty-three feed changes are available, ranging from 0.013 to 0.333 inch per revolution of the spindle. Thirty-three threads varying from 1 to 16 per inch may also be cut by simply changing the lever positions as indicated by the table on the gear-box. Either direct- or alternating-current motors of the constant-speed type may be applied to the headstock, and from 7½- to 15-horsepower motors are recommended, the size depending somewhat upon the nature of the work. The taper attachment is secured in place by a wide planed slide on the back of the bed, which has a T-slot in it to which the

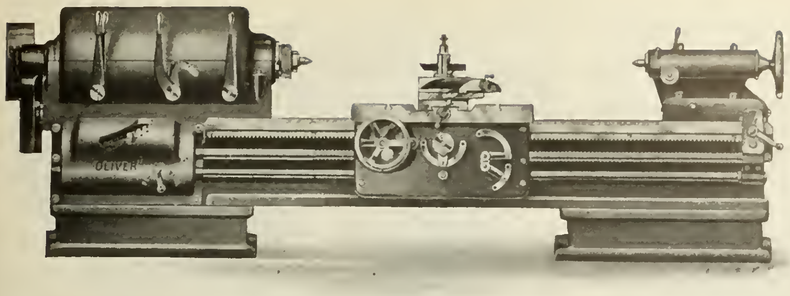


Fig. 1. Oliver Heavy-duty 26-inch Engine Lathe

holding bolts are locked. The swing over the bed is 28½ inches, and over the carriage, 17 inches. The maximum length between the centers is 72 inches. The general massiveness of the design throughout is apparent from the illustration.

The speed lathe illustrated in Fig. 2 swings a diameter of 12 inches over the bed and 9½ inches over the carriage. The machine will turn a length of 36 inches between the centers with a bed 60 inches long. This lathe is regularly equipped with a hand-feeding carriage and a compound swivel rest, but these may be omitted and a plain bed furnished if desired. The spindle has Parsons white bronze ring-oiling bearings that are adjustable for wear. The end thrust is taken at the ends of the cone pulley, which bear against bronze bushings. Adjustment is made by expanding the cone, the smallest step being threaded into the main part of the cone pulley. A motor drive may be applied to this lathe if desired. A special double adjustable motor bracket with foot-lever control is mounted below the headstock on the floor and attached to the machine leg. On this bracket a one-horsepower constant-speed motor is located. The motor shaft, which is extended and supported at the outer end, carries a four-step cone pulley, from which an endless leather belt runs through the enlarged headstock up to the headstock cone pulley.

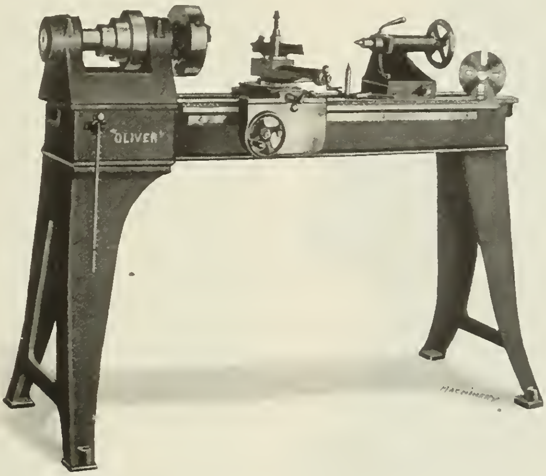


Fig. 2. Oliver 12-inch Speed Lathe

AKIMOFF DYNAMIC BALANCING MACHINE

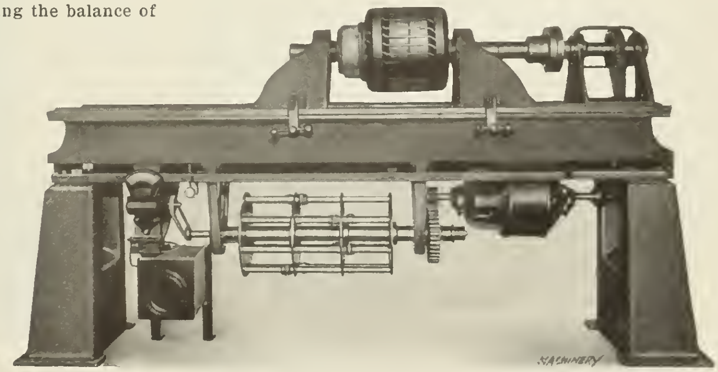
Manufacturers of high-speed machinery realize the importance of a dynamic or running balance for parts which revolve rapidly, in order to prevent trouble from vibration, excessive power consumption and abnormal wear of the bearings. The machine illustrated herewith is used for testing the balance of such parts as motor armatures, turbine rotors, automobile crankshafts, etc. It is manufactured by the Dynamic Balancing Machine Co., Philadelphia, Pa. Balancing the rotating elements of electrical machinery and automobile crankshafts has, up to the present time, been the most successful application of this machine. The illustration shows the machine arranged for testing the balance of a motor armature. The power for revolving this armature and the balancing element of the machine is derived from a Westinghouse motor.

When a body is balanced statically and not dynamically, two masses on opposite sides of the axis of rotation, located axially at a distance from each other, form a couple which develops vibrations when revolving at high speed, as noted in defective commutators in electrical machinery, etc.

The Akimoff dynamic balancing machine furnishes means for determining the magnitude and plane of the couple, by the establishment of another couple, which, while maintaining the static balance, counteracts the couple which produces dynamic unbalance. The magnitude and plane of this couple indicates the correction to be applied to the body that is being tested to produce a perfect dynamic balance.

A rigid horizontal beam or bed is hinged at one end of the machine and supported by a spring at the other. The body to be tested, which should be in perfect static balance, is rotatively supported on the beam to vibrate in a vertical plane. The object of the spring is to amplify the vibrations. A so-called "squirrel cage" is located on the under side of the beam, and in operation is rotated in unison with the body being tested. This squirrel cage consists of two circular disks carrying an even number of rods, arranged slidably in the two disks and parallel to the axis of rotation of the cages. When the ends of the rods are in one plane, the cage is in both static and dynamic balance, but if two opposite rods are displaced, the dynamic balance is destroyed and the couple produced will itself cause vibration of the beam. One pair of rods in the squirrel cage would suffice if the relative position of the rods could be altered through the transmission device, but for convenience three or four pairs are employed, and even then it is sometimes necessary to change the angular position of the cage so that it will be possible to do the balancing by one pair of rods and not two.

In making the test of a body, the cage is adjusted so that the vibrations produced in the beam by the body are counteracted by those set up by the squirrel cage. An arrangement by which the rods of the cage may be adjusted axially while the cage is in rotation is provided, and the rods can thus be shifted the necessary amount until the desired balancing effect is produced.



Akimoff Dynamic Balancing Machine

STANDARD FUSE BASE MILLING MACHINE

A highly specialized type of milling machine has been constructed by the Standard Mfg. Co., Bridgeport, Conn., for milling fuse bases. This machine is illustrated in Fig. 1, and an example of its work is shown in Fig. 2. The operation consists in milling two grooves across the fuse base at right angles to each other. After the base is inserted in the work-holding table, it is located in the correct position for milling the two grooves, and, after the milling operation, is ejected automatically. This machine is capable of cross-milling these fuse bases, as shown, at the rate of 900 an hour. It is driven by a belt operating on pulley *A*. This pulley transmits motion, through worm-gearing, to a cam-shaft, from which all parts of the machine receive their motion except the cutter-spindles. The two cutter-spindles are located at *B* and *C*. Both of these are carried by a vertical slide, which receives motion from a cam acting through lever *D*. By means of this lever the two cutters are moved downward for milling a groove of the required depth; and after the cutters have been located verti-

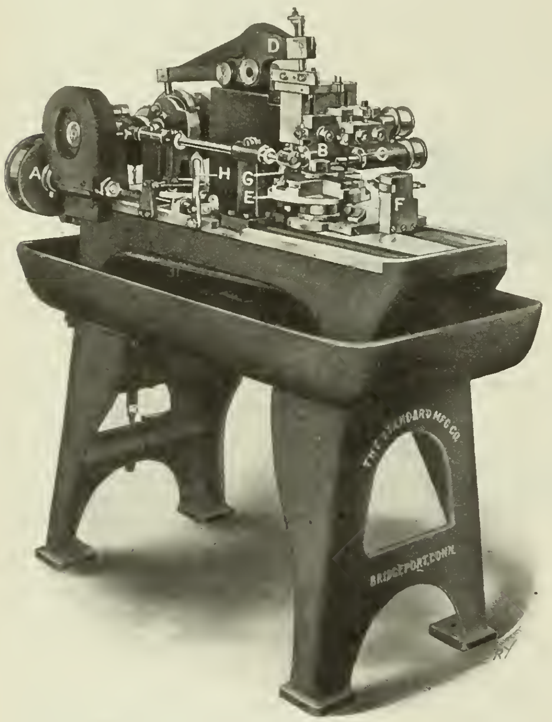


Fig. 1. Special Machine designed by Standard Mfg. Co. for milling Fuse Bases

cally they are traversed across the fuse base by a horizontal slide, the action of which is controlled by a cam on the rear shaft.

As soon as a cut is completed, the cutters are raised by the cam-operated lever *D*, and during the return stroke of the horizontal slide the work-table *E* is indexed. This indexing movement is also derived from a cam on the rear cam-shaft, and after indexing, the work-table is securely locked in position. The bearing block for cutter-spindle *B* has both vertical and horizontal adjustment for changing the position of the cutter relative to the work. The bearing block for spindle *C* may also be adjusted vertically and horizontally independently of spindle *B*. Both the cutter-spindles are rotated from one belt, which operates over the small flanged pulleys shown in the illustration. The connection between lever *D* and the vertical slide carrying the cutter-spindles is provided with a micrometer adjustment for accurately regulating the depth of cut.

The work-table *E* is provided with hardened fixtures for receiving the work, and block *F* serves to locate each fuse base after the work-table indexes from the "loading position." When the work has been indexed past this locating block, it is held firmly in position by the action of a plunger beneath it, which is forced upward by a cam surface below the work-table. After the milling operations are completed, the work is released and ejected from the work-table by a finger *G*. The starting or stopping of the machine is controlled by the vertical lever *H*, which operates a clutch on the worm-wheel shaft. When a groove is milled by the cutter on spindle *C*, the fuse base is indexed 90 degrees, thus locating the first groove at right angles to the cutter on spindle *B*, which mills the second groove. Both cutters operate at the same time, so that a finished part is ejected from the machine each time the work-table indexes.

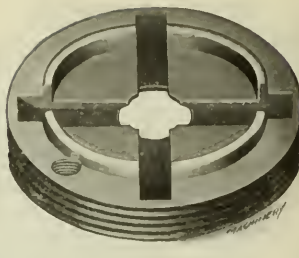


Fig. 2. Fuse Base which is milled in Machine shown in Fig. 1

STEEL PRODUCTS ENGINEERING CO.'S GAGE GRINDER

The universal gage grinder now being manufactured by the Steel Products Engineering Co., Springfield, Ohio, is adapted for grinding all classes of snap or master gages and it may also be used for various classes of special work. Gages having a maximum depth of 4½ inches and a maximum length of 21½ inches may be ground. Fig. 1 illustrates the general construction of the machine, and Fig. 2 shows more clearly the relation between the grinding wheel and the work-table.

The wheel-spindle is of the floating type designed to eliminate the jerk of the driving belt. The cross-feed is operated by the hand-lever seen at the left-hand end of the table in Fig. 1, which transmits motion through a rack and pinion. This lever provides a quick movement for removing an excessive amount of stock. In conjunction with this lever feed a fine feeding movement may be obtained by a handwheel which connects with a screw of fine pitch. This feeding movement is used when extreme accuracy is required or when it is desired to obtain a smooth finish.

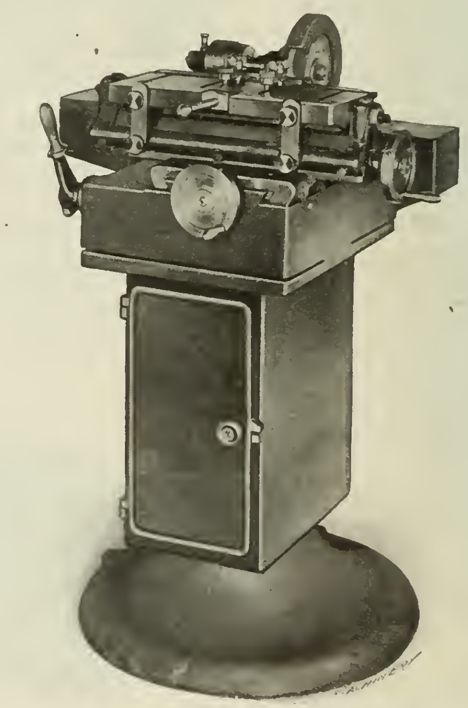


Fig. 1. No. 1 Universal Gage Grinder built by Steel Products Engineering Co.

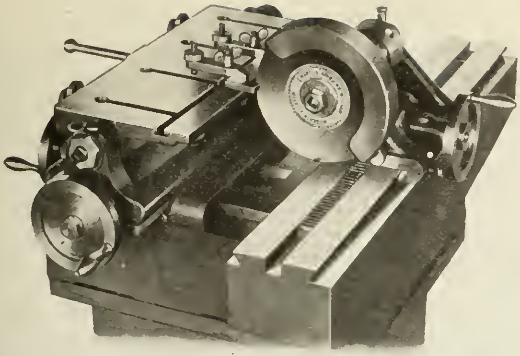
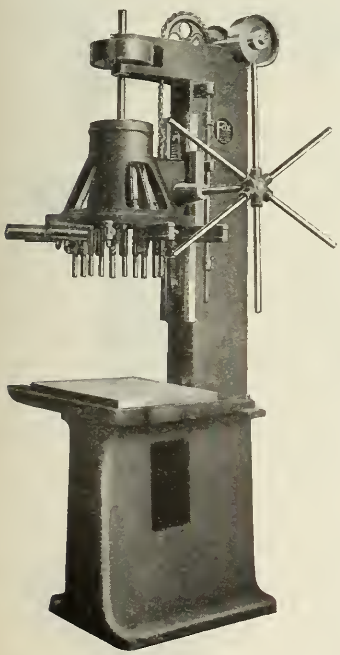


Fig. 2. Work-table and Wheel-slide of Gage Grinder

The ways on which the carriage slides, are covered with telescoping dust guards to protect the bearing surfaces. The table has a flat working surface on which the gages or other parts are fastened by means of strap clamps as illustrated in Fig. 2. A gage is used for locating duplicate parts. The table may be tilted upward or downward through an included angle of 10 degrees. This adjustment permits locating the center of gages of different thicknesses in line with the center of the wheel. The traversing movement is regulated by a feed-screw and handwheel graduated to read to 0.0005 inch. The table may be traversed 4¼ inches by means of this handwheel, and an additional 17½ inches in the same direction by the spindle-head adjustment. The stand or base of the machine has compartments for storing tools, grinding wheels, etc.

FOX MULTIPLE-SPINDLE DRILLING MACHINE

A small multiple-spindle drilling machine of the sensitive type is the latest addition to the line of drilling machines manufactured by the Fox Machine Co., 1401 W. Ganson St., Jackson, Mich. This machine, as it is regularly built, is shown in the accompanying illustration; it can, however, be converted into a machine of the bench type, if so desired, by mounting it on a suitable baseplate. The table is cast separate from the base so that tables of different size or special fixtures can be mounted on the base. The table has a wide oil flange in which are cast T-slots for receiving clamping bolts so that jig stops may be fastened to the table.



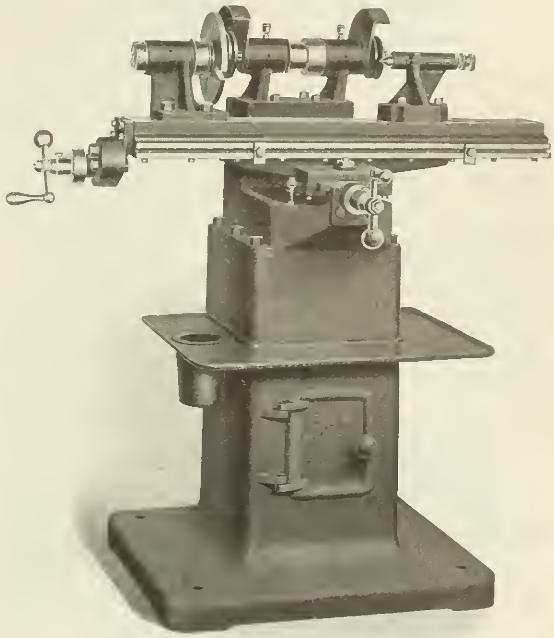
Fox D-01 Sensitive Multiple-spindle Drilling Machine

These machines are equipped with either 9-inch or 12-inch round heads. These heads can be provided with from two to ten spindles one inch diameter or from two to sixteen ¾-inch spindles. A six-arm pilot wheel keyed to the rack pinion shaft gives sufficient leverage for feeding the drills easily. All pinions are of open-hearth machinery steel (0.30 per cent carbon) and have double bearings turned integral with them. The gears run constantly in an oil bath.

This machine has a new type of adjusting arm, so that the adjustments may be made rapidly and the bearing held securely to the arm. The universal joints used in the machine are composed of three wearing parts only. The two forks and the center are milled from the solid and are hardened. No pins, screws or rivets are used in the construction of these joints. The drill spindles are of crucible steel, and provision is made for receiving the thrust upon ball bearings. The manufacturer is prepared to furnish cluster plates for these machines. These plates are used for a complicated lay-out when arms of the regular type cannot be employed.

RAM GRINDING MACHINE

The grinding machine illustrated herewith is manufactured by the Richmond Adding & Listing Machine Co., Richmond, Ind. While this machine is known as a plain grinder, it is adapted for internal as well as external grinding operations, and is equipped with an adjustable tailstock which permits taper work to be ground. The machine may be used for tapers up to 10 or 15 degrees, the angle depending upon the length



Ram Grinding Machine built by Richmond Adding & Listing Machine Co.

of the work. The longitudinal and cross feeding movements are hand-operated and the feed-screw dials are graduated for adjustments of 0.001 inch. The machine has a swing of 10 inches and will take 28 inches between centers. Grinding wheels 8 inches in diameter and 1 inch wide can be used. The wheel-spindle is hardened and ground and is mounted in adjustable manganese-bronze bearings. The headstock spindle is threaded to receive a chuck and faceplate and is provided with adjustable manganese-bronze bearings. The tailstock spindle is operated by a spring lever to permit inserting and removing work rapidly. It also has an adjusting screw and lock-nut for holding the center rigidly when grinding heavy parts. The attachments for this machine include a headstock for cylindrical grinding, a headstock for internal grinding, 3½-inch and 8-inch faceplates, a tooth rest for use when grinding small cutters, reamers, etc., and a clamp post for wheel dressing.

ENTERPRISE PUNCH PRESS

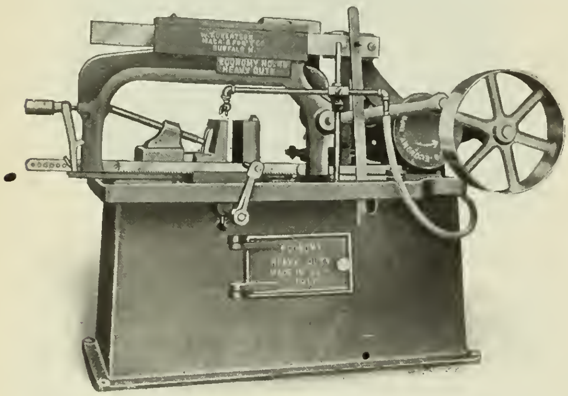
A small power-driven punch press of the bench type has been brought out by the Enterprise Machinery Co., 34 S. Clinton St., Chicago, Ill. The aim of the manufacturer has been to produce a power press which will not cost more than

Power-driven Punch Press of Bench Type

foot-operated presses and will do the same work by power. This machine is intended for the use of jewelers or manufacturers of electrical parts and work made of light metal, fiber or wire. The press may be bolted in an inclined position for discharging by gravity and can be fitted with an automatic feed for high-speed production. The stroke is ¾ inch and there is ½-inch adjustment. The depth of the throat is 3⅜ inches, and the die space, 4 inches. There are two striking pins, a brake and a standard clutch. This punch press is 20 inches high and weighs 110 pounds.

ROBERTSON HEAVY-DUTY POWER SAW

The W. Robertson Machine & Foundry Co., 56-58 Rano St., Buffalo, N. Y., is now manufacturing a heavy-duty power saw having a capacity of 8 by 8 inches. This machine uses blades varying from 10 to 17 inches in length, and like the other sizes built by this company, cuts on the draw stroke and lifts on the return stroke. The lifting of the frame to prevent the teeth from dragging over the work is effected by an oil compression lift, consisting of a two-cylinder plunger pump submerged in oil contained in a tank beneath the bed. One plunger is connected to and timed with the crankshaft, and the other is connected to the frame. In one cylinder there is a steel ball which acts as a valve. On the cutting stroke oil is drawn into the cylinder, and at the end of this stroke the ball seats, and the plunger starts downward, which forces the opposite plunger connected with the frame upward, thus relieving the saw on the return stroke. At the end of this idle or return stroke, the plunger passes a small port in the cylinder wall, which allows the oil to escape into the tank, so that the saw blade comes down into contact with the work for the cutting stroke. By means of a simple adjustment the lift may be varied from 0 to ⅜ inch.

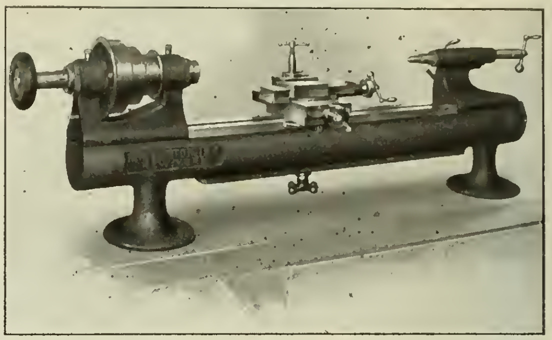


No. 40 Power Saw manufactured by W. Robertson Machine & Foundry Co.

The box base forms a large receptacle for holding the cooling liquid, which is delivered to the saw blade by a piston pump, operated by an eccentric. The volume of liquid is controlled by a cock at the end of the supply line, and any surplus drawn into the pump is returned to the tank by the automatic action of a valve in the pump. The pump valves are steel balls operated by suction and gravity. The machine vise is a quick-acting type and swivels to 45 degrees for cutting at an angle. The weight on the saw blade when cutting may be varied from 0 to 65 pounds. The machine can be furnished with legs instead of the box base if desired, and with either a belt or motor drive. It is also made in either single-speed or two-speed types.

COTTON BENCH LATHE

H. W. Cotton, Inc., 233 Broadway, New York City, is the manufacturer of the bench lathe illustrated herewith. This lathe has a swing of 7 inches and a 36-inch bed. The collet capacity is for diameters up to ⅝ inch. The spindle has the usual 3- and 45-degree angles, as this form of spindle has met with general approval. The spindle bearings are oiled from a channel around the outside of the bearings in the headstock. The oil is conveyed from the oil-well through a piece of felt placed in a slot in the bottom of the bearings and extending upward to the spindle. This arrangement allows any foreign matter which may enter the oil chambers to settle to the bottom, and the felt makes it impossible for the grit to reach the spindle bearings; in addition, this provides a continuous oiling system. The bench lathe is provided with either a two-speed or three-speed countershaft as desired, and with a 12-inch grooved pulley for grinding with the usual grinding attachments.



Cotton 7-inch Bench Lathe

NOBLE & WESTBROOK FILING MACHINE

The filing machine shown in the accompanying illustration was developed by the Noble & Westbrook Mfg. Co., Hartford, Conn. The machine is equipped with a three-step cone pulley for the driving belt, as experience has demonstrated that changes of speed are an advantage for filing varying classes of work. The foot-treadle seen at the base of the machine is connected to a clutch in the main drive and provides a convenient method of control. When the foot-treadle is pushed down by the operator, the machine is started, and when it is released the reciprocating motion of the file is immediately discontinued. The lower end of the file is steadied by a hardened roller bearing, which may be adjusted by knurled adjusting screws at the sides of the table. As this bearing takes the lateral thrust against the file, the latter may be subjected to considerable pressure when rough-filing without bending and breaking the file.

Noble & Westbrook Filing Machine

All bearings are made of phosphor-bronze and the working parts are above the file, so that the fine chips or filings cannot enter the bearing surfaces and cause excessive wear. When the machine is used for angular work, such

as filing the clearance in blanking dies, etc., the table remains fixed and the head is adjusted. The circular flange at the base of this head is graduated so that the file can be set at whatever angle is required without the use of a bevel protractor. The table is solidly supported by the column of the machine. The stroke of the file may be adjusted from 1½ inch to 2½ inches. The machine is provided with an adjustable chuck for holding standard straight files without any additional work, such as babbitting, etc.

THERMALENE FOR WELDING AND CUTTING METALS

The Thermalene Co., Chicago Heights, Ill., is manufacturing the welding and cutting outfit shown in Fig. 1. The thermalene used in connection with this apparatus differs in composition and method of production from the gases heretofore used in welding, cutting and brazing operations. Thermalene

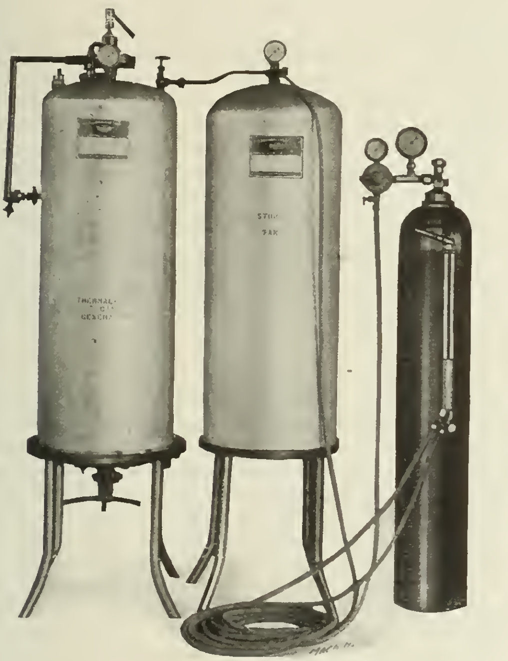


Fig. 1. Thermalene Welding and Cutting Apparatus

is a combination produced by the decomposition of calcium carbide and hydro-carbon oils, the heat generated by the carbide being used to vaporize the oils. The thermalene gas generator is shown at the left in Fig. 1 and the storage tank in the center. This acetylene oil gas may be used not only for welding, cutting, brazing and soldering metals, but also for lighting heating laboratory work and for a variety of miscellaneous purposes. Ten pounds of carbide and one and one-half pint of crude oil mixed with sawdust generates about 60 cubic feet of acetylene oil gas at a cost of 25 cents. This gas was formerly made in two separate plants, but with the apparatus here illustrated the gas may be generated at one time under any pressure desired and without danger from explosion or overheating of the carbide.

Fig. 2 shows an automatic seam-welding machine for welding tubes; this was built especially for making tubing from scrap rails, which contains a great deal of carbon. It is claimed that this work could not be done with acetylene and oxygen, but that thermalene, being a heavier and richer gas, mixes better with oxygen and produces satisfactory welds. This seam-welding machine operates at the rate of 30 to 34 inches per minute, and as it is a duplex type, from 60 to 68 inches per minute of 1¼-inch tubing of No. 14 inch gage may be welded. Thermalene

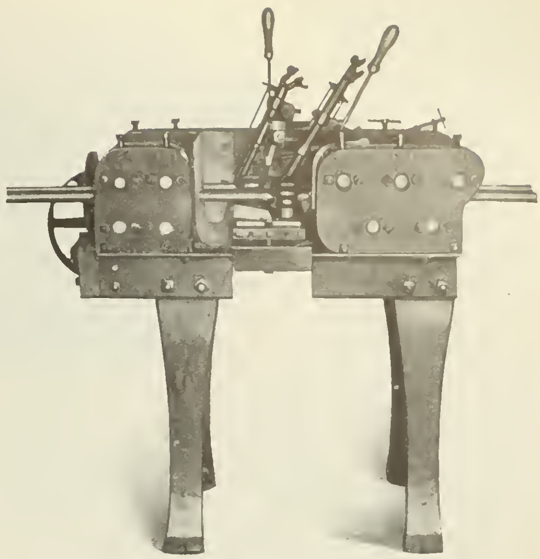


Fig. 2. Automatic Seam-welding Machine for Tubes, which operates with Thermalene Gas

gas is said to make a weld that is not brittle, and cast iron welded with it can always be machined.

BICKFORD TWIST DRILL FLUTING MACHINE

The twist drill fluting machine illustrated herewith is made by the Bickford Machine Co., Greenfield, Mass. This machine has been redesigned and embodies a number of important features not found in the type formerly manufactured. The drill blank to be fluted is held in a chuck, and the drill advances through a bushing which supports it while the cutter is milling the flute. After the drill blank is inserted in the chuck, the operation of the machine is entirely automatic until the two flutes are milled, when the feed is discontinued. The carriage, which holds the drill chuck, is moved forward and back by a crank-wheel, the crankpin of which engages a slot in an L-shaped arm as shown in Fig. 2. With this arrangement the carriage is given a practically constant rate of motion while the drill flute is being milled. This uniform movement is obtained by placing the fulcrum of the slotted lever out of line with the slot in which the crank-block travels.

The angle between the cutter-spindle and the line of carriage travel or the axis of the drill blank may be varied. A train of gearing between the cutter-spindle and feed shaft enables different feed ratios between the shafts to be obtained. The drill blank has a relatively high speed while the cutter is not working and a low speed while the flutes or grooves are being milled. This change is effected by a gear-box containing a set of differential gearing and clutches with means for shifting

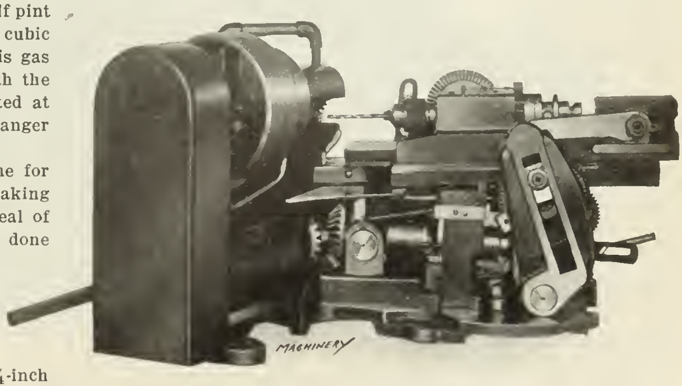


Fig. 1. Bickford Twist Drill Fluting Machine

from high to low speed and *vice versa*. This change of feed is controlled by a set of adjustable trip dogs mounted on the periphery of the crank-wheel. A rotating motion is given to the drill blank as the carriage slide advances, through a combination of spur and bevel gearing. This machine is so arranged that the lead of the spiral and the increase in the lead or twist may be varied. The combination of a friction plate, clutches and trip dogs serves to stop the rotation of the drill blank temporarily during its backward travel while the rotating mechanism is still operating, so that the drill blank is indexed for milling the second flute or groove. Provision is made for adjusting the movement of the carriage slide both for length and position.

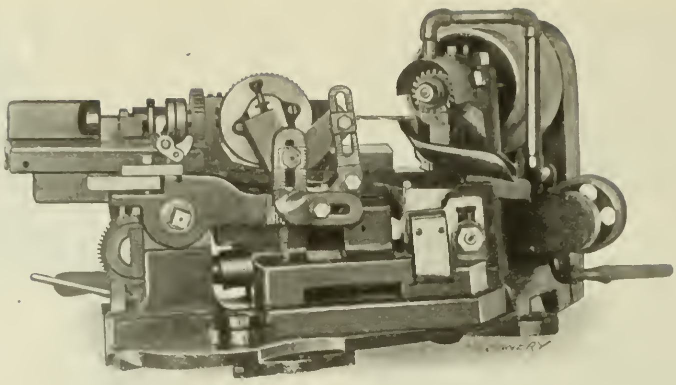


Fig. 2. Opposite Side of Bickford Fluting Machine

PUTNAM HEAVY-DUTY CAR-WHEEL GRINDER

A heavy-duty car-wheel grinder has been developed by the Putnam Machine Co., Fitchburg, Mass., that has a capacity in wheel diameters from 28 to 42 inches over the tread. The actual swing of the machine is 44 inches and axles up to 8 feet in length can be placed between the centers. The machine is entirely self-contained, as shown in the accompanying illustration, and the driven parts are directly connected to motors, thus eliminating belts. The faceplates have an independent motor drive, power being transmitted through a large shaft and gearing giving a suitable speed reduction. The faceplates are equipped with patented non-slip driving dogs which require no adjustment other than to release them by hand when the wheels are in position. The design of the dogs is such that the engagement is entirely automatic. The main spindles have adjustable sleeves so that variations in different axles are automatically compensated for and the "dogging distance" from the faceplate to the face of the wheel remains constant.

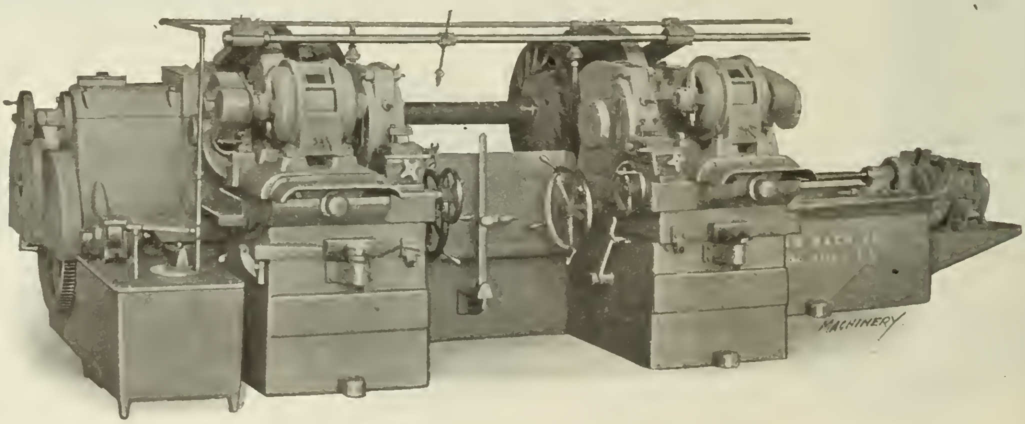
The grinding wheels are mounted on large high-carbon steel spindles with tapered bronze bearings having oil reservoirs. Ball bearings are used to take the thrust of the spindles. The bases for the grinding wheel slides are cast integral with the main bed of the machine, which gives a rigid support and insures a permanent alignment for the grinding-wheel spindles. The grinding wheels may be adjusted for the different standard wheel contours by a simple mechanism which may be operated while the machine is running. The grinding wheels are driven by means of individual motors which are directly connected to them through gearing.

Provision is made for furnishing a cooling compound to the working faces of the grinding wheels by means of a motor-driven pump and the necessary piping. Special pans and channels are provided throughout to confine the spray and prevent, as far as possible, the splashing of the cooling compound about the machine and floor. All gears and other dangerous parts are carefully guarded. The headstock of this machine is solidly bolted to the bed and the tailstock may be adjusted longitudinally by power derived from a separate motor. The tailstock is equipped with a patented automatic clamping device so that as it reaches the operating position it is clamped rigidly to the bed. The machine has a self-contained calipering attachment which forms part of the regular equipment. The net weight of the machine is 5000 pounds.

FEED MECHANISM FOR ANDERSON DIE FORMING MACHINE

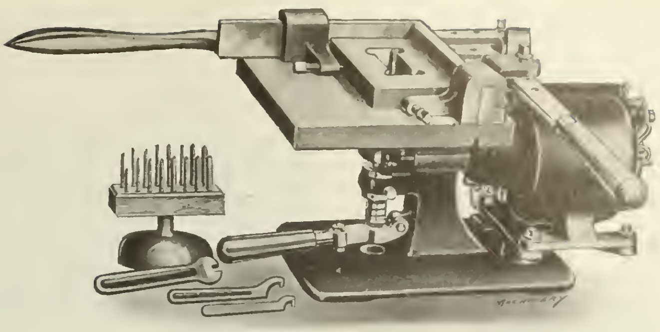
The first conception of the Anderson die forming machine and "super-helical" cutters was the result of an effort to find some more rapid way of performing those operations in the making of a die which were done by filing, either in a machine or by hand. Used by hand, a file requires great skill in order to secure satisfactory results, and when used in the machine it must be applied on one side only in order to make the draft or clearance uniform. With the use of the Anderson "super-helical" cutters in the die forming machine, the clearance is secured by tapering the cutter the proper amount; then by having the axis of the cutter at right angles with the table or platen a clearance will be produced in the die that is equal to the degree of taper on one side of the cutter, no matter from what direction the die is applied to the cutter.

In its original form, no mechanical means were provided on the die forming machine for controlling the die during the operation. This shortcoming has been realized by experience, and has led to the development of a universal pivoted feeding mechanism, illustrated in the accompanying illustration, which requires little or no explanation to make it clear to the average mechanic. The die rests upon the table or platen, and is secured to an arm or fixture by a pair of adjustable dogs or clamps. This fixture also rests on the platen and is pivoted to a lever at the rear of the platen. The lever



Car-wheel Grinder built by Putnam Machine Co.

has a series of holes placed about an inch apart, into which a plug can be inserted after passing through one side of a forked projection. This serves to locate the fixture and die so as to reach the opening in the die. The lever, in turn, is pivoted to an arm extending from and secured to the table. The pivot point for the lever is adjustable so that fixture and arm can be moved forward and backward in order to reach any part of the die.



Anderson Die Forming Machine with Universal Pivoted Feeding Mechanism

If the operator should desire to feed the die by hand in fitting a templet, the fixture can be removed in five seconds and placed on the bench, leaving the platen free. When the fixture and lever have been adjusted to the best location with respect to the opening in the die, the machine or cutter is started, and the die can be fed or guided so as to finish practically any outline without the operator's touching the die with his hands. From the foregoing it will be readily seen that this principle has made it possible to provide a means for guiding the die that relieves the operator of the necessity of holding the die with his hand, and still is so sensitive that the most intricate outline can be followed without difficulty. This fixture is now furnished as regular equipment on the No. 1 die forming machine made by the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn.

THOMSON THREAD MILLING MACHINE

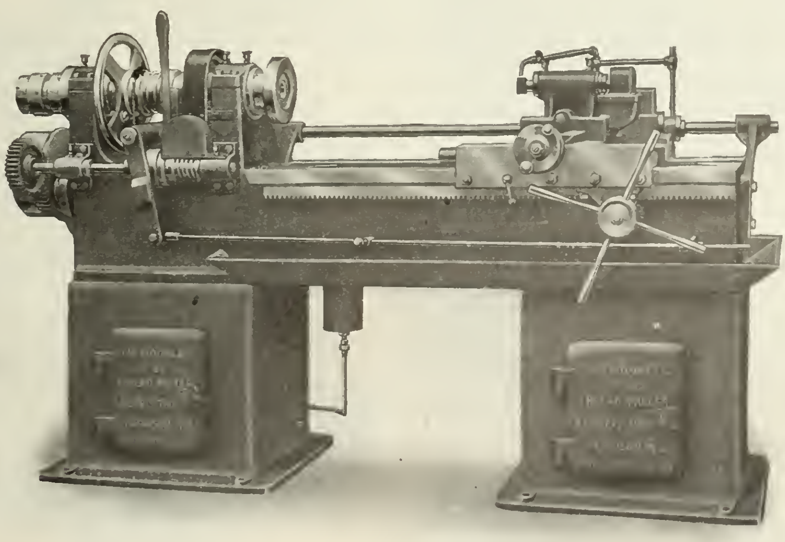
The machine which forms the subject of the following description is known as a Type 6-C thread miller and is built by the T. C. M. Mfg. Co., Hunterdon and First Sts., Harrison, N. J. It is suitable for milling internal or external threads on pieces up to 6 inches in diameter by 34 inches in length, and finds application in threading the smaller sizes of shells, water jackets, trunnion blocks, and other parts of machine guns. The machine is also employed for threading automobile parts, such as hubs, differential cases, universal joint members, and other parts having a comparatively short thread of a pitch not greater than ten threads per inch. This machine only performs the threading operation and no provision has been made for facing the work.

The spindle is made of steel and is 3 inches in diameter with a hole 1½ inch in diameter running through it. Heavy split bronze bearings support the spindle, and a threaded sleeve is fastened to the rear end to give the required lead to the thread that is being cut. This sleeve is engaged by a bronze nut which is split to provide means of compensating for wear, and these parts are easily exchanged for others suitable for cutting threads of different pitch. The front end of the spindle carries a faceplate to which a chuck or special fixture can be bolted, according to the requirements of the work that is being operated upon.

The cutter-spindle is made of tool steel hardened and ground to size. It runs in conical bronze bearings which are easily adjusted to compensate for wear. A cross-slide on the main carriage supports the cutter-head, and is operated by a feed-screw with a large graduated collar to give accurate adjustment for depth of cut. A substantial stop provided with micrometer adjustment enables accurate dimensions to be held on repetition work. The main carriage is traversed along the ways by a rack and pinion and its location is determined by the aid of an adjustable stop which is so designed that it may be rapidly operated.

The cutter-head is firmly locked to the carriage, and the carriage to the bed of the machine during the time that the thread is being milled, the only moving parts being the work-spindle, the work and the revolving cutter. This arrangement, together with the lead-nut, which is practically one piece with the work, insures obtaining a maximum degree of accuracy and the greatest possible speed and feed without trouble from chatter. The cutter is driven by skew gearing from a longitudinal shaft placed at the rear of the machine, and a single pulley transmits the power to both cutter- and work-spindles. A clutch operated by a hand-rod along the front of the machine gives the operator complete control over the work. This clutch is automatically thrown out when the thread milling operation has been completed, without requiring attention from the operator.

The regular equipment furnished with the machine includes the following: an oil pump and piping, a six-inch scroll chuck, a set of change-speed gears, a steadyrest, one multi-cutter of the desired pitch, and a set of wrenches for making all adjustments. The machine is driven by a countershaft having pulleys 12 inches in diameter by 4 inches face width, which run at 300 revolutions per minute. The machine pulley speed is 200 revolutions per minute, and five horsepower is required for driving the machine. The principal dimensions of the machine are as follows: capacity, for handling work up to 6 inches in diameter by 34 inches in length; over-all length of machine, 6 feet, 6 inches; over-all width, 3 feet; and weight of machine, complete, 2800 pounds.



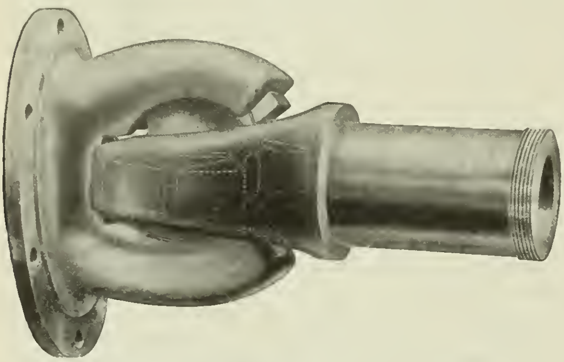
Type 6-C Thread Milling Machine built by the T. C. M. Mfg. Co.

PLANK UNIVERSAL JOINT

For use in pleasure cars and commercial trucks, the Plank Flexible Shaft Machine Co., Grand Rapids, Mich., has recently placed on the market the three-piece universal joint illustrated and described. This joint is of simple construction, there being only three working parts, namely, a center block, a slip-end shaft yoke and one transmission flange yoke. These three parts make up the complete joint, and they are enclosed in a pressed-steel grease-tight housing which keeps all foreign matter out of the working parts of the joint and at the same time retains the lubricant.

A feature of the design is the liberal amount of bearing surface provided in the joint, which means that it will be correspondingly long lived. Lubrication is effected by centrifugal force which distributes the lubricant from the dead center toward the bearings. The bearings of the center block are housed in by a grooved yoke construction which retains the lubricant in the proper place at all times. This construction prevents the lubricant from being thrown away from the bearings by centrifugal force.

The center block is locked within the grooved yoke housing by means of a special construction which provides a bearing



Improved Three-piece Universal Joint made by Plank Flexible Shaft Machine Co.

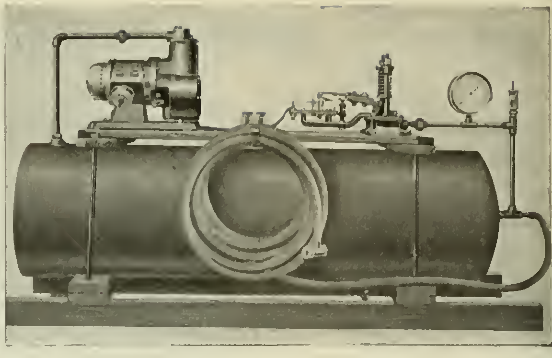
greater than 180 degrees and allows the center block, the outside diameter of which is equal to the inside diameter of the housing, to be circular. In this way a goodly amount of metal extends beyond the 180-degree center line and forms an interlock which will not allow the center block to be ejected. As a result, the center block is retained in its proper place without the use of pins, bushings, rivets or other parts.

All metal parts of this universal joint are made of drop-forgings, produced from a high grade of steel, and these are carefully machined. It is the intention to employ this same form of interlock construction in a smaller universal joint for use on milling machines, multiple-spindle drilling machines, etc. The design has been worked out in such a way that torsional strains are distributed over as large an area as possible, thus providing great strength for the center blocks.

BLACK & DECKER "LECTROFLATER"

The Black & Decker Mfg. Co., Calvert and Lombard Sts., Baltimore, Md., is now manufacturing what is known as a No. 2 automatic "lectroflater" tank outfit. As suggested by its name, this is an electrically driven air compressor outfit developed especially for the purpose of inflating automobile tires. However, the outfit may be used to advantage as a portable air compressor for supplying such pneumatic tools as chipping hammers, riveters, etc., and in this class of service is capable of giving very satisfactory results.

To use the "lectroflater," it is simply necessary to connect the fuse block on the outfit with an electric light line, either alternating or direct current. It will immediately start working and keep on until the pressure in the tank reaches 150 pounds per square inch; then the automatic pressure switch shown on the right comes into action and stops the "lectroflater." When enough air has been used to cause the pressure



Black & Decker "Lectroflater" Tank Outfit for inflating Automobile Tires and operating Pneumatic Tools

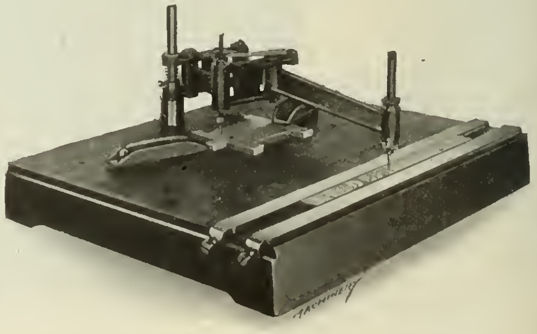
in the tank to drop to 120 pounds per square inch, the automatic switch starts the "lectroflater" again and brings the pressure back to 150 pounds per square inch and stops. Thus there will always be free air on tap, and plenty of pressure.

The "lectroflater" has no exposed mechanism, electrical or mechanical, so that it is impossible for anyone to be injured through coming in contact with moving armatures, gears, rods or shafts. These parts are enclosed and run in grease, which practically eliminates chance of accident and reduces wear to the minimum. A cover is furnished for the automatic switch on the right, completely enclosing all mechanical parts. All reciprocating parts are so accurately balanced that there is no vibration or pounding. This is the secret of long life in any machine. The lubrication of the "lectroflater" is entirely automatic, and it only requires repacking with grease about four times a year. This can be done in five minutes by the removal of a small plate and one grease cup. There is no expensive lubricating oil to buy and no danger of the outfit running dry and ruining itself on account of inattention. The cooling system is entirely automatic and requires no attention; and it has no liquid to freeze or evaporate. The automatic switch requires no attention and the large gage shows the exact pressure in the tank at all times. An automatic safety valve forms part of the outfit, as well as a drain cock for drawing off condensation at the under side of the tank.

The "lectroflater" system is so designed that in case an accident should happen to the compressor unit or the switch unit, either can be removed in five minutes by unscrewing one union and the base screws, and disconnecting two wires. The disabled unit can then be repaired and replaced with another. Universal motor windings will run on 110 volts direct current or alternating current of from 25 to 60 cycles. An outfit is also made with 220-volt windings. Length of outfit is 44 inches; width, 16 inches; height, 31 inches; weight, 140 pounds.

WASHINGTON ETCHING MACHINE

The distortion resulting from the use of hardened steel stamps for marking gages and other forms of measuring tools or delicate instruments is generally recognized among machinists and toolmakers. The etching machine illustrated



Washington Etching Machine for marking Fine Tools and Gages

herewith is designed for marking all sorts of fine tools which might be injured by the use of stamps. A suitable resist is applied to the surface of the hardened tool and the machine is used for tracing the letters or designs required, which are afterward cut into the surface by applying an etching fluid. The machine operates on the pantograph principle. It is equipped with metal matrices or copy blocks which can be arranged like type in any desired combination of letters or figures.

In use, the stylus is guided by these matrices and the tracing point reproduces the lettering or figures on a smaller scale. The pantograph mechanism gives a reduction of 4 to 1 so that if $\frac{1}{8}$-inch characters are required on the work, matrices with $\frac{1}{2}$-inch face are necessary. The part to be etched is held in position on the table of the machine by the clamps shown, and the matrices are held in proper alignment by two parallel strips or bars, as the illustration shows. This machine is the product of the Spicer Tabulating Machine Co., 3318 Volta Place, N. W., Washington, D. C.

BUCKEYE PORTABLE FILE SHARPENING MACHINE

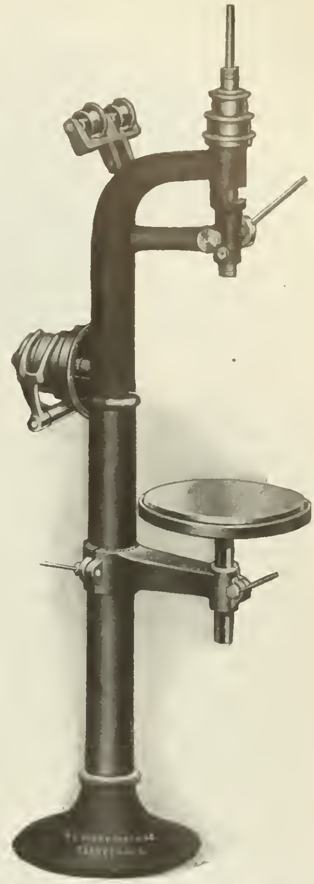
The Macleod Co., of 2232-2236 Bogen St., Cincinnati, Ohio, has brought out a file sharpening machine which is a portable self-contained unit that may be operated either by steam or compressed air. The file to be cleaned or sharpened is held at a fixed angle by suitable guides and is acted upon by a blast of either air or steam carrying in suspension an abrasive material. A few strokes of the file in each direction are all that is required. The air or steam pressure should vary from 80 to 150 pounds per square inch, the higher pressure giving a much better cutting action than the lower pressure. The abrasive is a special flint, which may be used repeatedly or as long as it possesses any cutting qualities. A water jet is used in the nozzle which prevents the file from becoming overheated and also prevents the formation of dust. When the abrasive is too small or light for service, it flows away with the surplus water through the overflow. After the abrasive is discharged against the file, it falls into a lower hopper and is then drawn up again to the operating nozzle by the suction of the air or steam, as the case may be. This apparatus may also be used as a sandblast for cleaning small castings, there being a hand-hole in the rear of the upper hopper through which articles may be inserted for cleaning.

Buckeye File Sharpening Machine, which may be operated either by Steam or Compressed Air

DEMOOY DRILLING MACHINE

In the October, 1916, number of MACHINERY a description was published of a sensitive bench drilling machine that had been placed on the market at that time by the DeMooy Machine Co., 1833 E. 55th St., Cleveland, Ohio. This firm is now manufacturing a drilling machine of essentially the same design except that it is provided with a stand, as illustrated, to adapt it for use as a floor machine instead of setting it up on the bench.

The principal dimensions of this machine are as follows: maximum distance from spindle to table, 37 inches; maximum vertical movement of spindle, 4 inches; maximum vertical movement of table, 7 inches; maximum vertical movement of sliding arm, 27 inches; diameter of table over oil groove, $11\frac{1}{2}$ inches; distance from center of spindle to frame, $7\frac{1}{2}$ inches; drilling capacity, for holes up to $\frac{1}{2}$ inch in diameter; size of tight and loose pulleys, 5 inches in diameter by $1\frac{5}{8}$ inch face width; speed of driving pulley, 350 revolutions per minute; height of machine, 64 inches; floor space occupied, 26 by 15 inches; and net weight of machine, 190 pounds.



Floor Type of Sensitive Drilling Machine made by DeMooy Machine Co.

PEDRICK HORIZONTAL BORING MACHINE

The possibilities of the horizontal boring machine recently placed on the market by the Pedrick Tool & Machine Co., 3639 Lawrence St., Philadelphia, Pa., for performing boring and drilling operations and work of a similar nature are well shown by the illustration presented in connection with the following description. Several inherent features of this company's portable cylinder boring-bar have been incorporated in the present design, and this has resulted in the production of a universal boring machine having a range for handling a great variety of work. It consists of a heavy bed to which are fitted two housings that are movable to suit conditions. T-slots are provided on both sides of the housings by means of which the bar supports are held in position at the required height above the bed. The main bearing for the boring-bar is a long quill with cross-heads at both ends which are bolted to the front housing on both sides. The quill is bored to fit the bar, and the cross members are faced from the bore so that proper alignment is insured for any setting. A handwheel shown in the illustration operates the elevating screw for raising or lowering the bar to the desired position.

For shops which prefer to use individual electric motor drive, a motor may be connected to the drive as shown in the illustration. The main gear is divided and the teeth in one part are opposite the spaces in the other part of the gear, thus imparting a smooth motion without appreciable backlash. Gearing from the motor to the drive is variable, and the motor

Horizontal Boring Machine built by Pedrick Tool & Machine Co.

may also be connected to either the primary or intermediate shafts of the drive, so that various speeds are readily obtainable for boring holes of different diameters. At the end of the bar there is a feed case which is automatic in action and provides three changes of feed. The boring-bar has a feed-screw in a recess on one side, thus permitting much longer traversing feed than the conventional traveling bar affords. Quick return of the bar is made possible by removing the half feed-nut and sliding the bar through the bearing. In the end of the bar there is a taper hole in which auxiliary bars or drills may be fitted for boring holes of smaller size than the main bar. Fitted with a main boring-bar three inches in diameter, this machine will bore from the smallest hole up to a hole six inches in diameter, and an important feature is that the bar may be used as a traveling bar or as a fixed bar upon which the cutter-head travels. Both of these movements are accomplished by the same mechanism, thus providing for handling a wide range of work.

If the hole being bored is large enough to be conveniently handled by the main boring-bar, the work is set up on the bed, and the bar with a proper sized cutter-head on it is fed through the hole and through the bearing on the back housing, so that the bar is rigidly supported at both ends and the cutter-head travels along it, boring the hole to the required diameter. If the hole being bored is smaller than the main bar, it is necessary to use an auxiliary bar, and in such a case the main bar travels and feeds the smaller one. It will be apparent from the illustration that very little mechanism is required to make a horizontal boring machine of unusual capacity, which is capable of producing accurate work and will machine a wide range of parts. For instance, the machine illustrated is used to bore holes in large machine castings, the diameters ranging from $2\frac{1}{2}$ to 6 inches and lengths from 24 to 36 inches, but these sizes do not represent the total range of the machine as regards either length or diameter. A table may be placed at right angles to the bed and provided with a cross-slide to adapt the machine for handling various classes of work which would not otherwise come within its range.

BLEVNEY FINISHING MACHINE

The accompanying illustrations show a Type F two-belt 6- by 14-inch finishing machine with a turret attachment for finishing flat surfaces that has recently been placed on the market by John C. Blevney, 209 Parkhurst St., Newark, N. J. Fig. 1 shows a machine with a turret attachment for finishing lock-fronts while secured to the lock, hinges, striking-plates, sash-lifts, escutcheon plates and planer blades; in another factory it surfaces all kinds of cutting dies, etc. The machine is of the Blevney two-belt system, having a cushion belt running over two pulleys, with an abrasive belt running above this and over a third pulley, held under proper tension by levers *A*. The new feature is a platen *B* formed of bars, between which bars move freely up and down hardened mortised platen blocks *C*, Fig. 2. These platen blocks are separated from one another by platen block separators *D*, and the blocks and separators are locked in position by the platen lock *E*. The platen blocks *C* have projections at the top against which a rubber cushion *F* presses. The projections are of a predetermined size in relation to the other end or contact surface.

The rubber cushion *F* is placed over these blocks, and over this goes the rubber cushion holder *G*. The pins provided on this are for the purpose of holding the weights *H* which are required to provide grinding pressure. A lever *I* when in the position shown in Fig. 1 holds the platen from contact with the belts, and so stops grinding or finishing; when in the position shown in Fig. 2, the platen is acting upon the belt. Platen *B* is reciprocated by the crank *J*, Fig. 1, which is adjustable so as to give more or less reciprocation, according to the requirements of the work. It will be seen that with the belts resting on the work, the platen blocks, under pressure of the weights pressing through the rubber cushion, will cause the belts to conform to the irregularities in shape of the work; because of the rubber cushion, the belts press harder on the high points of the work than on the low points, so that in the grinding action the high points are cut down, while the low points are less affected. This action is increased by the reciprocation of the platen, and may be compared with an operator trying to find the high and low places while finishing work on a wheel.

Below the belts there is a side oscillating table *K*, the oscillations of which are adjustable by crank *L* as to length, and by screw *M* for centering in relation to the belts. On this plate is placed turret *N*, the face of which is H-shaped, and its bar extensions have holes. The two tables *O* are provided with pins which register with the holes in the turret. These tables *O* have other holes which serve to hold, with corresponding pins, the work-holding plate *P*. Work-holder *P* may be provided with pins or bars to hold the work from sliding sideways; and the belts hold it down on the plate.

In setting the machine, place the work on holder *P*, have stop *I* in the position shown in Fig. 1, rotate the turret to

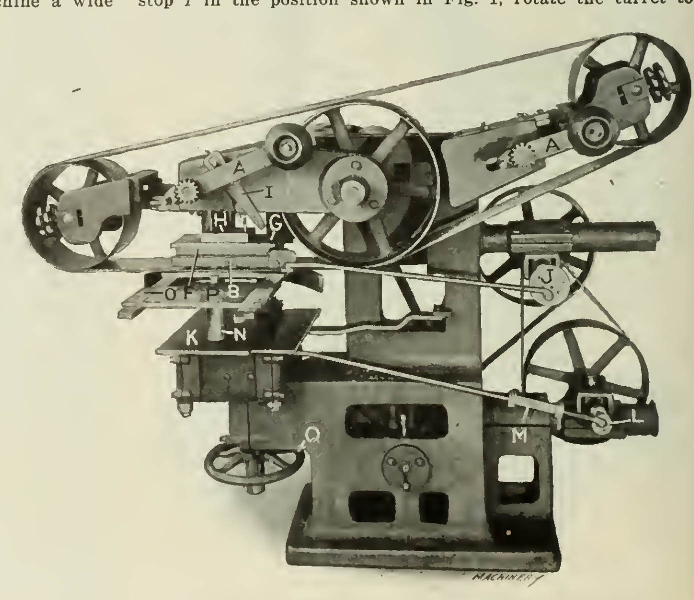


Fig. 1. Type F 6- by 14-inch Finishing Machine made by John C. Blevney

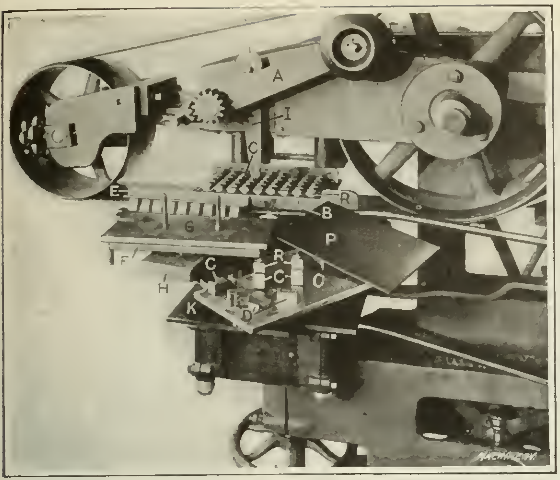


Fig. 2. Close View of Mechanism of Blevney Finishing Machine

bring the work under the belts, allow stop I to assume the position shown in Fig. 2, adjust by means of setting wheel Q, Fig. 1, so that the work will press the belts and the platen blocks upward until the upper edge of the mortise R on block C will have the proper limit finishing distance in its relation to the adjoining bar of platen B; in other words, limit the descent of these blocks. When the upper edge R of the mortise in block C and the adjoining bar is in contact, no further finishing can take place. For rough work, it is only necessary to have stop I in the position shown in Fig. 1, with the belts under tension, when the surface of the work to be finished is moved by wheel Q to within 1/8 inch of the belts.

In operation, place the work on holder P and bring stop I as shown in Fig. 1; swing turret to bring the work under the belts, and allow stop I to drop as shown in Fig. 2; fill up the second holder P with work, manipulate stop I as before, swing the work under the belts, allow stop I to assume the position shown in Fig. 1, take off finished pieces and reload and proceed as before.

ANDERSON DIE MUZZLING MACHINE

One of the most difficult operations in the manufacture of threading dies is that known as "muzzling." This consists of beveling the first two or three threads of the die in such a way as to secure a clearance, so that as the die is fed onto the work it will cut without dragging. This clearance is similar to that on the end of a machine reamer, though the clearance is internal in the die and the opposite in the reamer. The muzzling operation is usually performed by hand with a small file and requires considerable skill.

In the development of the machine shown in the accompanying illustrations, the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn., has endeavored to eliminate hand work on this particular operation. This firm's form of "super-helical" cutter has made it possible to machine the delicate threaded cutting edges without raising a burr. The cutter is made to represent a cone, being pointed toward the end; the angle of the side of the cone depends on the number of threads to relieve or back off; as, for example, a cutter with an angle of 30 degrees on the side will machine a clearance of about two and one-half to three threads, whereas a cutter with an angle of 45 degrees on the side will form a clearance on one and one-half thread only. It is usual in making dies, to back off one side more than the other; that is, three threads are backed off on one side and one and one-half on the opposite, so that the die can be used for threading long rods when it is not important to cut close to a shoulder; and then by reversing the die, threads can be cut close to a shoulder or extension.

The machine in the main consists of a hollow vertical spindle mounted on a frame and running in S. K. F. ball bearings. The chuck for holding the cutter is a split collet, so that the cutter will run true under all conditions. On the spindle is mounted a friction member which is driven by means of a spherical faced disk mounted on the armature shaft of the motor. The motor is pivoted in the frame of the machine in such a way that by tilting it the speed of the cutting tool can be varied to suit dies of various diameters. The spindle can be locked by means of a bolt at the side or front of the machine, so as to enable the operator to fasten the cutter securely in the chuck or collet; and a sleeve or draw-bar having a knob or handwheel at the top of the machine operates the chuck mechanism. This is quite similar to the draw-bar used in ordinary bench lathes.

The table is rectangular and provided with a crosswise slot into which the fixture is secured. The fixture consists primarily of two slides that permit adjustment in all directions, making it possible not only to operate on large as well as small diameters, but also to vary the amount of clearance on the cutting edges of the die. On the upper slide of this fixture is located a pivoted finger mechanism that is also adjustable. This index finger locates the cutting edge of the die in the right relation to the cutter. The finger is pressed down by a spring into the die openings and rests with a slight tension on the top of the die; it is so constructed that the die can be rotated under the finger from one cutting edge to the other. This does away with the necessity of removing the die or raising the finger, so that the die can be turned under this spring finger from one cutting edge to the other, making it a rapid operation. The part of this finger which engages the die can be removed and as many shapes and forms of fingers as necessary can be made and applied by inserting in a holder.

The table is mounted on a square quill, the lower end of which is turned and a fine thread chased thereon. On this threaded part are two knurled nuts, which come in contact with the lower face of the adjustable knee that carries the quill or table spindle. The table is raised and lowered by means of a foot-treadle mechanism which is located at the lower right-hand side of the pedestal. The rods connecting

Fig. 1. Die Muzzling Machine made by Anderson Die Machine Co.

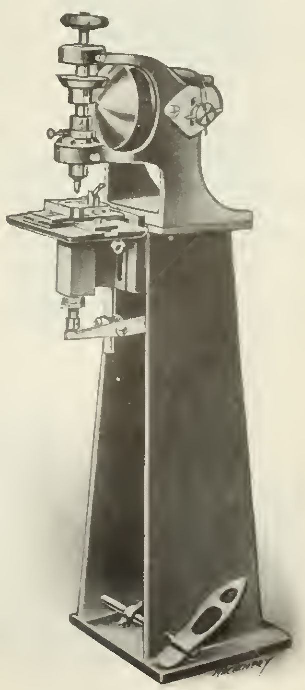


Fig. 2. Opposite Side of Machine shown in Fig. 1

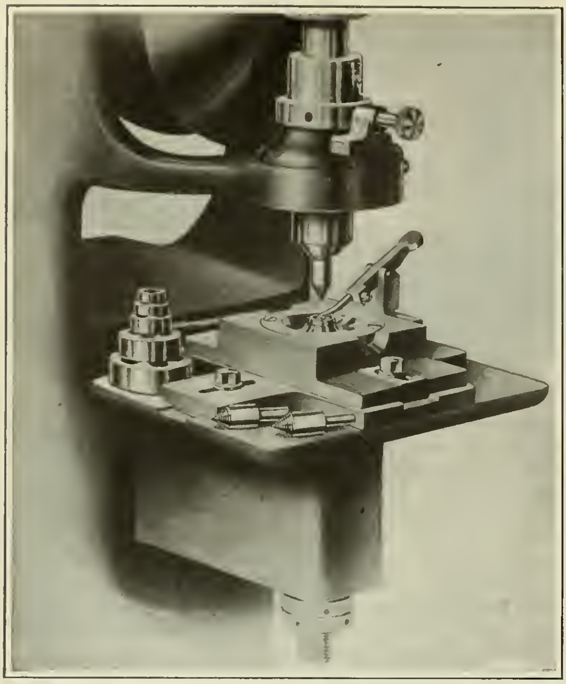


Fig. 3. Close View of Anderson Die Muzzling Machine in Operation

the foot-treadle and lever which operates directly on the end of the quill or table spindle are made adjustable, so that the whole mechanism can be readily adjusted to suit the operator's convenience. If necessary, a safety spring device can be introduced between the foot-treadle and the table, so that, regardless of the pressure applied by the operator on the foot-treadle, the pressure on the table spindle will be uniform. Any make of motor not exceeding 6 inches in diameter can be applied to this machine, 1/6 horsepower, 1700 revolutions per minute being ample for the operation. A switch is conveniently located for starting and stopping the machine, and a cord with attachment plug is provided so that the machine can be run from an ordinary lamp socket.

"NATCO" STRAIGHT-LINE DRILLING MACHINES

The National Automatic Tool Co., Richmond, Ind., has recently added to its line of multiple-spindle drilling and tapping machinery three sizes of "straight-line" drilling machines, which are illustrated and described herewith. The design of these machines embodies many features that provide for efficient operation and rapid production. For instance, the machines may be equipped either with or without the "Natco" patented mechanism to provide for independent changing of speeds in the rail, which permits of drilling large and small holes simultaneously at the proper speeds and affords a neutral position for all spindles that are not in use. The machines that have independent change of speed are provided with a full complement of upper joints, whether or not there is need for as many drill spindles as the full number that can be carried in the rail.

Provision is made for a three-inch in and three-inch out adjustment of the drill spindles, thereby giving a drilling area six inches wide by the full length of the rail. All spindles are provided with a two-inch vertical adjustment to compensate for tools of uneven length or for uneven wear of tools. The minimum center distance is the diameter of the spindles plus 1/16 inch, which makes it possible to drill holes very close together. The machines may be equipped with a tapping attachment; a spot-facing attachment which is a new feature of the "Natco" drilling machines and permits of multiple spot-facing; a lubricating system for lubricating the work; and either belt or individual motor drive, in the latter case a five- to seven-horsepower motor running at 1800 revolutions per minute being used.

Fig. 1 shows what is known as the No. 39 machine, which

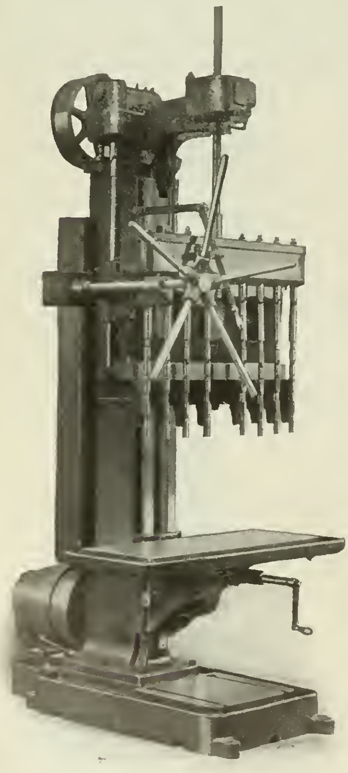


Fig. 1. "Natco" No. 39 Straight-line Drilling Machine

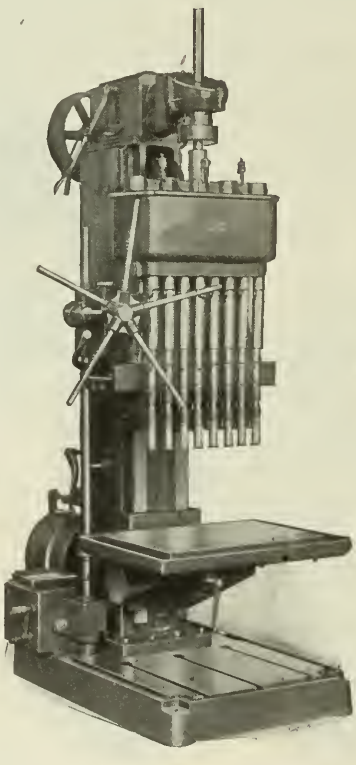


Fig. 2. "Natco" No. 40 Straight-line Drilling Machine

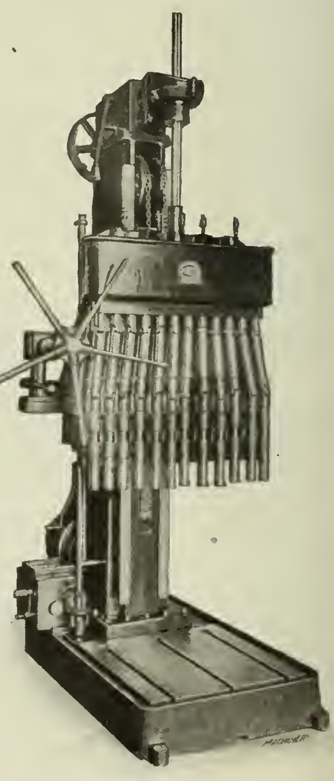
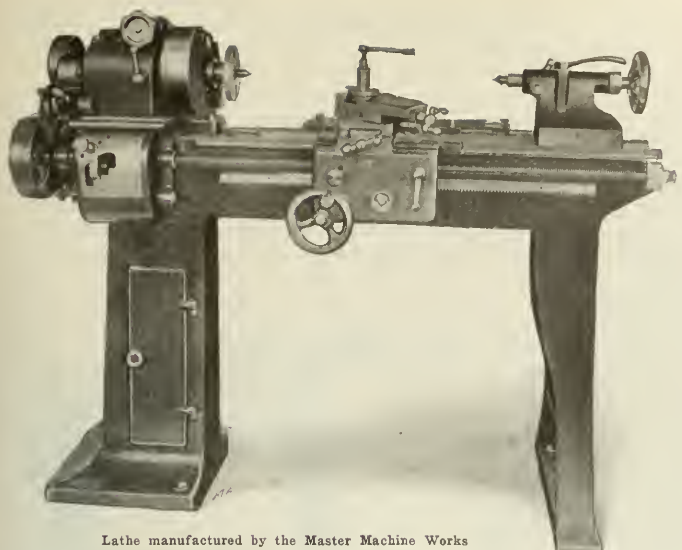


Fig. 3. "Natco" No. 41 Straight-line Drilling Machine



Lathe manufactured by the Master Machine Works

is equipped with a rail either 24 or 36 inches in length. The 24-inch rail is bored for a maximum of twelve spindles, and the machine with the 36-inch rail may be provided with as many as sixteen spindles. Six changes of speed are available on this machine, covering a range of from 363 to 1188 revolutions per minute. These speeds may be obtained as six single or three double speeds, in which the ratio of low to high speed is 2 to 1. The rate of feed in inches per minute varies from one to six, three feeds being obtained through a gear-box located on top of the machine. The capacity for drilling cast iron is twelve ½-inch holes or their equivalent, or twelve ⅝-inch cored holes. The driving pulley is 14 inches in diameter by 4 inches face width and is mounted on Hyatt roller bearings. The countershaft runs at 600 R. P. M. On this machine the maximum distance from the top of the table to the bottom of the drill spindles is 31 inches, while from the base to the bottom of the drill spindle the maximum distance is 49 inches. The area of the working surface of the table is 20 by 40 inches; the floor space occupied by the belt-driven machine is 63 by 61 inches; the floor space occupied by the motor-driven machine is 63 by 80 inches; and the weight of the machine is 4200 pounds.

The machines shown in Figs. 2 and 3 are known as the "Natco" No. 40 and No. 41 drilling machines, respectively, and it will be seen that they are of very similar design. The No. 41 machine is slightly heavier and more powerful than the No. 40. The latter is equipped with either a 26- or 32-inch rail and is bored for a maximum of either six or eight spindles; while the No. 41 machine has either a 32-inch rail bored for eight spindles, or a 48-inch rail bored for twelve spindles. Both of these machines are furnished with six changes of feed which are independent of the speeds, the rate of feed covering a range of from ¾ to 4¾ inches per minute, while six changes of speed are available, ranging from 128 to 525 revolutions per minute. The six changes may be obtained as six single speeds or three double speeds, and the ratio of low to high speed is about 2 to 1. The drill spindles are provided with a heavy ball thrust, and the spindle bearings are lined with bronze.

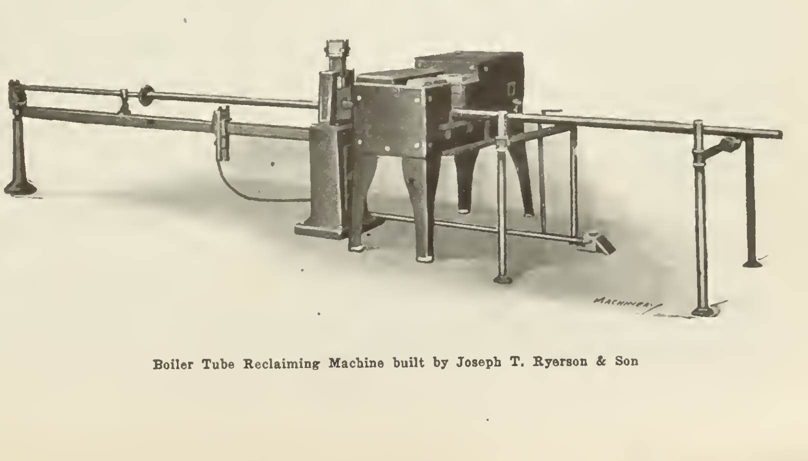
The drilling capacity of the No. 40 machine in cast iron is up to eight 1-inch holes or eight 2½-inch cored holes, while the No. 41 machine has a capacity of drilling in cast iron up to twelve 1-inch holes or twelve 2½-inch cored holes. The No. 40 machine is provided with a 30- by 32- by 20-inch box table, or with an adjustable table 29 by 42 inches in size; and the No. 41 machine is furnished with a 30- by 42- by 20-inch box table, or an adjustable table 29 by 42 inches in size. Both of these machines are equipped with tight and loose pulleys 16 inches in diameter by 5¼ inches face width, which run at 650 revolutions per minute. On the No. 40 machine the maximum distance from the top of the base to the bottom of the spindles is 32 inches, and on the No. 41 machine the corresponding distance is 46 inches. The floor space occupied by either machine when equipped with belt drive is 66 by 86 inches, and when equipped with motor drive, 66 by 107 inches. The weight of the No. 40 machine is 7500 pounds, and the No. 41 machine weighs 10,000 pounds.

MASTER 12-INCH ENGINE LATHE

The Master Machine Works, 110 W. 40th St., New York City, are now manufacturing a light lathe intended for tool-room use as well as for general manufacturing operations. The headstock is of the all-geared design, and six spindle speeds are available, ranging from 28 to 418. These speed changes are controlled by means of two levers located on the headstock, and the arrangement is such that no two speed combinations can be engaged simultaneously. The carbon-steel spindle is provided with phosphor-bronze bearings and has a hole through it of ample size to accommodate a draw-in attachment and collets. The lead-screw is splined for the driving worm which operates the automatic cross and longitudinal feeds. The cross-feed screw has a micrometer collar graduated to read in thousandths inch. The lathe has a geared feed-box for obtaining rapid changes when turning or thread cutting. The actual swing over the bed is 12 inches and over the carriage 6½ inches.

RYERSON BOILER TUBE RECLAIMING MACHINE

Joseph T. Ryerson & Son, Chicago, Ill., have recently added to their line the boiler tube reclaiming machine here illustrated and described. This equipment is intended for use in railroad shops and provides for the utilization of short boiler tubes which would otherwise be scrapped. The machine provides for welding such tubes together in order to make pieces of the proper length for use in locomotives. This equipment comprises a special pneumatic flue welding machine provided with an extension mandrel, an oil burning furnace, straightening and storage rack, automatic operating valves, etc. The entire outfit is of simple construction, and there is no intricate mechanism to complicate the method of operation; in addition to its use in reclaiming short pieces of tubing, this machine may also be employed for ordinary safe-ending operations. As regularly furnished, the machine is provided complete with one size of welding die and mandrel; and the oil burning furnace is equipped with a burner and completely bricked ready



Boiler Tube Reclaiming Machine built by Joseph T. Ryerson & Son

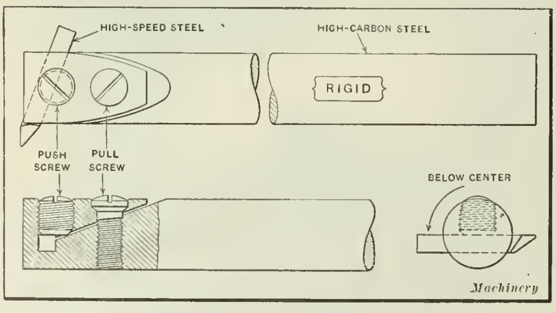
for service. Special machines may be furnished for any special class of work.

Until recently the reclaiming of old boiler tubes had been given little consideration by the railroads, owing to the fact that the reclamation of old materials in general had not received much attention. Another reason for this condition is that while machines were available for the performance of common safe-ending operations, there were no satisfactory machines for handling longer pieces of tubing. The safe-ending process was often carried to such an extent that not infrequently five or six and sometimes more pieces were welded to a tube used in a high-pressure boiler. When safe-ending is carried to such an extent the remainder of the tube is generally not worth reclaiming after the last removal from the boiler. More stringent regulations of the Interstate Commerce Commission, coupled with the wide "safety first" movement, have done much to improve this class of tube welding, and the number of safe ends that are pieced onto a tube is generally less than was the case a few years ago. As a result, a great many railroad companies have a large number of short tubes which are in good condition and can be used, provided they can be properly welded together to make suitable lengths with not more than one or two welds. It is for the reclamation of such pieces of tubing that the new Ryerson machine was developed. In operation, the tube is heated and belled out in the usual way and the safe end of the tube inserted. The tube with the safe end inserted is then passed through the furnace and over the mandrel until the point to be welded is in the proper place for heating in the furnace. When the desired temperature has been reached, the tube is shoved forward through the furnace until it reaches the desired position in the welding die, the welding machine being in direct line with the furnace.

This machine is of the hammer type and a stop or guide is arranged on the mandrel which acts as a gage to locate the welding point under the die as well as an automatic starting device for the welding machine. When the farther end of the tube strikes this stop or guide, it operates a lever that, in turn, opens the air valve on the welding machine, thus permitting entrance of air into the cylinder. As soon as the pressure of the tube is taken off the gage stop, the air supply is cut off and the welder is stopped. Afterward the tube is pulled back through the furnace and the operation is completed. The principal dimensions of the welding machine are as follows: capacity for handling tubes from three to six inches in diameter; floor space occupied, 30 by 30 inches; and weight of machine, 800 pounds. The principal dimensions of the furnace are: capacity for handling tubes from three to six inches in diameter; floor space occupied, 3 feet, 5 inches by 5 feet, 6 inches; and weight of furnace, 2250 pounds.

RIGID BORING-BAR

The Rigid Tool Holder Co., 149 Carroll St., S.E., Washington, D. C., is now manufacturing the tool shown in the accompanying illustration. This is known as an improved lever-

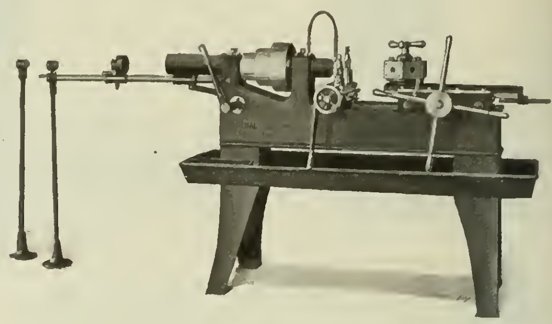


Improved Type of Boring-bar made by Rigid Tool Holder Co.

clamp boring-bar and was developed by the firm's manager, E. F. Gibbs. The important features of this tool are its simplicity, the liberal amount of power provided for clamping the cutter, the fact that it is unnecessary to use special wrenches, and the position of the cutter below the center of the boring-bar, which reduces the tendency for the tool to dig into the work.

FEDERAL PLAIN-HEAD SCREW MACHINE

A machine known as a No. 3 or 14-inch plain-head screw machine has recently been placed on the market by the Federal Machine Co., 1602-1618 S. Lafayette St., South Bend, Ind. It is equipped with an automatic chuck and bar feed and will handle the following sizes of bar stock: round, up to 1 15/16



Federal Plain-head Screw Machine

inch in diameter; square, up to 29/32 inch; hexagonal, up to 1⅛ inch. All sizes of stock are handled by means of an automatic chuck and tool-steel spring collet. It will be seen that this machine is driven by a three-step cone pulley which has steps 3½ inches in width, which provide ample power to enable the machine to take heavy cuts at high speed. The head and bed are cast in one piece to obtain the maximum strength, and the bed is designed with thick walls and closely spaced internal braces to further reduce the tendency for the machine to spring while taking heavy cuts. Further provision against trouble from this source is made by having a three-point bearing on which the machine rests, thus counteracting any twisting action due to an uneven foundation.

The spindle is made of high-carbon forged crucible steel bored from the solid and accurately ground to size. The spindle bearings are lined with phosphor-bronze, the front bearing being 5¼ inches long and the rear bearing 4½ inches in length. Six tool holes are provided in the faces of the turret, which measures 8¼ inches across the flats. Each hole is fitted with self-raising and self-aligning binders, and there are bolt holes for securing tools to the faces. The turret stud is a taper fit in the slide and revolves with the turret, provision being made for adjustment; it is claimed that this keeps the alignment of the turret accurate throughout the life of the machine. The lock bolt and lock bolt bushings in the turret and slide are made of tool steel hardened and ground to size. Bar stock can be fed through the turret, which obviates the necessity of removing the turret saddle in cases where it is required to cut off long pieces. By a reverse movement of the turret saddle turn slide, the turret lock bolt is automatically released and the turret revolves to the next station. Adjustable independent stops automatically operate for each position of the turret. The turret saddle is fitted with adjustable taper gibs for its entire length which provide means for adjusting the slide.

The cut-off is furnished with a combination lever and screw feed. A square jaw clutch cut in the hub of the lever is directly engaged with the pinion, which, in turn, meshes with a rack on the cross-slide. The lever may be brought into different positions by simply advancing or retarding the clutch. The screw is instantly engaged or disengaged by a small eccentric lever at the left-hand side of the cross-slide; this lever engages a hardened tool-steel lock yoke of the split nut type placed between two hardened and ground collars on the screw. These collars serve the additional purpose of providing a bearing for the screw in the slide, and the cross-slide has adjustable stops and a micrometer dial for fine adjustment. The

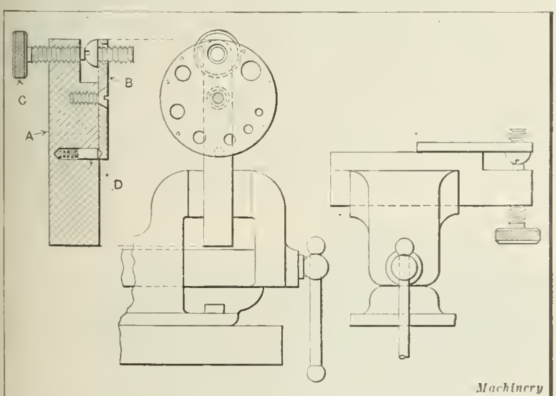
toolposts have adjustable wedges for raising or lowering the tools, and the cut-off can be removed from the bed without disturbing the turret saddle.

A Brown & Sharpe oil pump driven by a belt from the countershaft delivers an abundant supply of lubricant to the cutting tools and operates when the machine is running in either direction. The oil or chip pan is cast integral with the blocks supporting the bed, and the deep space under the bed from which the chips can be removed is a convenient feature. There is a drop of ½ inch from the rear end of the pan to the oil strainer located directly below the rear spindle bearing, thus insuring quick return of lubricant to the tank, which is cast in one leg and arranged so that it may be easily drained by simply removing a pipe plug from the bottom. In addition to the accessories shown in the illustration, the regular equipment of this machine consists of a double friction countershaft, tool tray, splash board, reversible oil pump, one hardened and ground collet, and the necessary wrenches for making all adjustments. A turret lathe is also made by the Federal Machine Co. which is of essentially the same design, except that it does not have an automatic chuck and bar feed, oil pan and pump. The end of the spindle is of sufficient length to allow for threading it for any standard air chuck.

The principal dimensions of this machine are as follows: diameter of hole in automatic chuck plunger, 1 5/16 inch; diameter of hole in spindle, 1 9/16 inch; maximum length of work that can be turned, 8 inches; maximum distance from end of spindle to turret face, 19 inches; swing over bed, 14 inches; swing over cut-off slide, 6½ inches; distance from center of turret holes to top of slide, 2¾ inches; diameter of turret holes, 1¼ inch; size of tapped holes in turret faces, 7/16 inch; diameter of countershaft pulley, 12 inches; face width of countershaft pulley, 4 inches; size of cut-off tools, ⅝ by 1¼ inch; floor space occupied, 2 feet, 3 inches by 7 feet; and net weight of machine, 1670 pounds.

DUNCAN SCREW AND RIVET HOLDER

Toolmakers and machinists often experience difficulty in holding screws or rivets when the ends need to be filed or sawed off. The usual method is to clamp the head of the screw or rivet in a vise, but owing to the circular form of the head, the screw is not firmly held and there is likely to be more or less distortion of the head due to the clamping pressure of the jaws. The screw and rivet holder shown in the accompanying illustration provides a simple and effective method of holding screws or rivets without marring them. This holder, which has been brought out by John C. Duncan 204 E. North Ave., Pittsburg, Pa., consists of a shank *A* which is clamped between the vise jaws; a circular plate *B* containing holes of different sizes for receiving the screws or



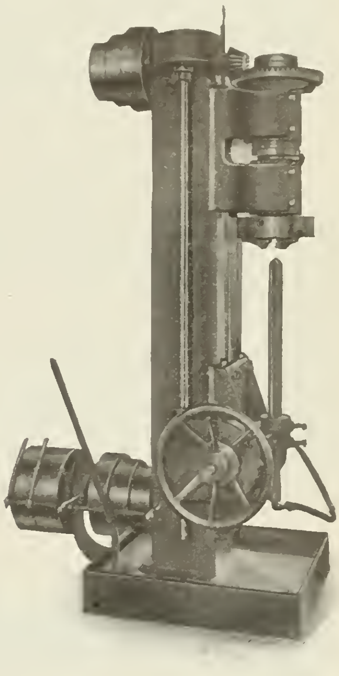
Duncan Screw and Rivet Holder

rivets; a clamping screw *C* for holding the screw to be operated upon firmly in position; and a small spring detent *D*, the end of which engages conical seats in plate *B* so that any one of the holes in this plate may readily be aligned with the clamping screw.

After a screw is inserted through one of the holes, the plate *B* is turned to locate the head opposite the clamping screw, which is then tightened. The holder can be secured between the vise jaws in any position that will be most convenient for the workman. The central view shows the holder in a vertical position, whereas the view to the right shows it in a horizontal position.

STECHER SPINDLE DRILLING MACHINE

For use in drilling lathe spindles and for similar operations, the Charles Stecher Co., 1574-1580 Crossing St., Chicago, Ill., is now building a machine which is shown in the accompanying illustration. It will be seen that the drill is held in a vertical position and feeds up into the work, thus preventing the hole from becoming clogged with chips. A small force pump, which is included as part of the regular equipment, keeps the drill cool and free from obstruction. It will be seen that the machine spindle is furnished with a chuck at the lower end which is capable of holding all work that does not exceed 30 inches in length, but for longer pieces it is desirable to employ a chuck at both ends of the spindle.



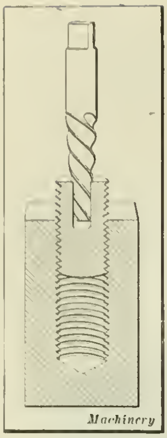
Spindle Drilling Machine made by Charles Stecher Co.

In drilling long holes, *i. e.*, those exceeding 24 inches in length, experience has shown that the drilling can be done much faster by working from both ends of the piece, because in this way the drill need only be slightly in excess of one-half the length otherwise required. With a feed of 0.005 inch per revolution of the work, holes 36 inches in length by 1 29/32 inch in diameter have been drilled in 35 minutes. These spindles were drilled from both ends, and the time includes setting up the work and removing it from the machine. The upper and lower horizontal shafts are provided with ball bearings and the main spindle is provided with a ball thrust bearing. The feed mechanism is so arranged that any desired feed can readily be obtained by means of removable gears furnished with the machine.

The principal dimensions of the machine are as follows: distance between face of chuck and drill-holder, 32½ inches; diameter of hole through spindle, 4¼ inches; swing over face of bed, 14 inches; diameters of cone pulley steps, 9½, 11½ and 13½ inches in diameter; face width of cone pulley, 3 inches; diameter of tight and loose pulleys, 14 inches; face width of tight and loose pulleys, 4 inches; speed of tight and loose pulleys, 450 R. P. M.; width of column, 12 inches; height of machine, 7 feet, 6 inches; diameter of steel scroll chuck, 12 inches; floor space occupied, 32 by 48 inches; and net weight of machine, 1800 pounds.

CLEVELAND SCREW EXTRACTOR

Every machinist knows how difficult it is to remove the end of a set-screw or bolt which has broken off in the hole or below the top of the hole. In many cases the only method of removing the broken end is by drilling it out completely, which usually requires considerable time. The Cleveland Twist Drill



Cleveland Screw Extractor

Co., Cleveland, Ohio, has placed on the market a simple form of tool for removing broken screw ends, known as the "Ezy-Out" screw extractor. This extractor is sold in sets of three and is made in different sizes which are applicable to different classes of work. The principle upon which the extractor operates is indicated by the accompanying illustration. The gripping end is slightly tapering and has left-hand spiral ridges. When a screw is to be removed a hole is drilled in one end, into which the extractor is inserted. A slight twist seats it firmly in the hole and continued rotation to the left causes the left-hand spiral to grip the sides of the drilled hole, thus exerting an unscrewing action on the broken screw end, which is backed out on its own thread. If the screw should fit tightly or stick because of rust, the extractor grips it more tightly. With this method of removal there is no danger of injuring the threads in the hole, which is often done when the broken screw end is removed in the form of chips by drilling a hole through it from end to end. These extractors are made of a tough grade of steel and are specially treated to withstand the torsional strains to which they are naturally subjected.

WILSON SYSTEM OF ELECTRIC WELDING

For use in repairing broken machine parts ranging from pieces of small size up to parts machined from heavy castings, the Wilson Welder & Metals Co., Inc., Vanderbilt Ave. and 45th St., New York City, has developed a system of electric welding. In addition to its application in the repair of broken parts, the Wilson system may be applied in the manufacture

Fig. 1. Welding Tool or Electrode Holder with Distant Control Switch

of such products as metal-cutting tools where a cutter of high-grade tool steel is welded onto a machine steel shank. By this method cast steel, cast iron, wrought iron, brass, copper, or any other weldable metal can be welded with satisfactory results. It is claimed for this system that the consumption of power is very low and that a material saving of labor is effected by having the control of the heat or amperage at the arc placed conveniently for the operator, so that he does not have to go back and forth between the work and control board when it is necessary to adjust the heat to meet conditions. Another important feature is that a number of welders can work from a single machine without one interfering with the work of another; power is located at one point, where it can have proper supervision, and it can be distributed to convenient points throughout the shop.

With this system of electric welding, the heat may be accurately controlled at the point of application of the metal, which insures obtaining welds of uniform quality. There is a critical temperature at which steel can be welded to give the greatest

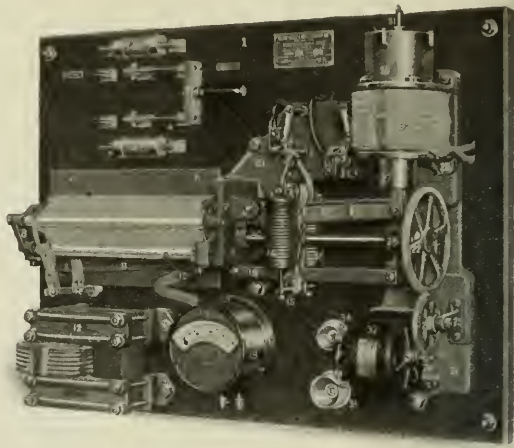


Fig. 2. (1) Slate Panel; (2) Double-throw Switch; (3) 300-ampere Fuse; (4) Switch Receptacle; (5) Carbon Pile; (9) Back End Disk Cable; (10) Front End Disk Cable; (11) Asbestos Board; (12) Choke Coil; (13) Ammeter; (19) Toggle Circuit Breakers; (27) Solenoid Plunger; (28) Solenoid Casting; (29) Solenoid; (30) Dash Pot; (31) Piston-rod to Dash Pot; (32) 1/10-horsepower Motor; (33) Welding Circuit Plug; (34) Control Circuit Plug

tensile strength and ductility, and by heating above this, a fracture of the welded section will show a segregation of carbon and slag, which naturally weakens the weld. If, on the other hand, the temperature is lower than the critical temperature, a fracture through the welded section will show that the metal has been deposited in globules with many open spaces between them, this being a fairly sure indication that the weld has been made at too low a temperature. With the Wilson system it is claimed that the heat at the arc does not fluctuate; therefore welds made are high grade and uniform.

Experience has shown that in order to secure satisfactory results in electric welding, the use of a proper grade of metal is of as great importance as having a properly designed machine. Recognizing this fact, the Wilson Welder & Metals Co. has developed specially prepared welding metals which are not adversely affected by the heat of the arc. These metals are used in the form of an electrode. This metal is a homogeneous alloy combined with an excess of manganese to compensate for losses while passing through the electric arc, thus insuring a substantial amount of manganese in the welded joint which is essential to its toughness. In addition, a

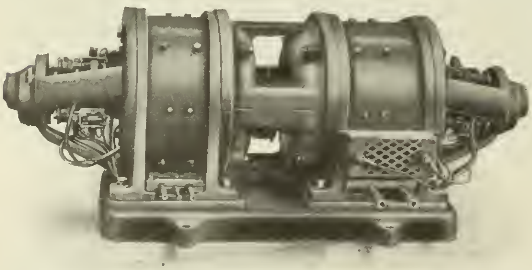


Fig. 3. Four-arc or 600-ampere Capacity Motor-generator Set for Direct Current

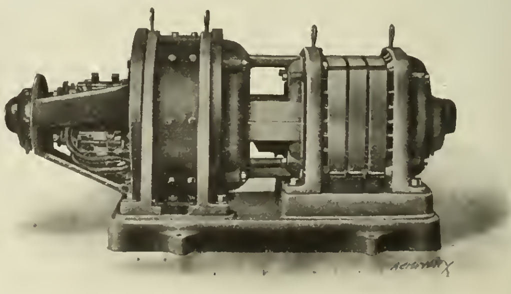


Fig. 4. Four-arc or 600-ampere Capacity Motor-generator Set for Alternating Current

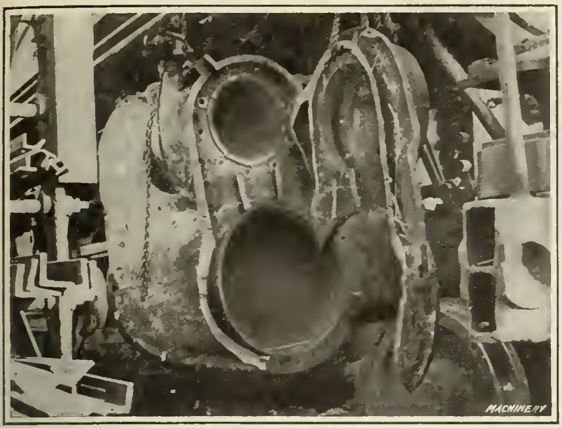


Fig. 5. Fractured Steam Chest and Cylinder on Locomotive to be welded

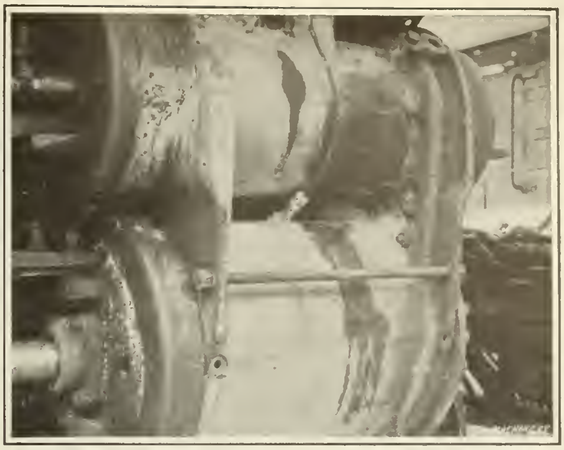


Fig. 6. View of Parts shown in Fig. 5 after being repaired with Wilson Electric Welder

manganese-copper alloy welding electrode has been developed, which is composed of iron homogeneously combined with such an excess of manganese and copper over the amount lost in the arc as will insure to the welded joint an additional degree of toughness and ductility, but leave it soft enough to be readily machined. Fig. 1 shows the welding tool or electrode holder provided with a distant control switch in which these special welding electrodes are held.

Fig. 2 shows the constant-current control panel for welding and cutting, provided for use in connection with the Wilson equipment, and in the caption are listed the more important parts, which may be readily identified by corresponding numbers which appear on the illustration and in the caption. The general function of this panel is to maintain a constant flow of current between the welding tool and the material operated upon, regardless of variations in the resistance of the welding circuit due to varying lengths of arc or other causes. The current regulator consists of a carbon pile held under compression by one or more helical springs, the pull of which is opposed by a solenoid through which the current to be regulated is passed. A suitable air dash pot is connected to the solenoid plunger to prevent all "hunting" or chattering due to the tendency of the plunger and connected parts to travel beyond the desired point. The pressure of the springs is transmitted to the carbon disks or plates through a lever, and the springs are mounted on a carriage in such a manner that the point at which they act upon the lever may be changed, thereby increasing or decreasing the leverage, as may be necessary. The position of the control solenoid in relation to the lever is fixed, and the movement of the spring carriage is produced by a small electric motor so wired that it may be controlled by two push buttons located at the welding tool or near enough to the welding tool so that the operator can use them without changing his position. The panel is also provided with a reactance coil of a size sufficient to assist the operator in maintaining an arc with a graphite pencil when the panel is used for cutting or burning away metal in preparing for the welding operation or for other purposes. An ammeter is provided to indicate the amount of current used in the welding process, and a double-throw switch of 200 amperes capacity is employed for changing from the welding to the cutting circuit.

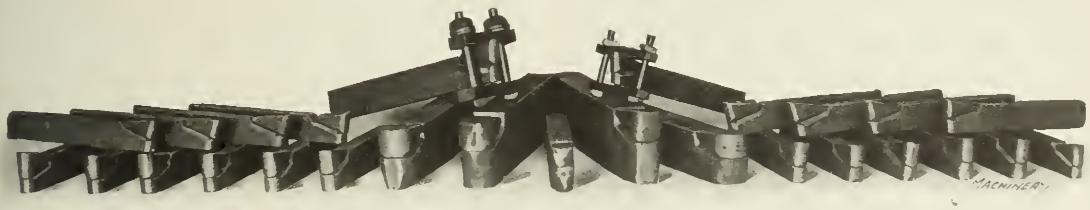


Fig. 7. Cutting Tools prepared for welding Points onto Shanks

In Fig. 3 is shown the Wilson arc welding motor-generator set, consisting of a direct-current compound interpole generator and an interpole direct-current motor. This machine is designed with especial reference to the intermittent nature of the load and is adjusted to operate with fixed brushes at any load from no load up to the maximum capacity of the machine. It will not show any tendency to flash when the maximum load is suddenly removed. The entire magnetic circuit of the generator is constructed of thin sheet-steel plates, castings being used only for mechanical and not for magnetic purposes, thus providing an exceptionally quick recovery coefficient and permitting the operation of more than one welding circuit from the generator without interference. It is claimed that commutation will be sparkless under all conditions and changes of load within the rating of the machine, and that the set will operate without excessive noise or vibration.

The outfit is mounted on a heavy cast-iron sub-base and provided with self-

Fig. 8. Cutting Tools with Points welded onto Shanks

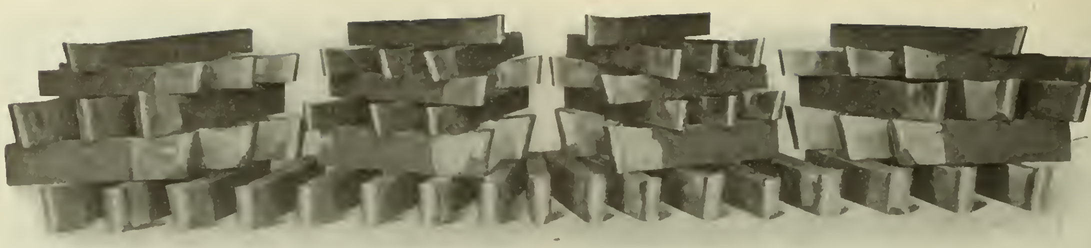


Fig. 9. Cutting Tools with Points welded onto Shanks after being ground Ready for Use

oiling bearings lined with hard babbitt. The rotors of both machines are mounted on a single shaft, which is made of high-carbon steel supported on two, three or four bearings. The bearing housings of the set are demountable to permit of easy removal of the rotors. Compensators equipped with no voltage release are furnished with each set. The fields of the direct-current generator and of the motor are of the ring type constructed of laminated steel, and the pole pieces are also built of laminated steel, bolted in place and so arranged that any field coil and its core may be easily removed. The field coils are form-wound without metal spools and thoroughly insulated.

Both machines are furnished with interpoles, one for each main pole on the machines, in order to provide for obtaining improved commutation and fixed brushes. The armatures are of the slotted drum type, having a core of thin sheet steel of high magnetic quality, each sheet being varnished to reduce core losses. The windings are formed coils or rectangular bars, thoroughly insulated. The commutators are built of hard copper bars, insulated with mica and rigidly held in place by heavy clamping rings. The brush-holders are of the radial type and fitted with carbon brushes; they have no sliding contacts which carry current. Particular care has been taken to provide ample facilities for ventilation by means of air ducts in the cores, so that free circulation is obtained through the cores and windings.

Fig. 4 shows the Wilson electric welding motor-generator set for alternating current, which consists of a direct-current compound interpole generator and a squirrel-cage polyphase induction motor. The general features of this outfit are the same as those described in connection with the direct-current motor-generator set. The stator core of the induction motor is built of punchings of thin sheet steel of high magnetic quality, each sheet being varnished to reduce core losses to a minimum. The core is rigidly supported by two heavy cast-iron clamping rings that form the frame of the stator. The windings consist of form-wound coils treated with insulating compound, after which they are taped, varnished and baked.

The slots of the winding of the six- and eight-arc machines are lined with insulating material, form-pressed coils being used in the smaller sized machines. The windings are securely held in place by wedges driven in between the tips of the core teeth, and the terminals of the winding are brought out so that connection to the power lines may be easily made. The rotor core is built from punchings of thin sheet steel, which are treated in the same way as those of the stator. The core is keyed to the shaft between clamp plates to prevent bending the end sheets. The rotor conductors are placed in partly closed insulated slots and securely riveted and soldered at both ends to short-circuiting rings. The periphery of the stator is entirely exposed to the air, and where necessary, ducts are provided in both the rotor and stator cores to permit thorough ventilation.

NEW MACHINERY AND TOOLS NOTES

Safety Goggles: Chicago Eye Shield Co., Chicago, Ill. Goggles made of glass that resists splintering. Nails have been driven through the lens without shattering the glass, which is of American manufacture.

Hydraulic Baling Press for Scrap Metal: Logemann Bros. Co., Milwaukee, Wis. This press forms the metal scrap into compact bales. One ram forces the scrap into a flat shape and another, operating at right angles to it, produces the solid bales.

Ball Bearing Grinder: United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, Ohio. This machine may be operated with either direct or alternating current. While it is provided with a knife switch located in the base, the push-button control will be furnished when desired.

Twin Angle Compound Air Compressor: Sullivan Machinery Co., Chicago, Ill. A compressor consisting of two units, each complete in itself, which are set side by side on a common foundation and are driven by a common shaft. Couplings at each end of this shaft permit either compressor to be cut out of service at any time.

Twenty-six-inch Heavy-duty Engine Lathe: Riter-Conley Co., Pittsburg, Pa. A heavy-duty geared-head engine lathe that, with a 16-foot bed, weighs 16,000 pounds. The spindle, which is 56 inches long, is made of high-carbon forged steel and runs in bronze bushings. The steel gears that provide the eight speed changes run in oil.

Heavy Turret Lathe: International Machine Tool Co., Indianapolis, Ind. This 26-inch lathe is adapted for both bar and chucking work. The gears that drive the spindle are located on each side of and close to the front main belt. The swing over the carriage is 24 inches, and both the toolpost and the turret carriages have a travel of 72 inches.

One-man Shop Truck with Detachable Tongue: Howe Chain Co., Muskegon, Mich. The special features of this truck are the large roller bearing wheels, which support the load to insure easy running, and a detachable jack tongue, with a small roller bearing lead wheel. A foot at the front of the truck takes the loads when the tongue is detached.

Truck Side-rail Press: Southwark Foundry & Machine Co., Philadelphia, Pa. A six-cylinder hydraulic press designed for forming the side members of automobile and motor-truck frames. It is built of steel castings and forgings and will handle two rails 175 inches long, of 5/32-inch stock, at the same time. The rate of operation is 100 strokes an hour.

Eighteen-inch Heavy-duty Engine Lathe: Carl G. Westlund Co., Worcester, Mass. This lathe is made with 8-, 10- and 12-foot beds, and has a swing of 20 inches over the bed; it will cut from three to twenty-four threads per inch, including pipe threads. It has double back-gears and a three-step cone pulley. A 14-inch lathe of the same design is made, but it has a single back-gear.

Machine for Washing and Pickling Metal Goods: Howard Iron Works, Buffalo, N. Y. This machine, which is designed to wash and pickle punchings, stampings, etc., is made in two types. Both require sixty pounds steam or air pressure to operate them. One type of machine has a capacity, in unbalanced loads, of 4000 pounds and the other machine will handle loads of 500 pounds.

"Prestwich" Fluid Gage: Coats Machine Tool Co., Inc., New York City. This instrument has a fixed and an adjustable anvil which are so placed, when set, that work of the correct size brings the fluid in the small tube to the level of the indicating pointer. A variation from this size causes a displacement of the anvils and a much greater displacement of the fluid in the tube.

Vernier Height Gage: L. S. Starrett Co., Athol, Mass. This gage consists of a bar graduated to read, by means of a vernier, to 0.001 inch on heights up to 8 inches, and a hardened base ground square with the bar. By means of a special attachment, measurements may be taken at the top or bottom sides of the gage, while the use of another attachment makes it possible to measure the depth of recesses or the inside of the frame of a jig, etc.

Adjustable Fixture for Locating and Drilling Holes in Jigs: Wadell & Bowen Co., Newark, N. J. This fixture consists of a table mounted on two slides at right angles to each other; it also has at its back a vertical post to which is fastened an arm. This arm is adjustable vertically and its outer end is bored for a drill bushing. The work is adjusted with relation

to the drill bushing by using length bars one inch thick and the micrometer screws in each slide.

Light Tool-room Lathe: Master Machine Works, New York City. A machine suitable for light manufacturing that requires no countershaft, as the belt passes directly from the main lineshaft to tight and loose pulleys on the headstock. The swing over the bed is 12 inches, and over the carriage, 6½ inches; the capacity between centers is 2½ feet. The six spindle speeds may be obtained by means of two controlling levers and the apron is arranged for screw cutting and has longitudinal and cross power feeds.

Semi-automatic Thread Milling Machine: T. C. M. Mfg. Co., Harrison, N. J. A machine designed primarily for milling threads on rifle barrels, fuse bodies, etc. This machine has cut in one hour the 14-pitch thread on 120 bronze primers 1/2 inch long and 1 3/16 inch in diameter. The work is held in a collet chuck operated by a hand-lever; the work-spindle is rotated by a worm and worm-wheel acting through a clutch that is automatically engaged by advancing the cutter into the work and is disengaged when the spindle has made a complete revolution and the thread is finished.

Tilting Band-saw Machine: J. A. Fay & Egan Co., Cincinnati, Ohio. This saw, while in operation, can be moved by power through an arc of 90 degrees, 45 degrees each side of the vertical. The exact angle at which the blade is tilted is shown by an index. The column is a massive one-piece casting with broad floor bases. Its face is planed and fitted with roller bearings and carries the saw carriage, guides, etc. A 48-inch square iron table is also rigidly mounted in this column. The mechanism for moving the blade is mounted upon an auxiliary column in the rear.

Steel-jacketed Electric Heater Unit: Cutler-Hammer Mfg. Co., Milwaukee, Wis. These units are used to heat crane cabs and warm the feet of shearmen and tablemen in steel plants. They may be used with either direct or alternating current of a voltage of 115, 230 or 250 and have a capacity of 500 watts. The nickel-chromium resistor, which furnishes the heat, is enclosed with mica, and this, in turn, is surrounded with a steel jacket. Each unit is 2 feet long, 1½ inch wide, and 3/16 inch thick. As no assembly of parts is required, the units can be installed singly or in groups.

Cincinnati Automatic Bed-type Millers: Cincinnati Milling Machine Co., Cincinnati, Ohio. The machines are designed for the quantity manufacture of such parts as enter into firearms, typewriters, etc. They are of the Lincoln type with the table supported directly on the bed without any saddle. The automatic features reduce the work to chucking new pieces, shifting the starting lever, and removing the finished work. The working surface of the table is 9½ by 24 inches, and the effective table feed, 12 inches. There are twenty-four spindle speeds and twelve table feeds, ranging from 1 to 18 inches per minute.

Machine Tool Motor Controller: Cutler-Hammer Mfg. Co., Milwaukee, Wis. This controller, which is of the drum type, may be used with any class of motor-driven machine tool. A special resistance inserted in the shunt field circuit provides a speed regulation in a range of 3 to 1. The field regulating unit consists of a field-resistance commutator mounted on a drum shaft with the necessary resistances located underneath. The starting resistance on the armature circuit is mounted on a separate frame. The armature contact fingers and segments are of solid copper and are so arranged that dynamic braking is provided when the drum is returned to the "off" position.

Lathe Attachment for Boring and Grinding Cylinders: John Gibson Co., San Francisco, Cal. The attachment is intended principally for reboring and regrinding gas-engine cylinders, and the faceplate is arranged to take single or *en bloc* cylinder castings. The attachment is screwed to the lathe spindle and may be adjusted radially with reference to the axis of the lathe spindle. As a result, the abrasive wheel or cutting tool will travel in circles of varying diameters, corresponding to those of the cylinders being operated upon. The screw controlling this adjustment is graduated to 0.001 inch. This attachment is designed for use on lathes having a swing of 16 inches or more.

Arc Welding System Using Constant Current: Arc Welding Machine Co., Inc., New York City. This system consists of a generator to furnish the energy for welding, a regulator to maintain the current at constant value, and a motor for driving. By this arrangement, one size of wire may be used throughout the system, as the current is uniform and independent of the length of the circuit and the other operators. Switches are inserted in the line at the points where the welding is to be done and a special controller is plugged in across the switch. With this controller, it is possible to adjust the size of the arc to suit the work. When the welding operation is stopped, the arc is not broken, but is killed by placing a short-circuit across it.

* * *

To make your job "soft," put a lot of hard work into it.

INDUSTRIAL ENGINEERING AND AMERICANIZATION

The immigration problem of the United States, while serious before the outbreak of the European war, is likely to be much more serious following its close. An investigation made under the direction of the transportation interests indicates that there will be a tremendous influx of foreign people who will seek a more favored land in order to escape ruinous taxation and the horrors of another possible conflict. The part played by the engineer in the problem of assimilating the immigrant and making him an American citizen was discussed at a dinner given Friday evening, January 19, by Mr. and Mrs. Astor at their residence in New York City. Dr. Ira N. Hollis, president of the American Society of Mechanical Engineers, dwelt on the moral equivalent of war and the part played by the immigrant in conquering the forces of nature and making them subservient to the will of man. Dr. Hollis expressed the belief that the engineer and the work of the engineer would eventually bring about lasting peace. His is a warfare for the benefit and not the destruction of mankind. Other speakers were Howard E. Coffin of the Council of National Defense, Gano Dunn, president of the J. G. White Engineering Co., Raymond B. Price of the U. S. Rubber Co., and George A. Cullen of the Delaware, Lackawanna & Western Railroad. Richard A. Feiss of the Joseph Feiss Co., Cleveland, Ohio, spoke on the importance of teaching the immigrant the English language and making it a condition of promotion that the employe be able to read and write English. Mr. Feiss and others expressed the belief that no other factor tends to make a foreigner an American in mind and heart as effectively as the ability to speak the language. If he speaks the language he becomes acquainted with Americans and learns to understand American institutions and customs.

The meeting was attended by about one hundred sixty engineers, professors of mechanical engineering, editors, and others interested in engineering in one phase or another. The object of the movement is "to include in industrial engineering the human factor in industrial organizations; to standardize welfare work in industry in point of view, principle and method; to extend scientific methods to the human phases of industrial organization and to train men to carry out these methods. The agents of industrial Americanization are held to be the engineers of America, in whose hands are the human as well as the mechanical destinies of industry."

* * *

A SAD AWAKENING

The old saying, "Never too old to learn," is just as true today as ever. It has been particularly exemplified in the munition business in this country, and especially among the financiers in Wall St. The idea has prevailed in financial circles that money would do everything; for instance, that all it was necessary to do to manufacture a military rifle was to furnish the capital, and the rifles would be turned out automatically. That this is not the case has been forcibly pointed out of late by the failure of several munition manufacturers to make good.

Two years ago a large contract was placed in this country for 3,800,000 military rifles of a certain type. This contract was given to a financial concern who had enormous resources at its disposal. Contracts were immediately let for buildings of the very latest construction. The best machinery available in the country for this work was purchased and installed. Men were hired from the different arsenals throughout the country, and were put in charge of the various departments. These men had a wide experience in the production of military rifles. The fact was overlooked, however, that the production of a military rifle requires careful planning and a high order of executive ability. The men put in charge had not had experience with work done on so large a scale, and hence the planning—the most essential part—was completely ignored. Brick, mortar and machines were thought to be the chief requisites. Men with good mechanical experience and executive knowledge who did not appear to have the "pep" necessary

Fig. 1. New Machinery Warehouse built at Chicago, Ill., by Hill, Clarke & Co.

were quickly dispensed with and others possessing the faculty of "shooting the bluff" were placed in charge at fabulous salaries.

The financial world has had a sad awakening and one that it will remember for some time to come. It has learned that managing ability is of the greatest importance and should be considered first. It is to be regretted, however, that such a lesson was necessary before those possessed with large capital were able to see one of the fundamental issues in connection with the manufacture of any product, whether it be made on an interchangeable basis or not. D. T. H.

* * *

CHARLES H. BESLY & CO.'S FIRE

The offices and warehouse of Charles H. Besly & Co., 118-124 N. Clinton St., Chicago, were totally destroyed by fire Saturday morning, January 13. The building and contents were fully insured and the records found intact in the vaults. Edward P. Welles, the president, with his customary energy immediately arranged for temporary quarters, which were secured in the Ruprecht Building, on Randolph and Jefferson Sts. The Beloit factory is intact and running night and day, so there will be no trouble supplying the products manufactured there. Stocks of other tools and supplies of all kinds which C. H. Besly & Co. deal in are being rushed to Chicago, and with the kindly cooperation of other jobbers in that city and elsewhere the firm is already in a position to fill orders promptly.

The statements that the fire was of incendiary origin and that the company was manufacturing munitions are incorrect. Coming, as the fire did, immediately after the explosion of the DuPont Powder Works at Haskell, N. J., and the destruction of the Canadian Foundry & Machine Co.'s plant at Kingsland, N. J., many jumped to the conclusion that this also was an incendiary fire promoted by foreign interests. The company expects to rebuild on the old site immediately, and its architects are now preparing plans for a new building, which will be a model of its kind and embody many of Mr. Welles' up-to-date ideas in the construction of a warehouse and offices for the use of such a business.

MACHINERY WAREHOUSE OF HILL, CLARKE & CO.

To provide for carrying a stock of machine tools, Hill, Clarke & Co. of Chicago, Ill., have constructed a warehouse at Chicago. This building is of brick, concrete and steel construction, and is provided with all the facilities for handling heavy machinery and "re-manufacturing" machine tools, a large part of the space in the new warehouse being given over to this work.

The building, which is 160 feet wide by 360 feet long, provides a floor space of about 55,000 square feet. From floor to roof, the height is 40 feet, and there is a maximum clearance of 25 feet under the crane hook. Two Pawling & Harnischfeger cranes are provided, each of which has a span of 75 feet; the building is divided into two longitudinal bays, and the cranes serve the entire floor space. The crane in the north bay has a capacity of 40 tons, while the crane in the south bay has a capacity of 10 tons. The building is heated by a battery of two seventy-five-horsepower Kewanee boilers. There is liberal window space all around the building, and there are eight skylights 65 feet long. Radiators run along the entire window

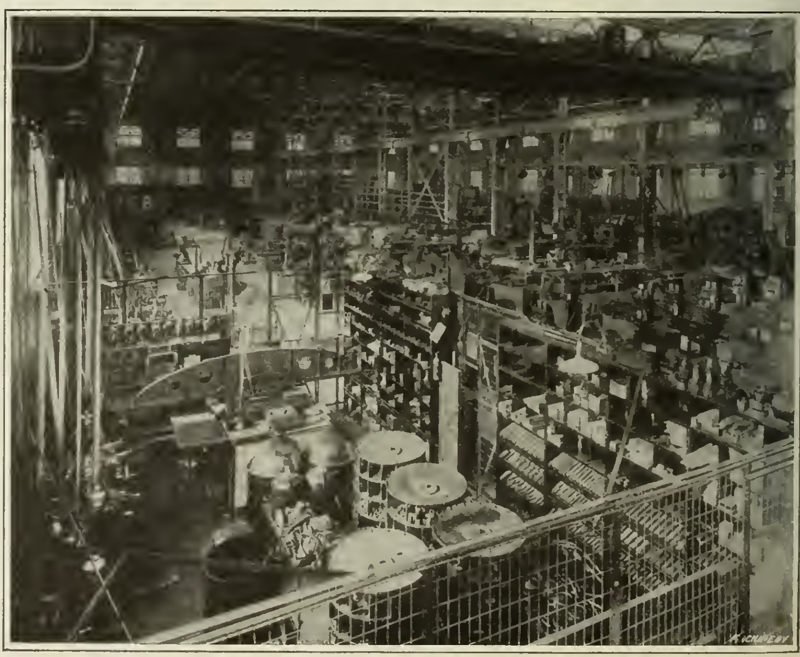


Fig. 2. View of Tool-room which is fully equipped with Tools and Supplies for re-manufacturing Machine Tools

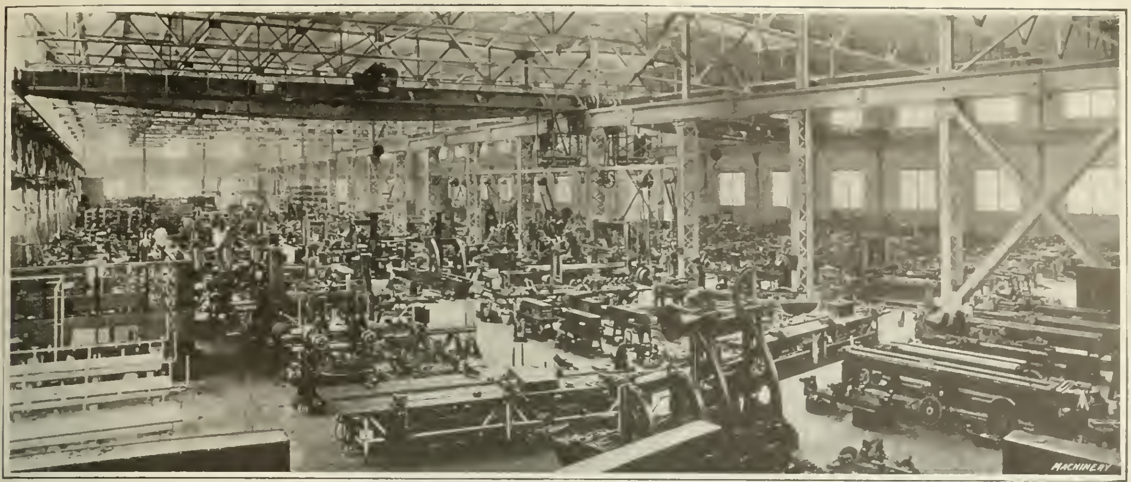


Fig. 3. Interior of Hill, Clarke & Co.'s Machinery Warehouse

space, and radiators are also furnished around each of the skylights. To insure efficient circulation of the steam, a vacuum pump is provided.

Two excellent features of the lay-out of this building are seen in the arrangement of window space and the design of the roof. It has already been stated that windows extend around the entire building, so that ample light is provided; these windows are placed at a height of about eight feet from the floor, so that the workman's attention is not distracted by occurrences outside. The roof slopes in toward the center, which directs the drainage to central pipes provided for carrying away the water. In winter this prevents the formation of icicles on the eaves.

Railroad shipping facilities are provided by a siding from the Chicago Belt Railroad, which makes connection with all lines coming into the city. In this way excellent shipping facilities are provided both to and from the warehouse. A track enters crosswise at the rear end of the building and runs the cars under one of the electric traveling cranes, making loading and unloading an easy matter. The doors at the front of the building are of sufficient height to clear any load that can be placed on horse-drawn or motor trucks by the electric cranes. The building is provided with a heavy concrete floor, which rests on a bed of cinders 18 inches in thickness. This floor is covered with a one-inch surface dressing, made of cement and granite screenings, instead of cement and sand, which does away with all tendency of the floor to "dust," not only making the building more sanitary, but also preventing fine grit from finding its way into machine bearings and causing damage.

Re-manufacturing Machine Tools

For several years Hill, Clarke & Co. of Chicago have been doing an extensive business in second-hand machinery, and have developed the process of rebuilding to a high plane. Each machine that comes into the shop is completely disassembled and all parts are carefully examined to ascertain any possible damage they may have received while in use. This practice is followed even in the case of machines which are practically new, the routine through which all machines are put consisting of first thoroughly cleaning all parts and testing all flat surfaces with straightedges or surface plates. The flat surfaces are then hand-scraped to B. & S. surface plates, and if badly worn they are planed before being scraped. All cylindrical bearings are re-aligned, and such bearings are renewed when necessary. Any damaged parts are repaired or replaced, the idea in all cases being to make them as good as new.

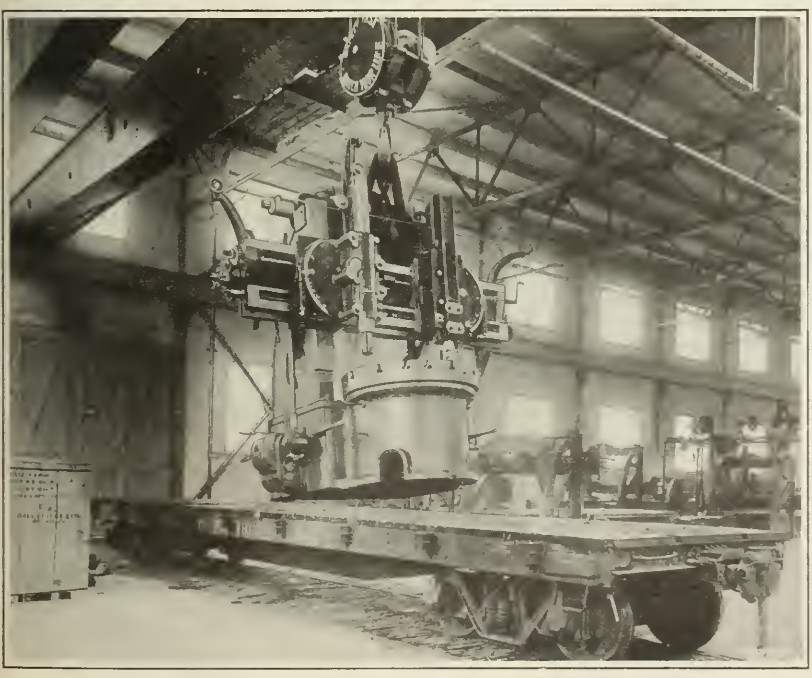


Fig. 4. Lifting a Heavy Machine from a Car with a Pawling & Harnischfeger Electric Crane

All enamel and filler is scraped off the castings, which are then refilled and re-enameled, and all bright parts are polished, which, in connection with the refinished castings, gives the machine the appearance of being new. All adjustments are made under the supervision of four competent foremen, who carry out instructions given by a superintendent who has had wide experience in machine tool building. Finally, each machine is tested under belt to determine its ability to give satisfactory results, both as regards smoothness of operation and accuracy of work produced. To the reader who is familiar with average practice in rebuilding second-hand machinery for the market, it will be apparent that the practice of Hill, Clarke & Co. is carried much further than that of the average

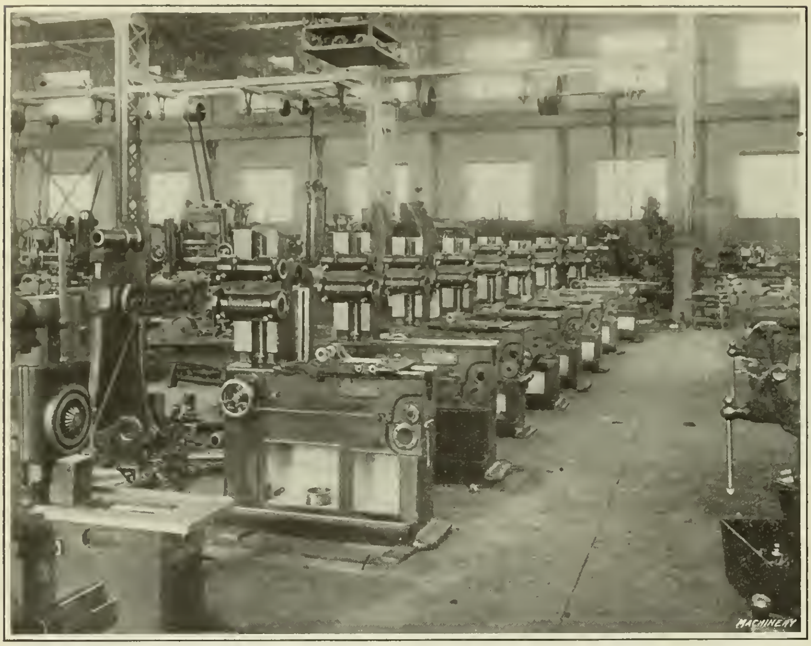


Fig. 5. Line of Brown & Sharpe No. 13 Gear-cutting Machines in Process of re-manufacturing

dealer in so-called rebuilt machine tools. It was on this account that the present firm adopted the term "re-manufactured" machine tools to designate its product. All machinery of this class is sold under the following guarantee: "If a machine is not suited for your work, if it disappoints you in any way, send it back within thirty days from date of shipment, freight prepaid, and we will cheerfully refund your purchase price in full." This guarantee, coupled with the favorable impression gained from an inspection of the way in which work is carried out in the shop, has led many firms that have never before placed any second-hand tools in their shops to purchase re-manufactured machinery.

* * *

PUBLIC OWNERSHIP DOES NOT PAY ?

The opponents of municipal and government ownership of public utilities claim that public ownership never pays a profit. Of course it does not; in fact, no human activity pays a profit in the last analysis, as can be easily shown. Let the advocates of private ownership analyze the economics of existence. Let them look back through history and determine what has been the inheritance of mankind. They will find that the only human things that endure are the race and a portion of its accumulated knowledge. Mankind bridges time by the succession of generations; but practically all its works eventually disappear. It makes little difference whether they are perishable products or engineering structures; they are all consumed or wasted away by the tooth of time. We are the inheritors of the past in name more than in fact; food, clothing, dwellings, factories, roads, railways, machinery, shipping and every form of wealth are constantly being used up and must constantly be renewed.

The companies enjoying the private ownership of public utilities are free to pick and choose the best labor, and leave the common, inefficient labor to shift for itself. Their rates are fixed at a liberal margin above cost, and as a result they are generally able to operate their utilities at a profit. But a publicly owned utility, if it is of broad extent, must necessarily employ that portion of the community that is representative of the average. If all utilities were publicly owned, it is quite evident that no profit from their operation could result. No government makes a profit; it is impossible. Profit means something accumulated at the expense of the customers. If everyone is customer and owner at once, there can be no such thing as profit or loss, except that in the last analysis everything is consumed.

All publicly owned utilities must necessarily be at a disadvantage when compared with private utilities. The private utility is able to hire a high-priced man to act as manager who may be of unusual ability. His talents are directed to saddling losses on others and profits on his own concern. If the able manager had to work for all the owners of the community, his fine showing would disappear.

* * *

ENGLISH AND METRIC DRILL SIZES

With the growth of the nation's export trade, there has come an increasing demand that the metric system of measurements be used in the manufacture of American machinery. Although it is improbable that this system will displace the English system of measurements in this country, shops that have an export trade must be familiar with both. For that reason we give here the English and metric twist drill sizes and the equivalent decimal parts of an inch. Millimeter drills can often be used in manufacturing where close limits are desired, and as they can be purchased in the open market, the expense of making special reamers will be avoided. H. J.

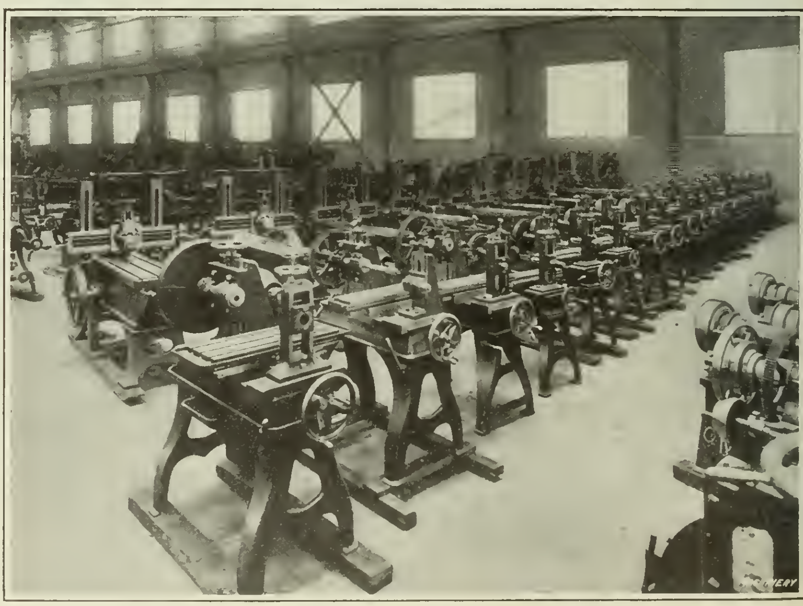


Fig. 6. Re-manufactured Planers and Lincoln Milling Machines Complete and Ready for Sale

ENGLISH AND METRIC TWIST DRILL SIZES

No. or Letter of Drill	Diameter, Inch	Diameter, Millimeters	Decimal Equivalent of Inch
80			0.0135
79			0.0145
	1/64		0.0156
		0.4	0.0157
78			0.0160
77			0.0180
		0.5	0.0197
76			0.0200
75			0.0210
74			0.0225
		0.6	0.0236
73			0.0240
72			0.0250
71			0.0260
		0.7	0.0276
70			0.0280
69			0.0292
68			0.0310
	1/32		0.0312
		0.8	0.0315
67			0.0320
66			0.0330
65			0.0350
		0.9	0.0354
64			0.0360
63			0.0370
62			0.0380
61			0.0390
		1.0	0.0394
60			0.0400
59			0.0410
58			0.0420
57			0.0430
		1.1	0.0433
56			0.0465
	3/64		0.0468
		1.2	0.0472
		1.3	0.0512
55			0.0520
54			0.0550
		1.4	0.0551
		1.5	0.0591
53			0.0595
	1/16		0.0625
		1.6	0.0630
52			0.0635
		1.7	0.0669
51			0.0670
50			0.0700
		1.8	0.0709
49			0.0730
		1.9	0.0748
48			0.0760
	5/64		0.0781
47			0.0785
		2.0	0.0787
46			0.0810
45			0.0820
		2.1	0.0827
44			0.0860
		2.2	0.0866
43			0.0890
		2.3	0.0906
42			0.0935
	3/32		0.0937
		2.4	0.0945
41			0.0960
40			0.0980
		2.5	0.0984
39			0.0995
38			0.1015
		2.6	0.1024
37			0.1040
		2.7	0.1063
36			0.1065
	7/64		0.1095
35			0.1100
		2.8	0.1102
34			0.1110
33			0.1130
		2.9	0.1142
32			0.1160
		3.0	0.1181
31			0.1200
		3.1	0.1221
	1/8		0.1250

No. or Letter of Drill	Diameter, Inch	Diameter, Millimeters	Decimal Equivalent of Inch
		3.2	0.1259
30			0.1285
		3.3	0.1299
		3.4	0.1339
29			0.1360
		3.5	0.1378
28			0.1405
	9/64		0.1406
		3.6	0.1417
27			0.1440
		3.7	0.1457
26			0.1470
25			0.1495
		3.8	0.1496
24			0.1520
		3.9	0.1535
23			0.1540
	5/32		0.1562
22			0.1570
		4.0	0.1575
21			0.1590
20			0.1610
		4.1	0.1614
		4.2	0.1654
19			0.1660
		4.3	0.1693
18			0.1695
	11/64		0.1718
17			0.1730
		4.4	0.1732
16			0.1770
		4.5	0.1772
15			0.1800
		4.6	0.1811
14			0.1820
13			0.1850
		4.7	0.1850
	3/16		0.1875
		4.8	0.1889
12			0.1890
11			0.1910
		4.9	0.1929
10			0.1935
9			0.1960
		5.0	0.1969
8			0.1990
		5.1	0.2008
7			0.2010
	13/64		0.2031
6			0.2040
		5.2	0.2047
5			0.2055
		5.3	0.2087
4			0.2090
		5.4	0.2126
3			0.2130
		5.5	0.2165
	7/32		0.2187
		5.6	0.2205
2			0.2210
		5.7	0.2244
1			0.2280
		5.8	0.2284
		5.9	0.2323
A			0.2340
	15/64		0.2343
		6.0	0.2362
B			0.2380
		6.1	0.2402
C			0.2420
		6.2	0.2441
D			0.2460
		6.3	0.2480
E			0.2500
	1/4		0.2500
		6.4	0.2519
		6.5	0.2559
F			0.2570
		6.6	0.2598
G			0.2610
		6.7	0.2638
	17/64		0.2656
H			0.2660
		6.8	0.2677
		6.9	0.2716
I			0.2720

No. or Letter of Drill	Diameter, Inch	Diameter, Millimeters	Decimal Equivalent of Inch
		7.0	0.2756
J			0.2770
		7.1	0.2795
K			0.2810
	9/32		0.2812
		7.2	0.2835
		7.3	0.2874
L			0.2900
		7.4	0.2913
M			0.2950
		7.5	0.2953
	19/64		0.2968
		7.6	0.2992
N			0.3020
		7.7	0.3031
		7.8	0.3071
		7.9	0.3110
	5/16		0.3125
		8.0	0.3149
O			0.3160
		8.1	0.3189
		8.2	0.3228
P			0.3230
		8.3	0.3268
	21/64		0.3281
		8.4	0.3307
Q			0.3320
		8.5	0.3347
		8.6	0.3386
R			0.3390
		8.7	0.3425
	11/32		0.3437
		8.8	0.3465
S			0.3480
		8.9	0.3504
		9.0	0.3543
T			0.3580
		9.1	0.3583
	23/64		0.3593
		9.2	0.3622
		9.3	0.3661
U			0.3680
		9.4	0.3701
		9.5	0.3740
	3/8		0.3750
V			0.3770
		9.6	0.3779
		9.7	0.3819
		9.8	0.3858
W			0.3860
		9.9	0.3898
	25/64		0.3906
		10.0	0.3937
X			0.3970
Y			0.4040
	13/32		0.4062
Z			0.4130
		10.5	0.4134
	27/64		0.4218
		11.0	0.4330
	7/16		0.4375
		11.5	0.4520
	29/64		0.4531
	15/32		0.4687
		12.0	0.4724
	31/64		0.4843
		12.5	0.4921
	1/2		0.5000
		13.0	0.5118
	33/64		0.5156
	17/32		0.5312
		13.5	0.5315
	35/64		0.5468
		14.0	0.5512
	9/16		0.5625
		14.5	0.5709
	37/64		0.5781
		15.0	0.5905
	19/32		0.5937
	39/64		0.6093
		15.5	0.6102
	5/8		0.6250
		16.0	0.6299
	41/64		0.6406
		16.5	0.6496
	21/32		0.6562

Machinery

ENGLISH AND METRIC TWIST DRILL SIZES

No. or Letter of Drill	Diameter, Inch	Diameter, Millimeters	Decimal Equivalent of Inch	No. or Letter of Drill	Diameter, Inch	Diameter, Millimeters	Decimal Equivalent of Inch	No. or Letter of Drill	Diameter, Inch	Diameter, Millimeters	Decimal Equivalent of Inch
		17.0	0.6693			28.5	1.1220			40.0	1.5748
	43/64		0.6718		1 1/8		1.1250		1 37/64		1.5781
	11/16		0.6875		1 9/64		1.1406		1 19/32		1.5937
		17.5	0.6890			29.0	1.1417			40.5	1.5945
	45/64		0.7031		1 5/32		1.1562		1 39/64		1.6093
		18.0	0.7087			29.5	1.1614			41.0	1.6142
	23/32		0.7187		1 11/64		1.1718		1 5/8		1.6250
		18.5	0.7283			30.0	1.1811			41.5	1.6339
	47/64		0.7343		1 3/16		1.1875		1 41/64		1.6406
		19.0	0.7480			30.5	1.2008			42.0	1.6535
	3/4		0.7500		1 13/64		1.2031		1 21/32		1.6562
	49/64		0.7656		1 7/32		1.2187		1 43/64		1.6718
		19.5	0.7677			31.0	1.2205			42.5	1.6732
	25/32		0.7812		1 15/64		1.2343		1 11/16		1.6875
		20.0	0.7874			31.5	1.2402			43.0	1.6929
	51/64		0.7968		1 1/4		1.2500		1 45/64		1.7031
		20.5	0.8071			32.0	1.2598			43.5	1.7126
	13/16		0.8125		1 17/64		1.2656		1 23/32		1.7187
		21.0	0.8268			32.5	1.2795			44.0	1.7323
	53/64		0.8281		1 9/32		1.2812		1 47/64		1.7343
	27/32		0.8437		1 19/64		1.2968		1 3/4		1.7500
		21.5	0.8465			33.0	1.2992			44.5	1.7520
	55/64		0.8593		1 5/16		1.3125		1 49/64		1.7656
		22.0	0.8661			33.5	1.3189			45.0	1.7716
	7/8		0.8750		1 21/64		1.3281		1 25/32		1.7812
		22.5	0.8858			34.0	1.3386			45.5	1.7913
	57/64		0.8906		1 11/32		1.3437		1 51/64		1.7968
		23.0	0.9055			34.5	1.3583			46.0	1.8110
	29/32		0.9062		1 23/64		1.3593		1 13/16		1.8125
	59/64		0.9218		1 3/8		1.3750		1 53/64		1.8281
		23.5	0.9252			35.0	1.3779			46.5	1.8307
	15/16		0.9375		1 25/64		1.3906		1 27/32		1.8437
		24.0	0.9449			35.5	1.3976			47.0	1.8504
	61/64		0.9531		1 13/32		1.4062		1 55/64		1.8593
		24.5	0.9646			36.0	1.4173			47.5	1.8701
	31/32		0.9687		1 27/64		1.4218		1 7/8		1.8750
		25.0	0.9842			36.5	1.4370			48.0	1.8898
	63/64		0.9843		1 7/16		1.4375		1 57/64		1.8906
	1		1.0000		1 29/64		1.4531		1 29/32		1.9062
		25.5	1.0039			37.0	1.4567			48.5	1.9094
	1 1/64		1.0156		1 15/32		1.4687		1 59/64		1.9218
		26.0	1.0236			37.5	1.4764			49.0	1.9291
	1 1/32		1.0312		1 31/64		1.4843		1 15/16		1.9375
		26.5	1.0433			38.0	1.4961			49.5	1.9488
	1 3/64		1.0468		1 1/2		1.5000		1 61/64		1.9531
	1 1/16		1.0625		1 33/64		1.5156			50.0	1.9685
		27.0	1.0630			38.5	1.5157		1 31/32		1.9687
	1 5/64		1.0781		1 17/32		1.5312		1 63/64		1.9843
		27.5	1.0827			39.0	1.5354			50.5	1.9882
	1 3/32		1.0937		1 35/64		1.5468		2		2.0000
		28.0	1.1024			39.5	1.5551				
	1 7/64		1.1093		1 9/16		1.5625				

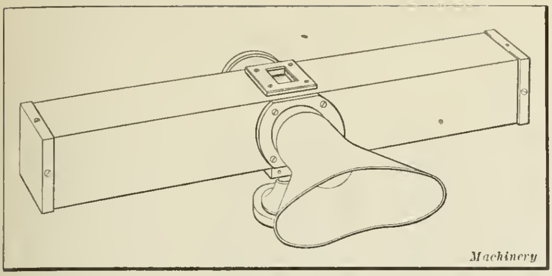
Machinery

WEDGE OPTICAL PYROMETER

To meet the demand for a simple form of pyrometer suitable for use by the average shop man, Barnes & Morris, 182 and 183 Temple Chambers, London, England, have recently placed on the market an instrument known as the Wedge optical pyrometer. It is stated that this is a perfectly reliable instrument, and that after half an hour's practice, any intelligent man can estimate temperature with a limit of accuracy of 18 degrees or even 9 degrees F. in exceptional cases. This instrument can be employed wherever the heated body is visible, either directly or by reflection. Its range is from any temperature at which the object becomes visibly red, say 932 degrees F., up to the highest temperatures.

The pyrometer consists of a brass tube furnished with a small telescope arranged in such a way that the objective of the telescope focuses the image of the heated object on a movable prism placed inside the tube. The eye-piece of the pyrometer telescope then reveals the magnified image on the prism. A suitable shield is provided to prevent exterior light from reaching the eye, and at one side of the pyrometer tube there is a knurled head which actuates a rack and pinion that moves the prism through the field of vision. This prism is made of specially prepared dark glass, so that it cuts off the light emitted by the heated body at various temperatures. For example, in looking at a heated bar of steel, suppose the temperature is 1832 degrees F.; upon turning the screw, the thicker part of the prism comes gradually into the field of vision and the image gradually appears to become darker and darker in color until at a given point the color entirely disappears. This point is marked by an indicator on top of the pyrometer tube, which consists of a scale that moves under a line on the glass window through which this scale is viewed. Reference to the scale enables the temperature of the heated object to be read. Naturally, a little practice is required to decide the exact moment when the color disappears, and it is on this account that a certain amount of experience is necessary in order to obtain accurate results with a Wedge pyrometer.

In the case of increasing temperatures the method of procedure is to watch the object through the telescope and gradually turn the milled head until the color is obliterated. The scale reading indicates the actual temperature of the heated object, and the distance of the object from the observer makes no difference to the reading, provided the heated surface is visible. In cases where layers of carbonic oxide, carbonic acid gas or steam intervene between the instrument and the heated object, the reading of temperature obtained will be slightly lower than the actual figure. For this reason, when observing the temperature of melted metal in a crucible, it is a good plan to plunge a tube a few inches below the surface of the metal, making the observation directly down the tube. In this way the surface is protected from fumes and greater accuracy is likely to result. Advantages claimed by the Wedge optical



Wedge Optical Pyrometer in which Measurement of Temperature is dependent upon Intensity of Light emitted from Heated Body

pyrometer are its simple construction and the ease with which it may be operated, the fact that it is self-contained and does not require the use of any accessories, elimination of danger of breaking the instrument—which is an important feature when compared with the more complicated instruments that are only suitable for use by scientific men—and, finally, the fact that this instrument enables accurate temperature regulation to be provided in many instances where it is not deemed advisable to install more complicated forms of temperature measuring apparatus. The instrument is calibrated to cover any range of temperatures desired between the limits of 500 degrees C. (932 degrees F.) and 2100 degrees C. (3812 degrees F.); generally speaking, a single instrument is arranged to cover a range of 400 degrees C. (720 degrees F.), the scale being divided into intervals of 20 degrees C. (36 degrees F.).

* * *

PUNCH GRINDING MACHINE

The grinding machine here described, which is in use at the factory of the Willemin Mfg. Co., Inc., Providence, R. I., is noticeable for its simplicity, yet it accomplishes certain results more satisfactorily than some larger and more expensive machines. At right angles to the center line of the emery wheel spindle is mounted the work-holding arm. There is a large hole at the working end of this arm, the lower portion of which is shaped to a V. This facilitates holding circular work, which is largely what a machine of this type is called upon to handle. The other end of the work-holding arm is constructed to slide or clamp around a rod which is parallel to the center line of the emery wheel spindle. This arm also swings radially around the rod mentioned, and in this way the work is brought into contact with the emery wheel. For large adjustments, such as two or three inches, the work arm is unclamped from the spindle on which it slides, and moved to the desired position. For minute adjustments up to one inch, the entire rod may be moved to or from the emery wheel by the knurled finger nut shown. This machine has been found useful for sharpening punches with a circular shank. There are numerous other uses to which it can be put, but it was found especially effective for squaring off a large number of small circular pieces which had been cut off in a screw machine. On work of this kind it is a simple operation to slip one of the pieces into the work arm and pass it across the emery wheel face. V. B.

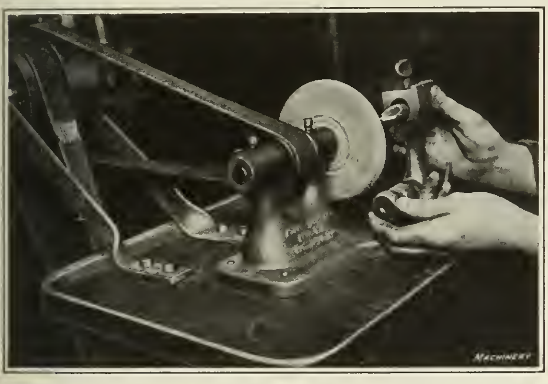


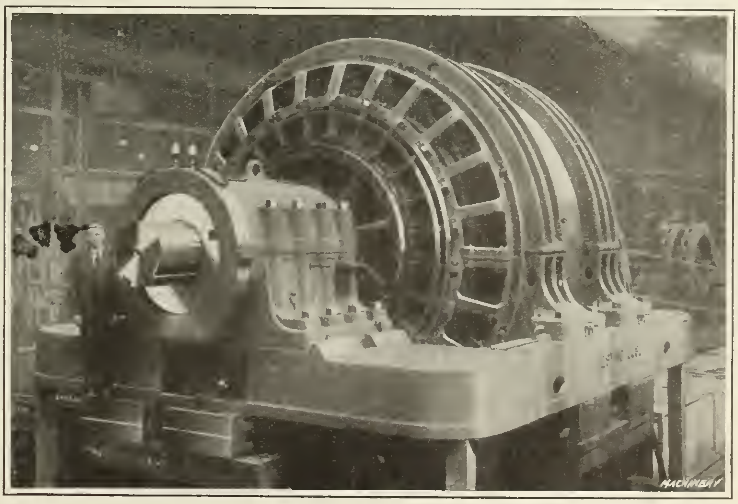
Fig. 1. Punch Grinding Machine in Operation, showing Micrometer Adjustment

Fig. 2. View of Punch Grinding Machine showing Motor Drive

* * *

HUGE REVERSING MOTOR

The illustration shows what is said to be the largest electric motor in the world. It was built by the Westinghouse Electric & Mfg. Co. for driving a 35-inch, two-high reversing blooming mill in a steel plant, and is rated at 15,000 horsepower. An idea of the size of this gigantic motor is gained from the figure of the man standing beside the bearing, who is 6 feet tall. Reversals can be made in two seconds from full speed ahead to full speed reverse. The complete motor weighs 250 tons, the rotor alone weighing about 100 tons. It stands twenty feet high and the shaft is two feet in diameter.



Westinghouse 15,000-horsepower Reversing Motor for Blooming Mill

AREAS OF CIRCLES IN SQUARE INCHES, WHEN DIAMETERS ARE GIVEN IN MILLIMETERS

Diameter Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches
1	0.001217	86	9.00366	171	35.59711	256	79.78156	341	141.55700	426	220.92343
2	0.004869	87	9.21427	172	36.01467	257	80.40607	342	142.38846	427	221.96185
3	0.010956	88	9.42731	173	36.43466	258	81.03301	343	143.22236	428	223.00270
4	0.019477	89	9.64278	174	36.85709	259	81.66239	344	144.05869	429	224.04599
5	0.030434	90	9.86069	175	37.28195	260	82.29421	345	144.89746	430	225.09171
6	0.043825	91	10.08104	176	37.70925	261	82.92846	346	145.73866	431	226.13986
7	0.059651	92	10.30381	177	38.13898	262	83.56514	347	146.58230	432	227.19045
8	0.077911	93	10.52903	178	38.57115	263	84.20426	348	147.58237	433	228.24348
9	0.098606	94	10.75668	179	39.00575	264	84.84581	349	148.27688	434	229.29894
10	0.121737	95	10.98676	180	39.44278	265	85.48980	350	149.12782	435	230.35683
11	0.147301	96	11.21928	181	39.88225	266	86.13623	351	149.98120	436	231.41716
12	0.175301	97	11.45423	182	40.32416	267	86.78508	352	150.83701	437	232.47993
13	0.205735	98	11.69162	183	40.76850	268	87.43638	353	151.69525	438	233.54513
14	0.238604	99	11.93144	184	41.21527	269	88.09011	354	152.55593	439	234.61276
15	0.273908	100	12.17370	185	41.66448	270	88.74627	355	153.41905	440	235.68283
16	0.311646	101	12.41839	186	42.11613	271	89.40487	356	154.28460	441	236.75533
17	0.351819	102	12.66551	187	42.57021	272	90.06590	357	155.15258	442	237.83027
18	0.394427	103	12.91507	188	43.02672	273	90.72936	358	156.02300	443	238.90764
19	0.439470	104	13.16707	189	43.48567	274	91.39527	359	156.89586	444	239.98745
20	0.486948	105	13.42150	190	43.94705	275	92.06360	360	157.77115	445	241.06969
21	0.536860	106	13.67836	191	44.41087	276	92.73437	361	158.64887	446	242.15437
22	0.589207	107	13.93766	192	44.87712	277	93.40758	362	159.52903	447	243.24148
23	0.643988	108	14.19940	193	45.34581	278	94.08322	363	160.41162	448	244.33102
24	0.701205	109	14.46357	194	45.81691	279	94.76129	364	161.29665	449	245.42300
25	0.760856	110	14.73017	195	46.29049	280	95.44180	365	162.18411	450	246.51742
26	0.822942	111	14.99921	196	46.76648	281	96.24752	366	163.07401	451	247.61427
27	0.887462	112	15.27068	197	47.24491	282	96.81013	367	163.96634	452	248.71356
28	0.954418	113	15.54459	198	47.72577	283	97.49794	368	164.86111	453	249.81528
29	1.02380	114	15.82094	199	48.20906	284	98.18819	369	165.75831	454	250.91943
30	1.09563	115	16.09971	200	48.69480	285	98.88087	370	166.65795	455	252.02602
31	1.16989	116	16.38093	201	49.18296	286	99.57599	371	167.56002	456	253.13504
32	1.24658	117	16.66457	202	49.67356	287	100.27354	372	168.46453	457	254.24650
33	1.32571	118	16.95065	203	50.16660	288	100.97353	373	169.37147	458	255.36040
34	1.40727	119	17.23917	204	50.66206	289	101.67595	374	170.28084	459	256.47672
35	1.49127	120	17.53012	205	51.15997	290	102.38081	375	171.19265	460	257.59549
36	1.57771	121	17.82351	206	51.66031	291	103.08810	376	172.10690	461	258.71668
37	1.66658	122	18.11933	207	52.16308	292	103.79783	377	173.02358	462	259.84032
38	1.75788	123	18.41759	208	52.66829	293	104.50999	378	173.94269	463	260.96638
39	1.85161	124	18.71828	209	53.17593	294	105.22459	379	174.86424	464	262.09489
40	1.94779	125	19.02140	210	53.68601	295	105.94162	380	175.78822	465	263.22582
41	2.04639	126	19.32696	211	54.19852	296	106.66108	381	176.71464	466	264.35919
42	2.14744	127	19.63496	212	54.71347	297	107.38279	382	177.64349	467	265.49500
43	2.25091	128	19.94539	213	55.23085	298	108.10732	383	178.27778	468	266.63324
44	2.35682	129	20.25825	214	55.75067	299	108.83409	384	179.50851	469	267.77392
45	2.46517	130	20.57355	215	56.27292	300	109.56330	385	180.44466	470	268.91703
46	2.57595	131	20.89128	216	56.79761	301	110.29493	386	181.38326	471	270.06257
47	2.68917	132	21.21145	217	57.32473	302	111.02901	387	182.32428	472	271.21055
48	2.80482	133	21.53405	218	57.85429	303	111.76552	388	183.26774	473	272.36097
49	2.92290	134	21.85909	219	58.38628	304	112.50446	389	184.21364	474	273.51382
50	3.04342	135	22.18656	220	58.92070	305	113.24584	390	185.16197	475	274.66910
51	3.16637	136	22.51647	221	59.45756	306	113.98965	391	186.11274	476	275.82682
52	3.29176	137	22.84881	222	59.99686	307	114.73590	392	187.06594	477	276.98697
53	3.41959	138	23.18359	223	60.53859	308	115.48458	393	188.02157	478	278.14956
54	3.54985	139	23.52080	224	61.08275	309	116.23570	394	188.97964	479	279.31459
55	3.68254	140	23.86045	225	61.62935	310	116.98925	395	189.94015	480	280.48204
56	3.81767	141	24.20253	226	62.17839	311	117.74524	396	190.90309	481	281.65194
57	3.95523	142	24.54704	227	62.72985	312	118.50366	397	191.86846	482	282.82426
58	4.09523	143	24.89399	228	63.28376	313	119.26452	398	192.83627	483	283.99902
59	4.23766	144	25.24338	229	63.84010	314	120.02781	399	193.80652	484	285.17622
60	4.38253	145	25.59520	230	64.39887	315	120.79353	400	194.77920	485	286.35585
61	4.52961	146	25.94945	231	64.96008	316	121.56169	401	195.75431	486	287.53792
62	4.67957	147	26.30614	232	65.52372	317	122.33229	402	196.73186	487	288.72242
63	4.83174	148	26.66527	233	66.08979	318	123.10532	403	197.71184	488	289.90936
64	4.98634	149	27.02683	234	66.65831	319	123.88078	404	198.69426	489	291.09873
65	5.14338	150	27.39082	235	67.22925	320	124.65865	405	199.67911	490	292.29053
66	5.30286	151	27.75725	236	67.80263	321	125.43902	406	200.66578	491	293.48477
67	5.46477	152	28.12611	237	68.37845	322	126.22179	407	201.81112	492	294.68145
68	5.64911	153	28.49741	238	68.95670	323	127.00699	408	202.64827	493	295.88056
69	5.79589	154	28.87114	239	69.53739	324	127.79463	409	203.64287	494	297.08210
70	5.96511	155	29.24731	240	70.12051	325	128.58470	410	204.63989	495	298.28608
71	6.13676	156	29.62591	241	70.70606	326	129.37721	411	205.63935	496	299.49429
72	6.31084	157	30.00695	242	71.29405	327	130.17215	412	206.64125	497	300.70134
73	6.48736	158	30.39042	243	71.88448	328	130.96953	413	207.64558	498	301.91262
74	6.66631	159	30.77633	244	72.47734	329	131.76934	414	208.65234	499	303.12634
75	6.84770	160	31.16467	245	73.07263	330	132.57159	415	209.66154	500	304.34250
76	7.03152	161	31.55544	246	73.67036	331	133.37627	416	210.67318	501	305.56108
77	7.21778	162	31.94865	247	74.27052	332	134.18339	417	211.68725	502	306.78310
78	7.40647	163	32.34420	248	74.87312	333	134.99294	418	212.69910	503	308.00556
79	7.59760	164	32.74238	249	75.47815	334	135.80492	419	213.72269	504	309.23145
80	7.79116	165	33.14289	250	76.08562	335	136.61934	420	214.74406	505	310.45978
81	7.98716	166	33.54584	251	76.69552	336	137.43620	421	215.76787	506	311.69054
82	8.18559	167	33.95123	252	77.30786	337	138.25549	422	216.79411	507	312.92374
83	8.38647	168	34.35905	253	77.92263	338	139.07721	423	217.82279	508	314.15937
84	8.58976	169	34.76930	254	78.53984	339	139.99013	424	218.85390	509	315.39743
85	8.79549	170	35.18199	255	79.15948	340	140.72797	425	219.88745	510	316.63793

Machinery

AREAS OF CIRCLES IN SQUARE INCHES, WHEN DIAMETERS ARE GIVEN IN MILLIMETERS

Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches
511	317.88087	596	432.42930	681	564.56872	766	714.29915	851	881.62057	936	1066.53298
512	319.12624	597	433.88162	682	566.22800	767	716.16537	852	883.69375	937	1068.81312
513	320.37404	598	435.33638	683	567.88971	768	718.03404	853	885.76936	938	1071.09569
514	321.62428	599	436.79357	684	569.55385	769	719.90514	854	887.84741	939	1073.38069
515	322.87695	600	438.25320	685	571.22043	770	721.77867	855	889.92790	940	1075.66813
516	324.13206	601	439.71526	686	572.88945	771	723.65464	856	892.01082	941	1077.95800
517	325.38960	602	441.17975	687	574.56090	772	725.53304	857	894.09617	942	1080.25031
518	326.64958	603	442.64668	688	576.23478	773	727.41387	858	896.18396	943	1082.54505
519	327.91200	604	444.11605	689	577.91110	774	729.29715	859	898.27419	944	1084.84223
520	329.17684	605	445.58785	690	579.58985	775	731.82856	860	900.36685	945	1087.14184
521	330.44413	606	447.06208	691	581.27104	776	733.07099	861	902.46194	946	1089.44389
522	331.71384	607	448.53875	692	582.95466	777	734.96157	862	904.55947	947	1091.74837
523	332.98599	608	450.01786	693	584.64072	778	736.85458	863	906.65943	948	1094.05528
524	334.26058	609	451.49940	694	586.32921	779	738.75002	864	908.76183	949	1096.36463
525	335.52760	610	452.98337	695	588.02014	780	740.64790	865	910.86666	950	1098.67642
526	336.81706	611	454.34804	696	589.71350	781	742.54822	866	912.97393	951	1100.99064
527	338.09895	612	455.95862	697	591.40930	782	744.45097	867	915.08363	952	1103.30730
528	339.38327	613	457.44990	698	593.10753	783	746.35615	868	917.19577	953	1105.62639
529	340.67003	614	458.94362	699	594.80819	784	748.26377	869	919.31034	954	1107.94791
530	341.95923	615	460.43976	700	596.51130	785	750.17382	870	921.42735	955	1110.27187
531	343.25086	616	461.93835	701	598.21683	786	752.08631	871	923.54679	956	1112.59826
532	344.54492	617	463.43936	702	599.92480	787	754.00123	872	925.57867	957	1114.92709
533	345.84142	618	464.94281	703	601.63521	788	755.91859	873	927.79298	958	1117.25836
534	347.14035	619	466.44870	704	603.34804	789	757.83838	874	929.91972	959	1119.59205
535	348.44172	620	467.95702	705	605.06332	790	759.76061	875	932.04890	960	1121.92819
536	349.74953	621	469.46778	706	606.78103	791	761.68527	876	934.18052	961	1124.26675
537	351.05176	622	470.98097	707	608.50117	792	763.61237	877	936.31457	962	1126.60776
538	352.36044	623	472.49660	708	610.22375	793	765.54190	878	938.45105	963	1128.95119
539	353.67154	624	474.01466	709	611.94876	794	767.47387	879	940.58997	964	1131.29707
540	354.98509	625	475.53515	710	613.67621	795	769.40827	880	942.73132	965	1133.64537
541	356.30706	626	477.05808	711	615.40609	796	771.34510	881	944.87511	966	1135.99611
542	357.61948	627	478.58344	712	617.13841	797	773.28438	882	947.02133	967	1138.34929
543	358.94032	628	480.11125	713	618.87316	798	775.22608	883	949.16999	968	1140.70490
544	360.26360	629	481.64148	714	620.61035	799	777.17022	884	951.32109	969	1143.06295
545	361.58932	630	483.17415	715	622.34998	800	779.16800	885	953.47461	970	1145.42343
546	362.91747	631	484.70925	716	624.09203	801	781.06580	886	955.63058	971	1147.78634
547	364.24806	632	486.24679	717	625.83652	802	783.01725	887	957.78897	972	1150.15169
548	365.58108	633	487.78676	718	627.58345	803	784.97113	888	959.94980	973	1152.51948
549	366.91653	634	489.32917	719	629.33261	804	786.92744	889	962.11307	974	1154.88970
550	368.25442	635	490.87401	720	631.08460	805	788.88619	890	964.27877	975	1157.26235
551	369.59474	636	492.42129	721	632.83838	806	790.84737	891	966.44691	976	1159.63744
552	370.93750	637	493.97100	722	634.59550	807	792.81099	892	968.61748	977	1162.01496
553	372.28270	638	495.52315	723	636.35460	808	794.77704	893	970.79048	978	1164.39492
554	373.63033	639	497.07773	724	638.11613	809	796.74553	894	972.96592	979	1166.77732
555	374.98039	640	498.63475	725	639.88010	810	798.71645	895	975.14380	980	1169.16214
556	376.33289	641	500.19420	726	641.64651	811	800.68981	896	977.32411	981	1171.54941
557	377.68782	642	501.75608	727	643.41534	812	802.66560	897	979.50685	982	1173.93910
558	379.04519	643	503.32040	728	645.18662	813	804.64383	898	981.69203	983	1176.33123
559	380.40499	644	504.88716	729	646.96023	814	806.62449	899	983.87965	984	1178.72580
560	381.76723	645	506.45635	730	648.73647	815	808.60758	900	986.06970	985	1181.12280
561	383.13190	646	508.02797	731	650.51505	816	810.59311	901	988.26218	986	1183.52224
562	384.49901	647	509.60203	732	652.29606	817	812.58108	902	990.45710	987	1185.92411
563	385.86855	648	511.17853	733	654.07950	818	814.57148	903	992.65445	988	1188.32842
564	387.24052	649	512.75746	734	655.86539	819	816.56431	904	994.85424	989	1190.73516
565	388.61493	650	514.33882	735	657.65370	820	818.55958	905	997.05646	990	1193.14433
566	389.99178	651	515.92262	736	659.44445	821	820.55729	906	999.26132	991	1195.55594
567	391.37106	652	517.50885	737	661.23764	822	822.55743	907	1001.46821	992	1197.96999
568	392.75277	653	519.09752	738	663.03326	823	824.56000	908	1003.67773	993	1200.38647
569	394.13692	654	520.68862	739	664.83132	824	826.56501	909	1005.88970	994	1202.80538
570	395.52351	655	522.28216	740	666.63181	825	828.57245	910	1008.10409	995	1205.22673
571	396.91253	656	523.87813	741	668.43473	826	830.58203	911	1010.32092	996	1207.65051
572	398.30398	657	525.47654	742	670.24009	827	832.59464	912	1012.54019	997	1210.07673
573	399.69787	658	527.07738	743	672.04789	828	834.60939	913	1014.76189	998	1212.50538
574	401.09419	659	528.68066	744	673.85812	829	836.62657	914	1016.98602	999	1214.93647
575	402.49295	660	530.28637	745	675.67078	830	838.64619	915	1019.21259	1000	1217.37000
576	403.89414	661	531.89451	746	677.48588	831	840.66824	916	1021.44160	1001	1219.80575
577	405.29777	662	533.50509	747	679.30341	832	842.69273	917	1023.67304	1002	1222.24434
578	406.70383	663	535.11811	748	681.12338	833	844.71965	918	1025.90691	1003	1224.68517
579	408.11233	664	536.73356	749	682.94578	834	846.74900	919	1028.14322	1004	1227.12843
580	409.52326	665	538.35144	750	684.77062	835	848.78079	920	1030.38196	1005	1229.57413
581	410.93663	666	539.97176	751	686.59789	836	850.81502	921	1032.62314	1006	1232.02226
582	412.35243	667	541.59452	752	688.42760	837	852.85168	922	1034.86675	1007	1234.47283
583	413.77067	668	543.21971	753	690.25974	838	854.89077	923	1037.11280	1008	1236.92583
584	415.19134	669	544.84733	754	692.09432	839	856.93230	924	1039.36128	1009	1239.38126
585	416.61444	670	546.47739	755	693.93133	840	858.97627	925	1041.61220	1010	1241.83913
586	418.03998	671	548.10988	756	695.77078	841	861.02670	926	1043.86555	1011	1244.29944
587	419.46796	672	549.74481	757	697.61266	842	863.07150	927	1046.12134	1012	1246.76218
588	420.89837	673	551.38217	758	699.45697	843	865.12277	928	1048.37956	1013	1249.22735
589	422.33121	674	553.02197	759	701.30372	844	867.17647	929	1050.64022	1014	1251.69496
590	423.76649	675	554.66420	760	703.15291	845	869.23261	930	1052.90331	1015	1254.16500
591	425.20421	676	556.30887	761	705.00453	846	871.29118	931	1055.16883	1016	1256.63748
592	426.64435	677	557.95597	762	706.85858	847	873.35419	932	1057.43679	1017	1259.11239
593	428.08694	678	559.60551	763	708.71507	848	875.41563	933	1059.70719	1018	1261.58974
594	429.53196	679	561.25748	764	710.57399	849	877.48151	934	1061.98002	1019	1264.06953
595	430.97941	680	562.91188	765	712.43535	850	879.54982	935	1064.25528	1020	1266.56174

Machinery

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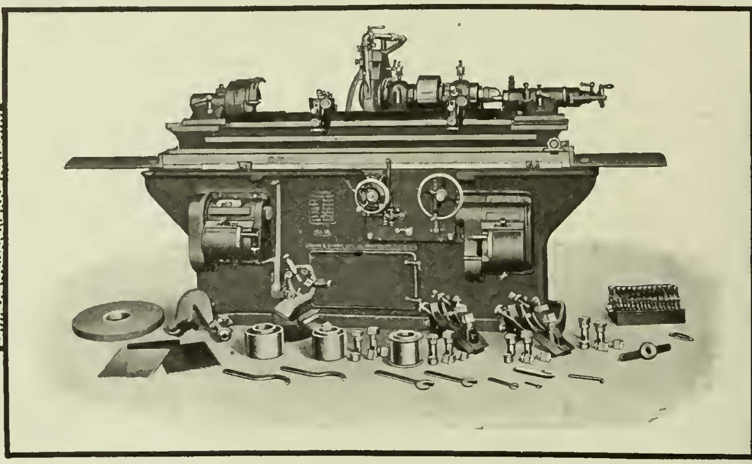

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AREAS OF CIRCLES IN SQUARE INCHES, WHEN DIAMETERS ARE GIVEN IN MILLIMETERS

Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches	Diameter, Milli-meters	Area, Square Inches
1021	1269.03640	1055	1354.96324	1089	1443.70464	1123	1535.26061	1157	1629.63113	1191	1726.81621
1022	1271.52348	1056	1357.53311	1090	1446.35729	1124	1537.99604	1158	1632.44934	1192	1729.71720
1023	1274.01300	1057	1360.10541	1091	1449.01238	1125	1540.73390	1159	1635.26999	1193	1732.62063
1024	1276.50496	1058	1362.68015	1092	1451.66989	1126	1543.47420	1160	1638.09307	1194	1735.52649
1025	1278.99935	1059	1365.25732	1093	1454.32985	1127	1546.21694	1161	1640.91858	1195	1738.43479
1026	1281.49618	1060	1367.83693	1094	1456.99224	1128	1548.96211	1162	1643.74653	1196	1741.34552
1027	1283.99544	1061	1370.41897	1095	1459.65706	1129	1551.70971	1163	1646.57692	1197	1744.25869
1028	1286.49713	1062	1373.00345	1096	1462.32432	1130	1554.45975	1164	1649.40974	1198	1747.17429
1029	1289.00126	1063	1375.59036	1097	1464.99401	1131	1557.21222	1165	1652.24499	1199	1750.09232
1030	1291.50783	1064	1378.17970	1098	1467.66614	1132	1559.96713	1166	1655.08268	1200	1753.01280
1031	1294.01683	1065	1380.77148	1099	1470.34070	1133	1562.72447	1167	1657.92281	1201	1755.93570
1032	1296.52826	1066	1383.36570	1100	1473.01770	1134	1565.48425	1168	1660.76537	1202	1758.88804
1033	1299.04213	1067	1385.96235	1101	1475.69713	1135	1568.24646	1169	1663.61036	1203	1761.78882
1034	1301.55843	1068	1388.56143	1102	1478.37899	1136	1571.01111	1170	1666.45779	1204	1764.71902
1035	1304.07717	1069	1391.16295	1103	1481.06329	1137	1573.77819	1171	1669.30765	1205	1767.65167
1036	1306.59835	1070	1393.76691	1104	1483.75003	1138	1576.54771	1172	1672.15995	1206	1770.58675
1037	1309.12195	1071	1396.37330	1105	1486.43920	1139	1579.31966	1173	1675.01468	1207	1773.52426
1038	1311.64800	1072	1398.98212	1106	1489.13080	1140	1582.09405	1174	1677.87185	1208	1776.46421
1039	1314.17647	1073	1401.59338	1107	1491.82484	1141	1584.87087	1175	1680.73145	1209	1779.40659
1040	1316.70739	1074	1404.20707	1108	1494.52132	1142	1587.65012	1176	1683.59349	1210	1782.35141
1041	1319.24073	1075	1406.82320	1109	1497.22023	1143	1590.43181	1177	1686.45796	1211	1784.20303
1042	1321.77652	1076	1409.44176	1110	1499.92157	1144	1593.21594	1178	1689.32487	1212	1788.24835
1043	1324.31473	1077	1412.06276	1111	1502.62535	1145	1596.00250	1179	1692.19421	1213	1791.20047
1044	1326.85538	1078	1414.68619	1112	1505.33156	1146	1598.79149	1180	1695.06598	1214	1794.15503
1045	1329.39847	1079	1417.31206	1113	1508.04021	1147	1601.58292	1181	1697.94019	1215	1797.11202
1046	1331.94399	1080	1419.94036	1114	1510.75130	1148	1604.37679	1182	1700.81684	1216	1800.07145
1047	1334.49195	1081	1422.57110	1115	1513.46481	1149	1607.17309	1183	1703.69592	1217	1803.03331
1048	1337.04234	1082	1425.20427	1116	1516.18077	1150	1609.97182	1184	1706.57743	1218	1805.99761
1049	1339.59516	1083	1427.83988	1117	1518.89915	1151	1612.77299	1185	1709.46138	1219	1808.96434
1050	1342.15042	1084	1430.47792	1118	1521.61997	1152	1615.57659	1186	1712.34777	1220	1811.93350
1051	1344.70811	1085	1433.22098	1119	1524.34323	1153	1618.38263	1187	1715.23659	....	....
1052	1347.26824	1086	1435.76130	1120	1527.06892	1154	1621.19110	1188	1718.12784	....	....
1053	1349.83081	1087	1438.40665	1121	1529.79705	1155	1624.00201	1189	1721.02153	....	....
1054	1352.39581	1088	1441.05443	1122	1532.52761	1156	1626.81535	1190	1723.91765	....	....

Machinery

TABLE CONVERTING MILLIMETER DIAMETERS INTO SQUARE INCHES

The accompanying table gives the areas of circles, in square inches, when their diameters are given in millimeters. In view of the increasing demand for work measured by the metric system, caused by our growing foreign trade, conversion tables of this kind are of value in both the shop and the drafting-room.

Leeds, England A. LANE

PERSONALS

H. A. Runge, vice-president of the Internations Commercial Corporation, New York City, has resigned his position.

H. D. Gumpper, until recently associated with the Emerson Co., New York City, efficiency engineer, is now with W. F. Hebard in the electric truck sales department of the Buda Co., Chicago, Ill.

James W. Barr, formerly the Eastern representative of the Cincinnati Milling Machine Co., Cincinnati, Ohio, is now general machine tool salesman for the Vandyck-Churchill Co. of New York City.

W. J. Radcliffe, vice-president and general manager of the E. A. Kinsey Co., Cincinnati, Ohio, was elected president and general manager of the company at a meeting of the board of directors January 17.

L. C. Parrott, for four years assistant purchasing agent of the Standard Parts Co. (formerly the Standard Welding Co.), Cleveland, Ohio, has resigned his position to become purchasing agent of the Otis Steel Co. of Cleveland.

H. A. Shier, who for the past seven years has represented the Bethlehem Steel Co. in southern Ohio, has resigned and taken a position with the Onondaga Steel Co., Inc., Syracuse, N. Y., as representative in southern Ohio and western Pennsylvania.

A luncheon was given at the Bankers Club, New York City, January 11, by Arthur Williams, president of the American Museum of Safety, in honor of the new director, Arthur H. Young, and in recognition of the services rendered by acting-director, A. A. Hopkins.

D. M. Kagay has taken the position of manager of the publication department with S. F. Bowser & Co., Inc., Fort Wayne, Ind. Mr. Kagay was formerly advertising manager of the Richards-Wilcox Mfg. Co., Aurora, Ill., and editor of two house organs published by the company.

H. D. Savage, vice-president of the American Arch Co., has been appointed manager of sales of the industrial department of the Locomotive Pulverized Fuel Co., with offices at 30 Church St., New York City. He will continue to act in the capacity of vice-president of the American Arch.Co.

Paul R. Ketzer, formerly Eastern manager of the Metalwood Mfg. Co., Detroit, Mich., has gone into business for himself and organized a company called the Ketzer Machinery Co., which will specialize in power, steam, hydraulic and special machinery and tools. The office of the company is in the Bourse, Philadelphia, Pa.

H. H. Gildner, for the past three years chief engineer of the S. K. F. Ball Bearing Co., Hartford, Conn., has resigned and joined F. R. Blair & Co., Inc., 50 Church St., New York City, as manager of the company's "Flexite" department. Mr. Gildner will devote himself to the development and sale of "Flexite" universal joints and couplings.

Gorham C. Parker has resigned his position of sales manager for the T. R. Almond Mfg. Co., Ashburnham, Mass., and organized the Parker Mfg. Co. of Detroit, Mich. The company will manufacture a complete line of three-jawed keyed type of drill chucks. Mr. Parker was formerly sales manager for the Jacobs Mfg. Co. of Hartford, Conn., and is well known in the machinery trade.

A. L. Humphrey, vice-president of the Union Switch & Signal Co., has been elected president of the company. The control of the company will be taken over by the Westinghouse Air Brake Co. and the capitalization will be increased from $20,000,000 to $30,000,000. Mr. Humphrey has had charge of the ammunition contracts secured from several foreign governments within the past two years, amounting to about $20,000,000.

Carl M. Hansen, widely known through his activities in connection with accident prevention, compensation and casualty insurance, has been appointed chairman of the National Association of Manufacturers Committee for accident prevention and workmen's compensation. Mr. Hansen is the author of "Universal Safety Standards," a work of thirteen volumes, and has been a frequent contributor to technical journals on subjects relating to compensation, prevention and occupational diseases.

J. G. Blunt was recently appointed mechanical engineer of the American Locomotive Co. with headquarters at Schenectady, N. Y. Mr. Blunt took the mechanical engineering course at the University of Michigan, and after spending four years as machinist and draftsman with various manufacturing concerns, took a position in 1897 as draftsman with the Brooks

Locomotive Works at Dunkirk, N. Y., and later became chief draftsman of the company. When the engineering work of all the company's plants was consolidated at Schenectady Mr. Blunt was transferred as engineer of the drafting department and later was appointed superintendent of the general drawing-room, which position he held at the time of his appointment.

Charles M. Hammond, president and practical head of the Hammond Steel & Forging Co., Syracuse, N. Y., formerly connected with the Halcomb Steel Co. and the Sanderson Steel Co. of Syracuse, has sold his interest in the Hammond Steel & Forging Co. and retired to become president of a new concern, which will be located in Auburn, N. Y., known as the Cayuga Tool Steel Co., Ltd. Mr. Hammond will have associated with him some of the most prominent interests in America and Sweden. It is the purpose of the new company to erect and operate rolling mills, a hammer plant, crucible furnaces, electric furnaces and open-hearth furnaces for the manufacture of high-grade steel. It is the intention to specialize on high-grade tool and alloy steels.

OBITUARIES

Philip G. Fosdick, president of the Cincinnati Gear Co., Cincinnati, Ohio, died January 22, in Florida, aged fifty-nine years. Mr. Fosdick organized the Fosdick Machine Tool Co. of Cincinnati, but disposed of his interest in the company several years ago.

Col. Herbert Hughes, director of William Jessop & Sons, Inc., steel makers of Sheffield, England, and 91 John St., New York City, died recently at the age of sixty-four. Colonel Hughes represented the British government at the International Conference on Trademarks, held at Washington a few years ago, and was well known in commercial circles in America.

William E. Leard of New Brighton, Pa., died at Southern Pines, N. C., December 17, aged seventy-four years. Shortly after the close of the Civil War he engaged in the manufacture of drill presses in Cincinnati, Ohio. In 1882 he located a plant in New Brighton, Pa., for the manufacture of connecting-rods, strap joints, crankshafts and machine keys.

Alfred B. Jenkins, president of Jenkins Bros., New York City, manufacturers of valves and mechanical rubber goods, died at his home in West Orange, N. J., December 29, aged sixty-eight years. Mr. Jenkins formed a partnership with his brother, Charles Jenkins, in 1872, and the business has been carried on under the same name and management since. Mr. Jenkins was a veteran of the Civil War, and was prominent in the civic life of West Orange.

Charles C. Ramsey, president of the Crucible Steel Co. of America, died January 11, following an illness of five weeks with pneumonia, aged fifty-four years. Mr. Ramsey started his business career as a stenographer and was promoted from one position to another until he became manager of the Philadelphia branch of Park Bros. & Co. Later he was made manager of the New York City branch of that company, which post he held until the organization of the Crucible Steel Co. of America. After serving for a time with R. E. Jennings in the management of the Eastern business of the company, he was made fourth vice-president and manager of the Eastern office. He was elected president in 1910, following the death of Frank B. Smith, then president. Mr. Ramsey left a widow and three children.

Ellis J. Hannum, secretary of the Newton Machine Tool Works, Inc., Philadelphia, Pa., died suddenly January 7, following a short illness. Although Mr. Hannum had not enjoyed the best of health during the past few years, his sudden death was unexpected. Mr. Hannum entered the employ of the Newton Machine Tool Works, Inc., as a boy, and from the beginning showed exceptional talent for freehand sketching, drawing and similar work, and it was natural that he should have showed a preference for the drafting and engineering departments in which he progressed rapidly under the direction of the late Mr. Newton. During the past two years failing health had caused him to relinquish his active duties in the engineering department, and during this time he had acted in an advisory capacity to the drafting department.

COMING EVENTS

February 13.—Section meeting of the Providence Engineering Society, Providence, R. I. Luther D. Burlingame will read a paper "The Units of Measurements in Relation to the Metric System." Herman R. Simmons, secretary, 160 Chapel St., Saylesville, R. I.

February 21-24.—Tenth annual convention of the National Society for the Promotion of Industrial Education, at Indianapolis, Ind., Hotel Claypool, headquarters. Alvin E. Dodd, secretary, 140 W. 42nd St., New York City.

February 22.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

May 21-22.—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 22-25.—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

August 30-Sept. 1.—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill., Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

SOCIETIES, SCHOOLS AND COLLEGES

Purchasing Agents' Association of Rochester, Rochester, N. Y., decided at a recent meeting to permit representatives of manufacturers to appear at its meetings and address its members. The belief is expressed that the members will derive a great deal of benefit from demonstrations made by representatives of manufacturing concerns. Meetings of the association are held the fourth Friday of each month. Secretary, E. A. Scheive, Bosch & Lomb Optical Co., Rochester, N. Y.

University of Illinois, Urbana, Ill., maintains fourteen Engineering Experiment Station research fellowships. One other such fellowship has been established under the patronage of the Illinois Gas Association. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments to these fellowships are made for two consecutive collegiate years and must be accepted under those terms. At the expiration of this period, if all requirements have been met, the degree of Master of Science will be conferred. Additional information may be obtained by addressing the director.

NEW BOOKS AND PAMPHLETS

Operating Details of Gas Producers. By R. H. Fernald. 74 pages, 6 by 9 inches. Published by the Bureau of Mines, Department of the Interior, Washington, D. C., as Bulletin No. 109.

Subsidence Resulting from Mining. By L. E. Young and H. H. Stoek. 205 pages, 6 by 9 inches; illustrated. Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill., as Bulletin No. 91.

Different Methods of Workmen's Compensation Insurance. By Edison S. Lott, president, United States Casualty Co. 14 pages, 6 by 9 inches. Distributed by United States Casualty Co., 80 Maiden Lane, New York City.

Measurement of Electrical Energy, Electricity Meters, Rates for Electrical Energy. By George C. Schaad and C. A. Johnson. 93 pages, 6 by 9 inches; illustrated. Published by the University Engineering Experiment Station, University of Kansas, Lawrence, Kan., as Engineering Bulletin No. 8.

Statistics of Railways, 1905-1915. 57 pages, 6 by 9 inches. Published by the Bureau of Railway Economics (established by railways of the United States for the scientific study of transportation problems). The bulletin is designated as consecutive No. 103, miscellaneous series No. 26, and is distributed by the Bureau of Railway Economics, Washington, D. C.

Manual for Engineers. Compiled by Charles E. Ferris. 220 pages, 2¾ by 5½ inches. Published by the University Press, Knoxville, Tenn. Price, 50 cents.

This convenient compilation of tables and other data for engineers and business men has just appeared in the twentieth edition, which is an indication of its practical worth. Prof. Ferris, professor of mechanical engineering of the University of Tennessee, the compiler of the work, selected the data with an eye to presenting in small compass that which would be of the greatest general value to the average user.

Design of Marine Engines and Auxiliaries. By Edward M. Bragg. 183 pages, 6 by 9 inches; 110 illustrations and folding plates. Published by D. Van Nostrand Co., New York City. Price, $3 net.

This work deals with the reciprocating marine engine, taking up the determination of cylinder dimensions, design of engine parts, engine balancing, condensers and air pumps, turning engines and reversing engines. Much time and effort have been expended on the section on engine balancing, which treats of single-cylinder and multiple-cylinder engines up to six cylinders.

Molybdenum, Its Ores and Their Concentration, with a Discussion of Markets, Prices, and Uses. By Frederick W. Horton. Published by the U. S. Bureau of Mines, Department of the Interior, as Bulletin No. 111. Price, 30 cents. Address, Superintendent of Documents, Government Printing Office, Washington, D. C.

There are large deposits of low-grade molybdenum ore in the United States, but there has been no production worth mentioning prior to 1914. In fact, there was no output of molybdenum ore in this country except in 1905, 1906 and 1907, when a few small lots of molybdenite and wulfenite were marketed. In view of the value of molybdenum in imparting characteristics to alloy steels roughly similar to those produced by tungsten, the Bureau of Mines has undertaken to ascertain the character and extent of deposits of molybdenum ore in the United States.

Elementary Mathematics for Engineers. By Ernest H. Sprague. 236 pages, 4½ by 7 inches. Published by Scott, Greenwood & Son, London, England, and distributed in the United States by D. Van Nostrand Co., New York City. Price, $1.50 net.

The aim of this work is to present the vast subject of mathematics in a way to avoid extreme simplicity on one hand and profundity on the other. The aim has been to cover a wide field in a small compass, to bring out the essential parts, and to introduce useful matter as a means of illustrating principles. The work deals with arithmetical operations, algebra, plane trigonometry, mensuration, spherical trigonometry, algebraic geometry, differential calculus, integral calculus, mathematical data and formulas, etc. It is extremely condensed, and while not to be recommended to a beginner, the work should be extremely useful to those who have good ground work and wish to extend their knowledge of mathematics or to refresh their memories.

Elementary Cams. By Franklin DeRonde Furman. 87 pages, 6 by 9 inches; 69 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $1.25 net.

Cams are defined as rotating or oscillating pieces of mechanism having specially formed surfaces against which a follower slides or rolls and thus receives a reciprocating or intermittent motion such as cannot be generally obtained by gear wheels or link motions. The author states in his preface that the introduction of automatic machinery in which cams are largely used calls strongly for a comprehensive method of technical analysis. The work, written first in the form of lesson papers for Prof. Furman's students in Stevens Institute of Technology, has been published because of the belief of a general need for a book on the subject. It is divided into five sections, treating of definitions and classification, method of construction of base curves in common use, cam problems and exercise problems, timing and interference of cams, and cams for reproducing given curves or figures. The work is one that we would recommend to anyone wanting to study the principles of cam design.

Awakening of Business. By Edward N. Hurley. 237 pages, 5 by 7¾ inches. Published by Doubleday, Page & Co., New York City, and copyrighted by the Associated Advertising Clubs of the World. Price, $2.

This book, by one connected with the Federal Trade Commission who has given broad and comprehensive attention to business problems, was written with a definite purpose. It is a message of warning and construction offered in the hope of bettering business conditions and securing sound methods of co-operation. It deals with the fundamentals of cost accounting, merchandising, trade associations, price fixing, trade associations in Germany, commercial education, foreign trade opportunities, business organization of foreign competitors, banking and investment abroad, cooperation in American export trade, the Sherman law, constructive policy of the Federal Trade Commission, the Federal Trade Commission Act, the Clayton law. The book is one that may be very profitably studied by manufacturers in view of the serious problems likely to

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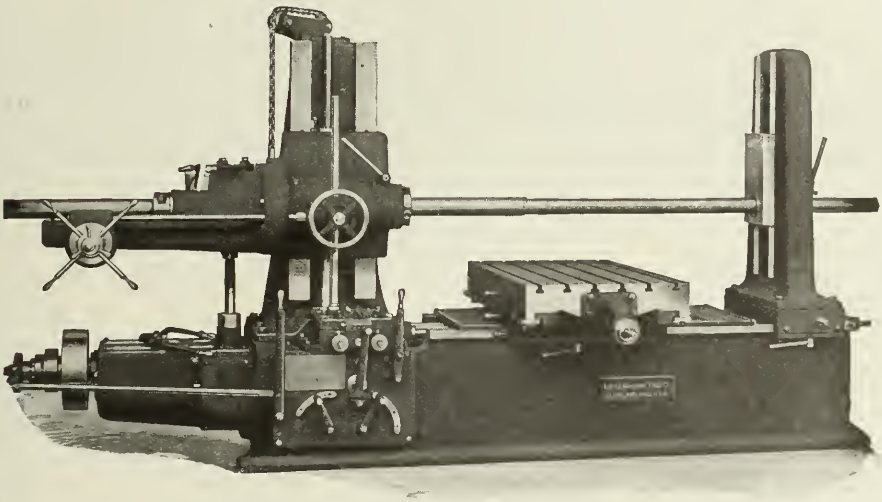

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LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF **CLEVELAND, O., U.S.A.**

confront them at the close of the European war and the probable development of merciless foreign competition.

NEW CATALOGUES AND CIRCULARS

Roth Bros. & Co., Adams and Loomis Sts., Chicago, Ill. Bulletin 182 of direct-current motors and generators.

J. H. Williams & Co., 61 Richards St., Brooklyn, N. Y. Circular of internal and double- and single-end external gages.

Buda Co., Railway Exchange Bldg., Chicago, Ill. Circular of Buda electric storage battery trucks for use in railway terminals, factories, warerooms, storehouses, etc.

Sprague Electric Works of General Electric Co., 527 W. 34th St., New York City. Circular of safety panels and dead front switchboards which minimize the danger of shock.

Wagner Electric Mfg. Co., St. Louis, Mo. Bulletin 114, describing a modern lumber mill and its electrical equipment, illustrating a number of motor applications and types of drive.

Mesta Machine Co., Pittsburg, Pa. Bulletin M, illustrating and describing Mesta improved pickling machines for use in pickling sheets, structural shapes, stamped metal products, pipes, etc.

R. G. Clyne, Columbia Bldg., St. Louis, Mo. Booklet outlining service offered in designing special labor-saving machinery, tools and devices, developing inventions, redesigning machinery, etc.

Vanadium-Alloys Steel Co., Pittsburg, Pa. Paper read by Roy C. McKenna, president, on "Crucible Tool Steel" at the annual convention of the sales representatives of the company, January 3.

Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletin 250, illustrating and describing "Spraco" equipment for washing and cooling ventilating air for steam-turbine-driven generators.

Harrison Safety Boiler Works, Philadelphia, Pa. Catalogue 710 on Cochrane heaters, designated as a treatise on the utilization of the exhaust system of heating, softening and metering of boiler feed water.

Federal Machine Co., South Bend, Ind. Circular of No. 3 plain-head screw machine with automatic chuck and bar feed. The chuck capacity for round, square and hexagon stock is 1 5/16, 29/32 and 1 1/8 inch, respectively.

Vacuum Oil Co., Rochester, N. Y. Catalogue of horizontal gas engines of small and medium size, treating of classification, field of service, construction, principle of operation, cooling, gas used, methods of lubrication, lubricating oil and deposits.

Foster Machine Co., Elkhart, Ind. Catalogue of the Foster No. 5 screw machine having a bar capacity of 1 13/16 inch and a chucking capacity of 8 inches. The various tools and attachments for this machine are also illustrated and described.

New Departure Mfg. Co., Bristol, Conn. Sheets Nos. 83 FE to 86 FE, inclusive, for loose-leaf binder, illustrating ball bearing applications in drilling machines, ball bearings in jib crane and trolley, the use of ball bearings in disintegrating machines and ball bearings in change speed and right-angle drive gearing.

Joseph T. Ryerson & Son, Chicago, Ill. Circular of the Ryerson boiler tube reclaiming machine designed for railroad shops, particularly for the purpose of utilizing short boiler tubes that otherwise would be scrapped. The machine welds short tubes together into tubes of proper length for locomotive service.

Vanadium-Alloys Steel Co., Pittsburg, Pa. Folder descriptive of "Vasco-Marvel," a semi-high-speed steel particularly suited for hot work. The circular gives information on the forging, hardening, cooling and annealing of "Vasco-Marvel" steel. A table of high-speed steel standard classification of extras is included.

Barnes & Morris, 182-183 Temple Chambers, London, E.C., England. Circular and booklet of the "Wedge" optical pyrometer, an optical instrument for determining the temperature of furnaces, molten metal, forgings, etc. The instrument is calibrated to cover any range desired between the limits of 500 and 2000 degrees C.

Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass. Catalogue of Whitcomb-Blaisdell planers with second-belt drive, containing a detailed description of the machines and their various parts, all of which are illustrated. Specifications are given for the 20-, 24-, 26- and 30-inch planers. Four different styles of motor drive can be furnished in connection with these planers.

United Hammer Co., 141 Milk St., Boston, Mass. Booklet describing Fairbanks power hammers which are adapted for a great variety of work by the provision of special dies. These hammers are equipped with motor or belt drive as desired. The pamphlet also illustrates special fork hammers and a tire-welding attachment that can be used with any regular pattern Fairbanks hammer.

T. C. M. Mfg. Co., Hunterdon and First Sts., Harrison, N. J. Catalogue illustrating and describing the Morris Thomson semi-automatic thread milling machine especially designed for quick, accurate production of threads by the use of multi-cutters on pieces varying from one to twelve inches in diameter. The catalogue illustrates this line of machines and shows examples of the work done, as well as the types of cutters used.

Winfield Electric Welding Machine Co., Warren, Ohio. Circular entitled "Electric Welding by the Winfield Way," showing the line of spot-welding and butt-welding machines made by this company and describing the principle on which they operate. The circular also shows views of installations of these machines engaged on a variety of work in different factories, and in addition to information on the construction of the machines, cost, etc., gives tables of butt-welding and spot-welding data.

Leeds & Northrup Co., Philadelphia, Pa. Bulletin 806-A, treating of apparatus for the location of thermal transformation points. The bulletin contains charts of transformation curves obtained with the Leeds & Northrup apparatus. It is stated that a complete chart, including all critical points during the heating and cooling of a sample, can be obtained in about thirty minutes. The heating is done in a small electrical furnace, and the apparatus can easily be installed on a table in an office or laboratory.

Gisholt Machine Co., 1202 E. Washington Ave., Madison, Wis. Reprints of recent advertisements in the "American Machinist" on the work done on Gisholt machines and the history of the Gisholt Machine Co. The company builds turret lathes, automatic turret lathes, vertical boring mills, universal tool grinders, horizontal boring and drilling machines, double emery grinders, toolpost tool-holders, solid adjustable reamers, boring-bars, adjustable cutters, special jigs and fixtures, and the periodograph—a workman's time recorder.

Doehler Die-Casting Co., Court and 9th Sts., Brooklyn, N. Y. Catalogue entitled "Creating an Industry," dealing with the die-casting industry from its inception to its present extensively developed state. The book shows interesting illustrations of early castings and molds, some of which date back as far as 1000 B.C. The first part of the book deals with the industry from prehistoric to modern times, and the second part takes up the development in the last decade. Many illustrations are shown of modern die-castings made from various alloys, the composition and chemical properties of which are given.

Hampden Corundum Wheel Co., Springfield, Mass. Catalogue of grinding wheels made of corundum, carborundum, oxylum and emery. This handsome piece of advertising literature contains illustrations of the company's Corundum Hill mine in North Carolina, and other interesting matter on the manufacture and testing of wheels. The safety code for the use and care of abrasive wheels recommended by the National Machine Tool Builders' Association is given, and data on the speeds of wheels, selection of grains and grades of wheels, etc. The wheel list is illustrated, showing the purchaser exactly the shape of wheel listed in each case, thus avoiding misunderstandings and mistakes.

Albro-Clem Elevator Co., Seventh St. and Glenwood Ave., Philadelphia, Pa. Folder on Hindley gearing, defining the distinctive characteristics of the Hindley type of worm-gearing and showing how it differs from the ordinary type of worm-gearing. The company has specialized in the making of Hindley gearing for many years, having made and sold it for application in various types of machines and to operate under varying conditions of load. It is claimed that the Hindley gear has straight-line elements in contact, the projection of which is an area; whereas in the common type a curve is in contact with a straight line, the projection of which is a line; hence the Hindley gear is superior in point of frictional resistance and wear.

S. K. F. Ball Bearing Co., Hartford, Conn. Bulletin entitled "S. K. F. Self-aligning Ball Bearing Hangers and Pillow Blocks," describing the construction of S. K. F. ball bearing hangers and pillow blocks and telling of some of the advantages gained by their use. The book discusses power saving; the use of smaller motors; saving in lubrication and inspection; and reduced fire hazard. Valuable tables of curves and engineering data upon mounting, lubrication, testing lubricants, felt seals, etc., are also included. Announcement is made of the S. K. F. service, by means of which users or prospective users of S. K. F. ball bearing hangers and pillow blocks can submit their problems to the transmission department. The engineers of the company will investigate the conditions and assist in determining the best means of reducing friction losses and selecting an equipment.

TRADE NOTES

Light Mfg. & Foundry Co., Pottstown, Pa., has opened an office in the Penobscot Bldg., Detroit, Mich. C. F. McRae will be in charge.

Covington Multiple Drill Co. has moved from Covington, Ky., and is now located at 2449 W. McMicken Ave., Cincinnati, Ohio.

Cleveland Metal Products Co., 7609 Platt Ave., Cleveland, Ohio, has acquired the business of the Cleveland Foundry Co., and assumed entire management of the business.

Napier Saw Works, Inc., Springfield, Mass., is the successor of the Quality Saw & Tool Works, manufacturers of "Quality" hacksaw blades and metal-cutting specialties.

Cincinnati Iron & Steel Co., Cincinnati, Ohio, is distributing to its business friends the "Cisco" Fahrenheit thermometer of the hand and dial type—a most acceptable fixture for office use.

J. N. Lapointe Co., New London, Conn., manufacturer of broaching machines and broaches, has increased the wages of its employes 10 per cent in addition to the monthly bonus based on the output of the company.

Exeter Machine Co., Pittston, Pa., which recently went into bankruptcy, will be sold at auction February 8. The company built steam engines, and recently completed a large order of 20-inch engine lathes for foreign customers.

Domestic Machinery Works, Wissinoming, Philadelphia, Pa., have incorporated their business under the name of Richter Machine Co. Wolfgang Richter of the original firm is president, and F. V. McMullin of the Pennsylvania Forge Co. is secretary and treasurer.

Chicago Pneumatic Tool Co., Chicago, Ill., held an annual convention of the sales and factory organizations at the Great Northern Hotel, January 11-13, inclusive. The company reports that December 31 closed the biggest month and the biggest year in the history of the company's business.

Parker Rust-Proof Co. of America, Detroit, Mich., has acquired by purchase the Thomas W. Coslett patents on the "Coslettizing" process for rust-proofing iron and steel. The company also controls the fundamental Richards, Allen and Parker patents on the rust-proofing art. The company will license manufacturers of motor cars, motor car parts, and other products to rust-proof the parts in their own plants.

George Gorton Machine Co., Racine, Wis., is erecting a one-story steel and brick structure, 75 feet high by 200 feet long, with concrete foundation and concrete floor. The building will have a monitor roof, and will be provided with a twenty-ton Pawling & Harnischfeger electric traveling crane. The machines will be individually motor driven throughout, and some new equipment will be purchased.

Moulton Engineering Corporation, consulting engineers dealing with hydraulic, electrical, steam, mechanical, electrolytic, structural, architectural and other engineering problems, have opened a New York office at 233 Broadway. The new office will be under the direction of Horace W. Flashman, who for a number of years was associated with the Westinghouse Electric & Mfg. Co. in engineering and commercial work.

Clark Equipment Co., Buchanan, Mich., is a new corporation organized for the purpose of taking over the Celfor Tool Co. and the Buchanan Electric Steel Co. The merger was effected for the purpose of strengthening both companies and enabling customers to be served better than in the past. No change in the manufacturing or selling methods of either company will be made, and the personnel of the organization will remain the same.

Marshall & Huschart Machinery Co., Chicago, Ill., announces that Mr. Marshall, the founder of the company, has resigned as president, but retains a financial interest in the company and will act in an advisory capacity. The following officers were elected at the January 3 meeting of the directors: H. W. Jones, president; George C. Edwards, vice-president; William H. Reid, treasurer; Frank Seese, secretary; and J. R. Porter, general manager. There will be no change in the general policy.

Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., has arranged with the "Free Press," a local newspaper, to publish several columns of "Shepard news" weekly, the object being to inform the men of the various plant activities, and also to interest the town people and attract the class of young men to whom the opportunity to learn a useful trade and secure a practical education would appeal. The first number contains an announcement of the night school classes in the Shepard technical school. Courses are given in blueprint reading, shop mechanics, shop drawing, practical electricity, and shop mathematics.

Parker Mfg. Co., Detroit, Mich., has been organized to manufacture drill chucks. The company will place a complete line of three-jawed keyed type chucks on the market. Gorham C. Parker, formerly sales manager for the T. R. Almond Mfg. Co., is general manager and will be made president when the concern is incorporated. Kenneth P. Albridge, who was formerly associated with the engineering department of the T. R. Almond Mfg. Co., is production manager. The company has located on Milwaukee Ave., Detroit, and is purchasing up-to-date equipment for the plant. The product will be marketed through the usual sources, such as machinery supply dealers and portable drill makers.

J. H. Williams & Co., 61 Richards St., Brooklyn, N. Y., have established a system of bonus payments which will be put into effect for the company's entire organization in Brooklyn and Buffalo, in accordance with the following provisions: Bonuses will be based on thirteen weeks' pay at a time, and paid on the next following payday to all men in the company's employ at the time. The normal rate of bonus based on the rate of pay will be 10 per cent on salaries less than \$1250 per year; 7½ per cent on salaries less than \$2000 and equal to \$1250; 5 per cent on salaries of \$2000 or more. The bonuses for hourly pay will be 10 per cent on less than 45 cents hourly rate; 7½ per cent on hourly rates equal to 45 cents but less than 60 cents; and 5 per cent on hourly rates equal to 60 cents or more. Bonuses for all piecework will be figured at 5 per cent, including overtime.

Kempsmith Mfg. Co., Milwaukee, Wis., recently notified its shop employes of an extra payment plan by which all employes remaining with the concern during this year will receive an extra payment amounting to 10 per cent of their total pay. The plan affects about 450 employes and will mean a distribution of about \$35,000 in addition to regular wages. The plan provides that employes on the payroll January 1, 1917, who continue in the employment of the company during the year, will receive an extra payment of 10 per cent of their total earnings for the year, distributed as follows: 2½ per cent of the earnings of the first quarter, payable at the end of that period; 5 per cent of the earnings for the first six months, less the sum previously distributed, payable at the end of that period; 7½ per cent of the earnings for the first nine months, less the sums previously distributed, payable at the end of that period; and 10 per cent of the earnings for the year, less the sums previously distributed, payable at the close of the year.

Manufacture of Steel Balls[1]-I

by Edward K. Hammond[2]

The manufacture of steel balls is an American industry that has been greatly developed since the outbreak of the European war. This article, which will appear in three installments, will describe the machines and methods of manufacturing balls employed by the Hoover Steel Ball Co., Ann Arbor, Mich., and will take up in detail all the essential processes, including the testing of the steel before manufacture and the gaging and inspection of the finished balls.

During recent years the application of ball bearings in machine design has increased rapidly, and this type of bearing is now used in many machines where plain bearings were formerly considered good enough. Until German export facilities were shut off by the war, the majority of the steel balls used in these bearings were made by the Deutsche Waffen und Munitions Fabriken of Berlin, Germany, and the product of this firm has become so celebrated that many persons think the steel ball industry was developed by the Germans. As a matter of fact, the art of ball making goes back to a very early date, and the development of original methods for doing this work is attributed to the Chinese. To those who have credited the Germans with the development of commercial methods of ball manufacture, it will doubtless be of interest to learn that the first commercial steel balls were made in this country under basic patents granted to Richardson of the Waltham Emery Wheel Co., Waltham, Mass., and that the original ball making machinery for the plant of the Deutsche Waffen und Munitions Fabriken was designed and built in the United States and shipped to Germany ready for use. This will be explained in detail in connection with the following historical outline of important epochs in the steel ball industry.

How the Steel Ball Industry Came Into Existence

It has been stated that basic patents for dry grinders used in roughing out ball blanks to a spherical form were granted to Richardson of the Waltham Emery Wheel Co., in 1887. These patent rights were subsequently sold to the Cleveland Machine Screw Co., Cleveland, Ohio, which had control of patents on ball making machinery taken out by John J. Grant.

One of the first firms to manufacture steel balls on a commercial basis was the Simonds Rolling Machine Co. of Fitchburg, Mass., and the Fitchburg Steel Ball Co. was subsequently formed by employes who left the Simonds firm. After a brief career, the latter firm was taken over by the Cleveland Machine Screw Co., and with facilities acquired through its own development work and purchase from other companies, it was in a position to manufacture the majority of balls used in the bicycle trade. In this connection it will be of interest to note that up to the year 1899 balls one-half inch in diameter were the largest size that were manufactured in quantities.

About 1890 the Cleveland Machine Screw Co. designed and built for the Deutsche Waffen und Munitions Fabriken, of Berlin, Germany, equipment used in its original steel ball plant, and this marked a most important step in the trade, owing to the reputation for making high-grade balls that was later acquired by this firm. The machines built and shipped to Germany had no reference to American manufacturing rights, and the Cleveland Machine Screw Co. continued to operate its plant in the usual way.

In 1894 when a consolidation of bicycle manufacturers was effected, the Cleveland Machine Screw Co. was sold to the Pope Mfg. Co. of Hartford, Conn., which at that time started to manufacture its own balls for use in bicycle bearings. The requirements of balls for the bicycle trade were not nearly as severe as the standards which must be met by balls used in high-grade annular bearings at the present time. This was largely due to the fact that the cup and cone form of races was employed, allowing compensation to be made, and while this form of race did not enable ball bearings to be operated under the most efficient conditions, it was the means of overcoming discrepancies due to inaccuracies in the size of the balls. Up to this time there had been six or seven firms engaged in the manufacture of steel balls, but with the decline of the bicycle industry a number failed.

In 1901 the Standard Roller Bearing Co., Philadelphia, Pa., acquired all obso-

L. J. Hoover, Vice-president and General Manager, Hoover Steel Ball Co.

[1] For previous articles on the manufacture of balls, published in MACHINERY, see "The Manufacture of Steel Balls," February, March and April, 1912. For other information relating to balls, see "Using Ball Bearings" in the January, 1917, number, and articles there referred to.

[2] Associate Editor of MACHINERY.

lete and existing plants engaged in the manufacture of steel balls. L. J. Hoover, who was formerly in the employ of the Standard Roller Bearing Co., left that firm in 1906 and formed the Grant & Hoover Co. at Merchantville, N. J. The name of this firm was later changed to Atlas Ball Co., and the plant transferred to Philadelphia, Pa., where it is still in operation. On March 1, 1913, the Hoover Steel Ball Co. of Ann Arbor, Mich., was organized by Mr. Hoover for the purpose of engaging in the manufacture of high-grade steel balls to take the place of those imported from Germany. When the European war started in 1914, the blockade of German ports by the British Navy shut off the supply of steel balls formerly exported by that country to the United States, and the insistent demand of consumers for balls made in this country imposed a heavy strain upon the facilities of domestic producers. Somewhat similar conditions existed in all branches of the machinery trade, making it difficult for the ball manufacturers to increase the capacity of their plants; but the management of the Hoover Steel Ball Co. showed commendable initiative by contracting for the entire output of machine building firms with which orders were placed for special machinery required in ball manufacture; and these firms were given financial assistance to enable them to handle work with the greatest possible rapidity. As a result, the Hoover Steel Ball Co. has increased its capacity 600 per cent, the growth being well illustrated by Fig. 1 and the heading illustration, that show, respectively, the original factory in which the firm started manufacturing in March, 1913, and the plant as it appears at present. An idea of the magnitude of the business will be gathered from the fact that the consumption of steel runs in excess of 900 tons a month, and calculated on the basis of 1/4-inch balls, the daily production is between 25,000,000 and 30,000,000 balls per day.


Fig. 1. Original Plant in which Hoover Steel Ball Co. started Manufacturing Operations in March, 1913

Raw Material of the Steel Ball Industry

The steel from which balls are made comes to the factory in coils or straight rods, according to its size. Stock less than 11/16 inch in diameter comes in coils and is known as "wire," while all stock exceeding 5/8 inch in diameter comes in straight bars. The size of the stock is referred to in thousandths, *i. e.*, stock 3/8 inch in diameter is known as 0.375-inch stock. The following is a typical analysis of steel wire used for making balls: carbon, 1.00 to 1.05 per cent; silicon, 0.25 to 0.30 per cent; manganese, 0.15 to 0.20 per cent; chromium, 0.45 to 0.55 per cent; sulphur and phosphorus, not to exceed 0.02 per cent. The following analysis is typical for the larger sizes of stock which comes in straight bars: carbon, 1.02 per cent; manganese, 0.28; silicon, 0.21; chromium, 0.65; sulphur, 0.016; and phosphorus, 0.014 per cent. A well equipped laboratory is maintained in which chemical and physical tests are conducted on each shipment of steel to determine its suitability for manufacture into balls, and an unloading ticket must be signed by the head of the laboratory before the steel is taken from the cars into the plant. Some very interesting conditions have been brought to light by the laboratory work, and a later section of this article will be devoted to a discussion of tests conducted on the raw material and product, data obtained from these tests, and a description of methods and apparatus used in the laboratory.

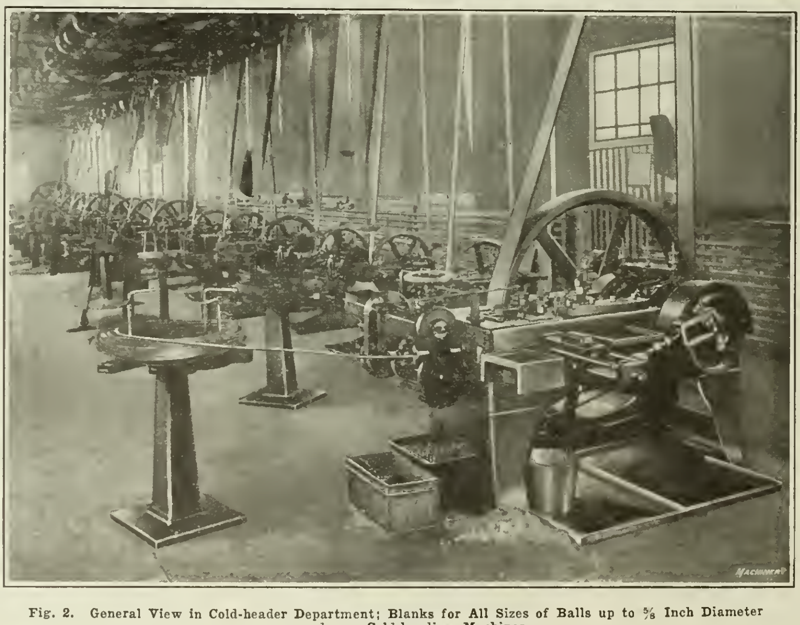


Fig. 2. General View in Cold-header Department; Blanks for All Sizes of Balls up to 5/8 Inch Diameter are made on Cold-heading Machines

Production of Ball Blanks by Cold-heading

Ball blanks made from stock ranging from 1/16 up to and including 5/8 inch in diameter are formed on special cold-headers designed for the production of ball blanks by the E. J. Manville Machine Co., Waterbury, Conn. A battery of these machines is shown in operation in Fig. 2, and in this connection it may be mentioned that the Hoover Steel Ball Co. is equipped with machines of the following sizes: 00, 0, 1, 2, 3, and 5. Production of ball blanks by the cold-heading process has several advantages in its favor. In the first place, there is practically no waste, with the exception of about 0.040 inch of metal left on the blank to provide for finishing. Blanks can be held to this close limit because the steel is worked cold and there is no tendency for it to become decarbonized. One man can look after three or four machines, so that the cost of labor is almost negligible. Cold-headers used in the production of ball blanks are of the type commonly known as single-blow solid-die machines, and the way in which they operate can best be explained in connection with Fig. 3. These machines consist of a heavy frame *A* which completely surrounds the working parts of the machine, thus insuring a high degree of rigidity. At one end of the machine there is a driving shaft *B*; and at the opposite end of the frame is die-block *C*. Between the sides of the frame is a movable ram *D* that actuates the heading punch *E*. Wire *F* to be made into ball blanks enters the machine through feed rolls *G* and then passes through

ut-off quill *H*. At the side f the machine is supported a racket *I* in which slide *J* nay be reciprocated by a rank motion from the main riving shaft. Slide *J* has a am groove cut in it in which oll *K* is fitted; this roll is nounted on cross-slide *L*, so hat a lateral motion is im- arted to cut-off knife *M* lo- ated on the end of cutter- ar *L*.

A ratchet feed advances the ire through the cut-off quill ntil it comes into contac. ith a stop, which is not hown in the illustration. 'his stop checks forward motion of the stock when a sufficient ength has passed the cut-off knife to produce a ball blank f the proper size. Cut-off knife *M* is advanced in the manner ıst described, severing the wire, but retaining it on the cut- ff blade by means of a spring finger. Advance of the cut-off nife and wire slug is continued until the slug reaches a osition directly in front of the opening in die *N*. Here it is eld stationary long enough for punch *E* to begin to push the lug of metal into the die, at which time cut-off knife *M* re- reats and allows punch *E* to continue its work by pushing ıe blank to the bottom of the die cavity. Wire slug *F*, when ushed into the die, is prevented from passing too far by a acking-pin *O*, and after the piece has been headed, this acking-pin is advanced by the ejecting mechanism operated y lever *P*, which also receives its motion from a crank at the ide of the machine connected to the main driving shaft. In ıis way the ball blank is knocked out of the die and dropped ırough an opening into a receptacle placed to receive it, this eing clearly shown in Fig. 2. Table II gives the diameter f stock used in making blanks for several different sizes of alls, and is presented to show the enlargement that takes lace during the heading operation. Various grades of steel ave been used for making dies employed on the cold-headers, ut the most sat- sfactory results ave been ob- ained with the ollowing rades: "Sander- on" or "Viking pecial" made y the Crucible teel Co. of merica; "In- ra" made by the Iermann Boker 'o.; "Gyro" nade by Brae- urn Steel Co.; nd tool steel nade by William essop & Sons.

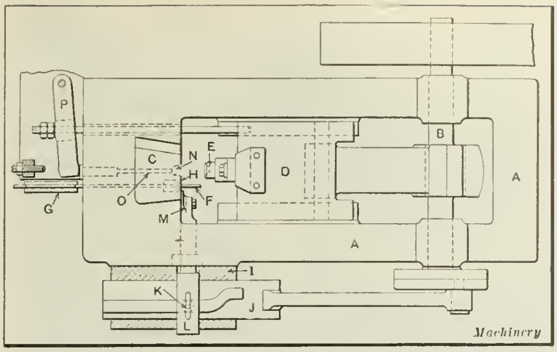


Fig. 3. Plan View of Cold-header Mechanism, illustrating Method of Operation

TABLE I. CAPACITIES OF COLD-HEADERS IN BALL BLANKS PER HOUR[1]

No. of Cold-header	Capacity for Ball Blanks, Diameter in Inch	Production, Blanks per Hour	No. of Cold-header	Capacity for Ball Blanks, Diameter in Inch	Production, Blanks per Hour
00	3/16	7800	2	3/8	6000
0	1/4	7675	3	1/2	4920
1	11/32	6250	5	5/8	4080

Machinery

[1] Note: Due to time lost in setting up, trouble with stock and breakdowns, the ctual average rate of production is from 80 to 90 per cent of above values.

Hot-forging Ball Blanks

It has previ- ously been stated that blanks for balls exceeding 5/8 inch in diameter are hot-forged from straight bars, and in handling this work multiple dies are employed which produce strings of balls containing up to ten balls, according to the size. The stock is heated in "Frankfort" furnaces made by the Strong, Carlisle & Hammond Co. of Cleveland, Ohio; these are oil furnaces which are operated with oil at a pressure of 8 pounds per square inch, and air at a pressure of 2 pounds per square inch. Twelve bars are arranged in the furnace as shown in Fig. 5. The hammer-man takes out the bar at the left-hand side of the furnace, and after forging a string of balls at the end of this bar and cutting it up into individual ball blanks, returns the bar to the furnace at a point at the extreme right. In this way, the bars are used in rotation, which prevents any bar from becoming overheated. This is a matter of considerable importance, because the furnaces are maintained at a temperature somewhat in excess of 1800 degrees F. in order to provide for heating the stock as rapidly as may be necessary; but should it happen that steel was left in the furnace for an undue length of time, there would be danger of burning the steel.

TABLE II. SIZE OF STOCK USED FOR MAKING BALLS ON COLD-HEADERS

Diameter of Ball, Inch	Diameter of Stock, Inch	Diameter of Ball, Inch	Diameter of Stock, Inch
1/8	0.095	9/32	0.200
5/32	0.120	5/16	0.225
3/16	0.145	3/8	0.265
7/32	0.165	7/16	0.312
1/4	0.180	1/2	0.355

Machinery

The multiple forging dies are shown in detail in Fig. 7, in which it will be seen that each die opening is elliptical; the purpose of this is to provide a clearance space at each side into which excess metal may flow. It must be borne in mind, however, that while this illustration only shows four die openings, the number of openings runs up to ten, according to the size of ball blanks that are being forged. In the cross-sectional views, the dimensions of the die are indicated by letters, and in Table III are given diameter *A* of cherrying cutter, distance *B* between centers, and depth *C* to which the cherrying cutter is sunk in making the dies for three sizes of balls, and these data are presented to indicate how dimensions of the dies vary for different sizes of balls. The depth *D* of the gate between adjacent dies is a matter of considerable importance, because it determines the size of the neck between adjacent balls, which is depended upon to hold the string of balls together until they are sheared. Also, this depth must be regulated so that there is no ten-

Fig. 4. View of Stock Racks in Hot-forging Department where Ball Blanks exceeding 5/8 Inch Diameter are made

dency to draw the stock adjacent to the neck and form a pipe in the ball blank, which would have a highly detrimental effect on its structure. A land of approximately one-third the diameter of the ball is provided for clearance at the bottom of the die and the upper die member. The dies are made from a special die steel made by the Ludlum Steel Co. of Watervliet, N. Y., or from "Firth-Sterling Special," made by the Firth-Sterling Steel Co., McKeesport, Pa. This is not an alloy steel, but a regular tool steel adapted for making hot-forging dies. In order to produce round balls in such dies, the bar is turned between each stroke of the hammer, which results in bringing the balls to a close approximation of the spherical form. Along one side of each die is a pipe with a number of holes drilled in it through which water flows onto the dies and work.

Fig. 5. "Frankfort" Oil-heated Furnaces made by Strong, Carlisle & Hammond Co., in which Bars are heated for Hot-forging Operation

In purchasing stock for the production of ball blanks for the hot-forging method, it is a matter of considerable importance to have all bars of the same length. This is due to the fact that when there is considerable variation in length, some bars will be used up before others, with the result that it is necessary to finish up a number of short pieces in the furnace before putting in an entire new charge. At the end of each bar there is left what is known as a "short end," and experience has shown that these short ends cannot be forged into ball blanks of the regular size, as they fail to fill out the dies properly. On this account, short ends are collected and forged into ball blanks of the next smaller size. By ordering stock in bars of a specified length, "short-ends" are eliminated.

After being forged, the hot string of balls is taken to punch presses made by the Ferracute Machine Co., Bridgeton, N. J., which are placed beside the Bradley helve hammers on which the forging operation is performed, the arrangement being clearly shown in Fig. 6. The punch presses are equipped with multiple shearing dies, which consist of a lower die member with holes of the same size as the balls and a multiple punch carried in the ram, one punch being in line with each opening in the die. The string of balls is dropped into place and the press tripped, resulting in pushing the balls through the holes in the die and leaving the scrap metal which is brushed off before the next operation is performed. The bar is then returned to the right-hand side of the heating furnace, as previously mentioned, and is moved to the left each time a heated bar is removed, until it reaches the extreme left ready for another string of balls to be forged from the heated metal at its end. Three sizes of helve hammers made by C. C. Bradley & Son, Inc., Syracuse, N. Y., are used for forging ball blanks, which have capacities for striking blows of 125, 150 and 300 pounds.

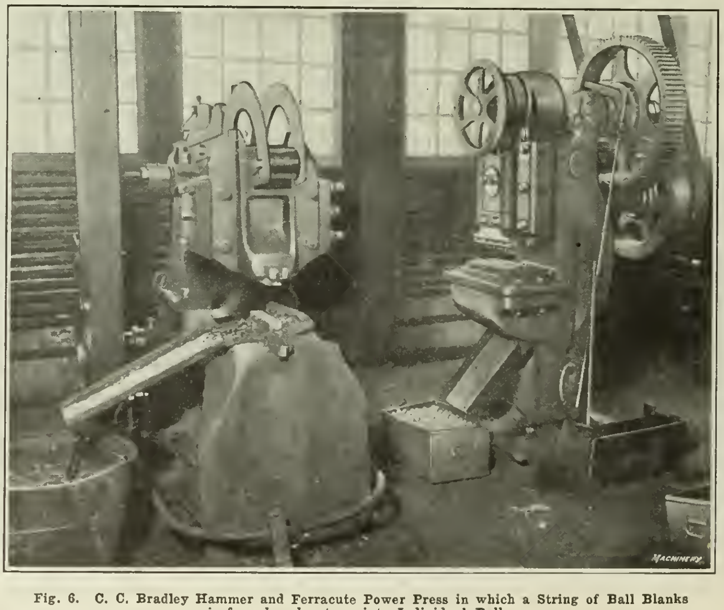


Fig. 6. C. C. Bradley Hammer and Ferracute Power Press in which a String of Ball Blanks is forged and cut up into Individual Balls

Fig. 8 shows the construction of shearing punches used for cutting up the string forgings into individual ball blanks. At A is shown the form of punch-holder used, which will be seen to consist of a cast-iron shoe with four set-screws for holding the punches. These are secured in a clamp B which is made by drilling holes of the proper size for the punch shanks in a block of the desired form and then sawing this block in half; the punches are then put in place and the entire clamp secured in punch-holder A. The diameter C of these punches is usually made about 1/8 inch less than the diameter of the balls in the string forging that is to be cut up. A plan view of the die is shown at D, and it will be evident that the spacing E between holes in this die is the same as the center distance between the die cavities in the forging die. Also a bridge is provided in the shearing die of sufficient depth to retain the neck left between adjacent ball blanks on the string forging while the balls are pushed through the die. After the shearing operation has been completed, the scrap metal is brushed off the shearing die before the next set of ball blanks is cut up.

It has been mentioned that balls ranging in size from 5/8 inch up to about 2 1/2 inches in diameter are made by forging strings of blanks according to the process which has just been described. In the case of the larger sizes of balls—from 2 5/8 to 4 inches in diameter—single blanks are usually forged under a steam hammer, making one blank at a time at the end of the bar. Slugs of the proper size are first cut off to the required length and both ends chamfered, the length of stock being determined by the weight of the finished balls after making a proper allowance for the material removed in finishing. These blanks are placed in the oil furnace and heated to a forging temperature; and each time a blank is removed to be forged a new slug of metal is put into the furnace in its place. Dies used for this kind of forging are of an entirely different form from those used in string forging; they are cupped out to the desired diameter, but are only turned to a depth of one-quarter the diameter of the ball to be forged and are not relieved. When the blank has been heated, the hammer-man

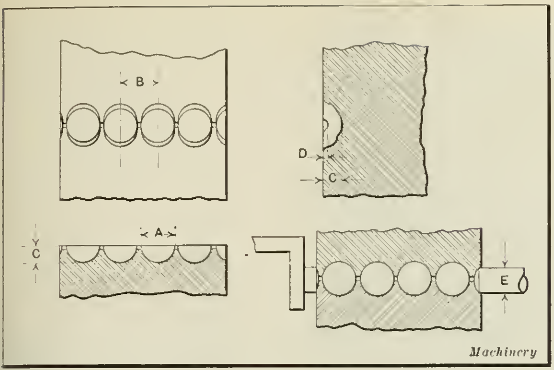


Fig. 7. Type of Die used for hot-forging Ball Blanks for Balls exceeding 5/8 Inch Diameter

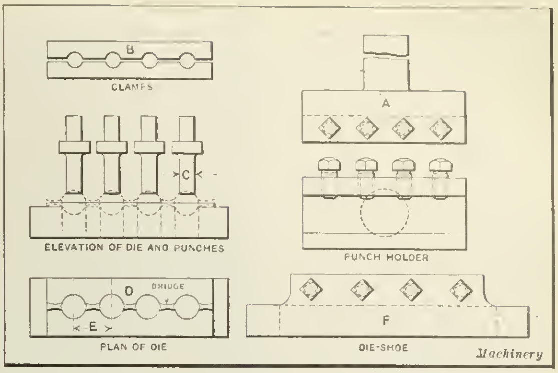


Fig. 8. Type of Die used for shearing String Forgings into Individual Ball Blanks

places it in the die and the hammer is worked very slowly until the blank begins to take a spherical shape, when quicker and heavier blows are struck. Owing to the shallowness of the die, the operator has ample room to turn the ball in all directions, and he can therefore produce an almost perfect sphere. Blanks up to 8 inches in diameter are forged without varying more than 0.005 inch from a true spherical form.

TABLE III. DIMENSIONS OF HOT-FORGING DIES FOR BALL BLANKS

Diameter of Ball, Inch	Diameter A of Die, Inch	Distance B between Centers, Inch	Depth C of Die, Inch	Depth D of Bridge, Inch	Diameter E of Stock, Inch
3/4	0.775	0.910	0.387	0.065	0.609
7/8	0.905	1.060	0.452	0.065	0.719
1	1.035	1.210	0.517	0.075	0.813

Machinery

Rough Dry-grinding

The method of making ball blanks varies according to their size, small blanks being made on cold-headers and large blanks forged from hot metal according to the methods which have just been described. After this preliminary work, all sizes of balls go through essentially the same treatment, certain minor modifications being made according to the quality of the balls; and the method of treatment may also vary somewhat in the case of balls of extremely large size. These modifications from standard practice will be taken up in detail.

Blanks made by either the cold-heading or hot-forging process are first sent to the dry-grinding room, where they are subjected to a rough-grinding operation before going to the heat-treating department. This rough-grinding results in removing a considerable part of the surplus metal and bringing each ball to a much closer approximation of a truly spherical form than it is possible to obtain in forgings made by either of the methods that have been described. In the case of hot-forged ball blanks, this rough-grinding also removes the decarbonized steel from the surface of the blanks produced in forging.

An exception to the general method of procedure is made in the case of balls from 1/16 to 3/16 inch in diameter. Such balls are not dry-ground before being heat-treated, but they get a rough and a finish dry-grinding after being hardened.

Figs. 9 to 11, inclusive, show the type of machine on which the dry-grinding operation is performed, and the best idea of its construction and method of operation will be obtained

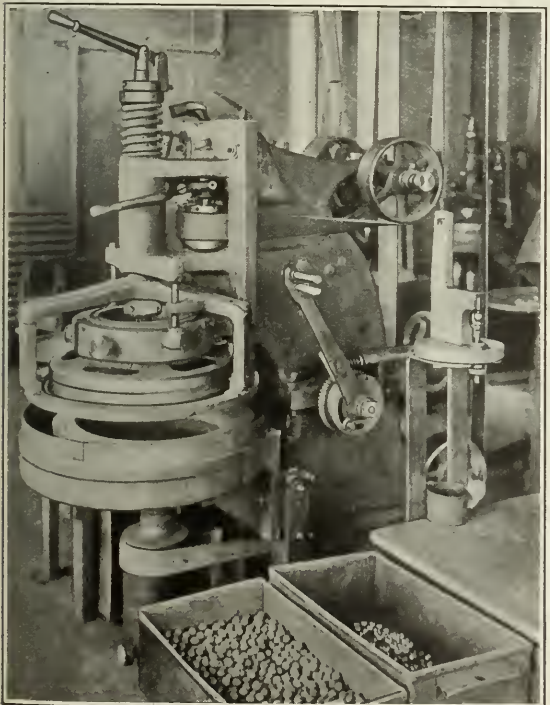


Fig. 9. Side View of Dry-grinder, showing Wheel dropped away from Work, a Charge of Balls ready to be dropped into Grinding Position, and Ball being measured for Size in Test Indicator

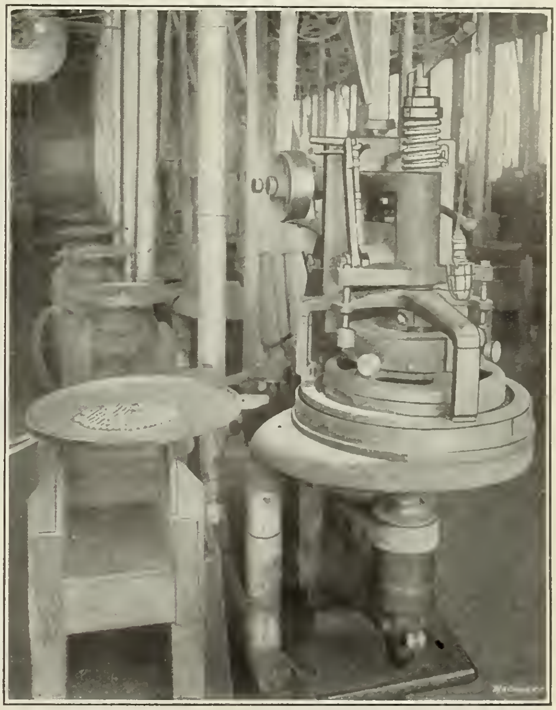


Fig. 10. Front View of Grinding Machine, showing Grinding Wheel raised to Operating Position and Tray of Ground Balls just removed from Machine; Balls seen in Ring are not in Grinding Position

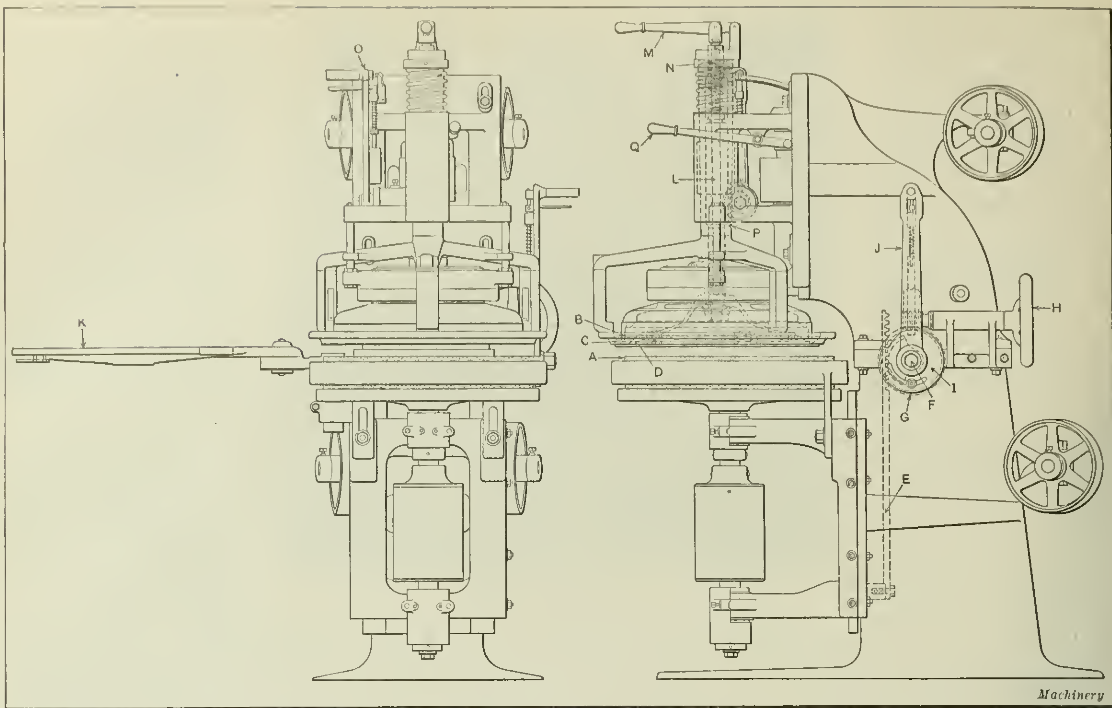


Fig. 11. Front and Side Views of Dry-grinding Machine, illustrating Principle of Operation

by reference to the two views shown in Fig. 11. The main parts of this machine consist of a carborundum grinding wheel *A* and an iron ring *B* which are driven in opposite directions. Two rings *C* and *D* are supported by spiders in such a way that there is a space between the beveled edges of the inner and outer rings sufficient to allow ball blanks that are to be ground to project through this space. In the side view of the machine illustrated in Fig. 11, these rings are shown with the wheel lowered, but when the machine is in operation the balls held between rings *C* and *D* are in contact with grinding wheel *A;* and ring *B* presses down and holds them against the grinding wheel. In order to provide for grinding the balls uniformly, the spindles on which grinding wheel *A* and driving ring *B* are carried are placed eccentric to each other, which results in giving the balls an oscillating motion in addition to their motion of rotation; and as a result of this combined movement all surfaces of the ball blanks are exposed to the action of the grinding wheel, which results in bringing them to a close approximation of the spherical form. The way in which the upper and lower spindles of the machine are driven is best illustrated in Fig. 9, which shows how open and crossed belts are brought to the machine pulleys from an overhead countershaft.

Probably the best way to describe the operation of one of these dry-grinders is to start at the point where a charge of ball blanks has been ground down to the required size and is to be removed from the machine. To provide for doing this, the head which supports grinding wheel *A* is carried on a slide on the base of the machine. Secured to the bottom of this slide is a rack *E* that meshes with a pinion at the end of cross-shaft *F*. Keyed to the opposite end of shaft *F* is a worm-wheel *G* that meshes with a worm actuated by handwheel *H* that provides fine adjustment. Secured to the bed of the machine is a disk *I*, and in order to drop grinding wheel *A* out of contact with the work held between rings *C* and *D*, the spring latch carried by lever *J* is withdrawn from a notch in disk *I* and the lever is moved to the left until the latch engages a stop notch in disk *I*, which limits the downward motion of the grinding wheel. It will be seen that sufficient clearance is now provided between grinding wheel *A* and

Fig. 12. Special Grinding Machines for grinding Rings shown at C and D in Fig. 11

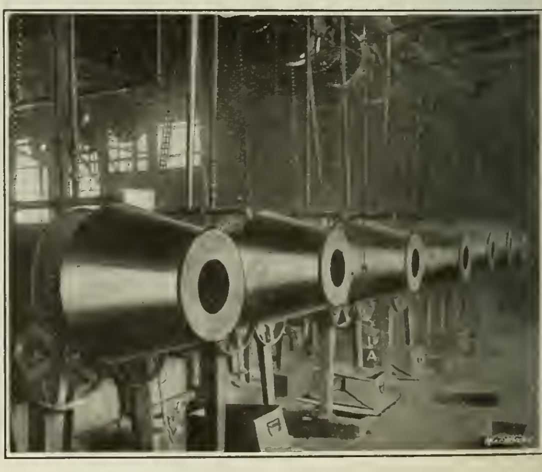


Fig. 13. Charging End of American Rotary Gas Furnaces in which Balls up to One Inch Diameter are heat-treated

rings C and D to enable tray K to be swung into position to catch the balls when they are discharged from the holding rings.

It will be seen that inner ring D is supported by a spider secured to the lower end of rod L, and in order to discharge the ground balls, ring D is dropped by pushing down lever M. This drops the inner ring and allows the ground balls to fall into tray K. When lever M is released, ring D is returned to its original position by means of a compression spring N. During the time that the charge of balls in the machine is being ground, a fresh charge of blanks is placed in the space between driving ring B and outer ring C; a few of these balls will be seen in position in Fig. 9. After the ground balls have been removed and inner ring D has been returned to the position shown in Fig. 11, it is necessary to place the charge of new blanks in position to be ground. This is done by dropping both rings C and D sufficiently so that the balls held between outer ring C and driving ring B may drop into position, after which the two rings are returned to the location shown in Fig. 11. This result is accomplished by means of lever O that is carried at the end of a cross-shaft which has a pinion at its right-hand end meshing with the rack P cut in the sleeve that supports the spider on which outer ring C is carried.

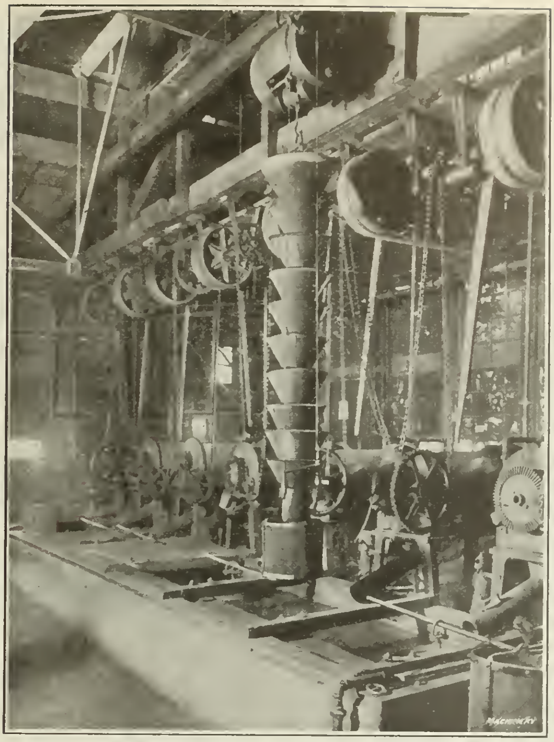


Fig. 14. Discharge End of American Rotary Gas Furnaces, showing Quenching Tanks and Deflector through which Balls are delivered to Baskets at Bottom of Tanks

In order to drop a charge of balls into place, the spring latch carried by lever O is released, and this lever is pulled forward which results in dropping both rings C and D, due to the fact that rod L, supporting inner ring D, is pinned to the upper end of sleeve P, to which the outer ring is connected by means of the spider. When the balls have been dropped into position as indicated, grinding wheel A is raised into contact with the work by raising lever J. Rings C and D are ground to a smooth surface and fine edge in order that the balls may run freely and reach through the space to come into contact with the grinding wheel A. This is done on special grinding machines, the method of grinding the inner and outer rings being clearly illustrated in Fig. 12. Lever Q at the front of the grinding machine operates a clutch that provides for starting or stopping the machine. It will be seen from Figs. 9 and 10 that the grinders are provided with an exhaust system to carry away the dust of the wheel.

Heat-treatment

During the process of making the steel for the balls and in forging and rough-grinding the ball blanks made from this steel, severe internal strains are likely to be set up in the metal that would often be of sufficient magnitude to cause the balls to be broken when subjected to only a small part of their rated load carrying capacity. Trouble from this source must be eliminated, and this is done by subjecting the balls to a preliminary annealing operation in rotary gas furnaces made by the American Gas Furnace Co. of Elizabethport, N. J., before the final hardening operation. The same type of furnace is used for the annealing and hardening operations, but for the former the delivery chute on the furnace is arranged to discharge the balls into pans, as shown at A in Fig. 13, while for the latter the balls are discharged into a quenching tank, as indicated in Fig. 14. The form of retort used in these American gas furnaces is shown in Fig. 16, and it will be seen to have a spiral path through which the balls pass as the retort is revolved. At the loading end of each furnace there is a hopper that is kept filled with ball blanks, and the retort draws blanks from this hopper and passes them through the furnace at such a rate that the steel is heated to the desired temperature when the balls are discharged. For annealing, a temperature of 1300 degrees F. is employed, and for hardening the balls are raised to a temperature of from 1425 to 1475 degrees F. according to the size and the composition of the steel. Pyrometers made by the Hoskins Mfg. Co. of Detroit, Mich., are used to determine the temperature of each furnace.

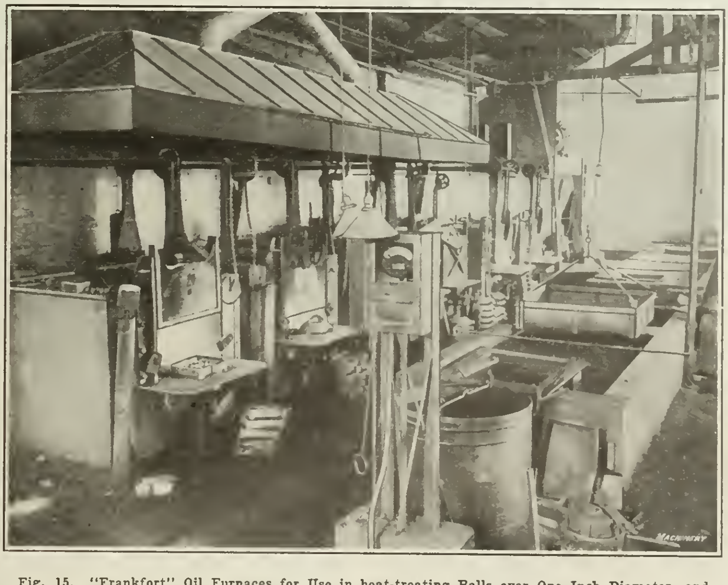


Fig. 15. "Frankfort" Oil Furnaces for Use in heat-treating Balls over One Inch Diameter, and Quenching Tank in which these Balls are hardened. Note Hoskins Pyrometer for showing Temperature of Furnaces

Quenching the Steel Balls

It has been mentioned that the same type of furnace is used for both the annealing and hardening operations, the only change being to place the tube so that the ball blanks are discharged into a pan in the case of annealing, and into the quenching tank in the case of the hardening operation. The retorts used in the furnaces were formerly made of cast iron, and great trouble was experienced through their destruction after they

had been in service a short time. This trouble has been overcome by substituting "Nichrome" in place of cast iron, and retorts made of this material last for a long time before they are burned out.

In hardening there is a difference of practice according to the size of the balls, those of 5/16 inch diameter and less being quenched in oil while balls of larger size are quenched in water. Balls made of some grades of steel are quenched in pure water and others are quenched in brine. In all cases the quenching tanks are provided with a device of the form shown in Fig. 14, which consists of a series of conical sheet metal deflectors through which the balls pass before reaching

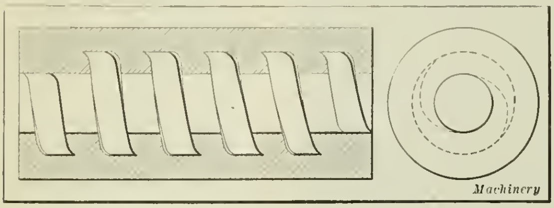


Fig. 16. Cross-sectional View of "Nichrome" Retort used in Rotary Gas Furnaces

the wire mesh basket at the bottom of the tank. The purpose of these sheet metal cones is to deflect the course of the balls so that they follow a winding path and are completely cooled before reaching the bottom of the tank. One complete furnace charge can be run into one of these wire baskets and when this is filled, the entire outfit is lifted out of the tank by means of an electric hoist as shown, and the balls are then removed from the basket. The depth of the quenching tank is about 14 feet. Rotary furnaces are used for annealing and hardening the smaller sizes of balls, and in the case of balls one inch in diameter and over, "Frankfort" oil furnaces are employed, into which the balls are introduced on trays as shown in Fig. 15. When the balls are heated to the proper temperature, these trays are withdrawn and the balls are dumped into the quenching tanks provided with the sheet metal cones described. The reason for quenching small balls in oil and large balls in water is that the oil does not absorb the heat as

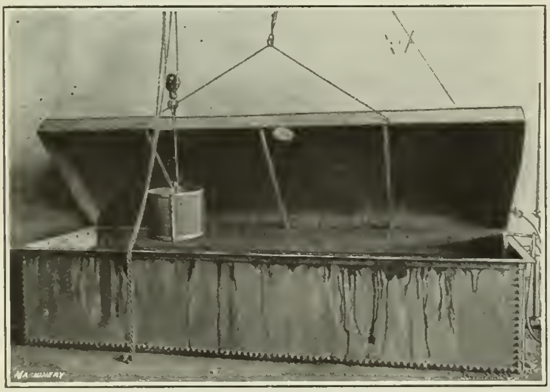


Fig. 17. Water Bath in which Severe Strains are removed from Balls quenched in Water by subjecting them to Temperature of Boiling Water for Two Hours. This Treatment also enables Balls to dry rapidly and prevents Rusting

rapidly as the water, and in the case of very small balls, the shock of dropping them into water would result in strains so great that many balls would either be cracked or broken, and the strength of those balls in which there were no visible defects would be seriously impaired. In the case of large balls, there is sufficient heat to prevent trouble from this cause. From time to time sample balls are tested by breaking them on an anvil and examining the structure of the steel to make sure that the heat-treatment is producing the desired results. Provision must be made for preventing overheating of the oil or water in the quenching baths, and this is done by having a circulating system through which the oil or water passes into a reservoir outside the building and then through a coil in this reservoir and back to the tank. In this way the contents of the quenching tank are kept in continual circulation, preventing overheating.

Water-anneal to Prevent Excessive Strain

During the process of hardening, internal strains are set up in the balls, and it is necessary, of course, to remove these strains. This is done by subjecting them to what is known as a "water-anneal," consisting of immersing wire baskets containing the balls in a tank of boiling water for two hours, which is said to remove excessive strains. The equipment used for this purpose is shown in Fig. 17. This practice of "water-annealing" is only followed in the case of balls that are hardened by quenching them in water; for small balls quenched in oil, the "water-anneal" is unnecessary. In addition to annealing, this treatment in hot water prevents the balls from rusting because they dry off more quickly than if they were quenched in cold water.

Finished Dry-grinding

After being hardened, the balls are sent back to the dry-grinding room, where they are subjected to what is known as a finished dry-grinding operation. This is the same as the rough dry-grinding that the balls receive before hardening, except that it is done with a finer wheel which results in removing the scale produced in hardening and also reducing their diameters a little closer to the finished size; the finished dry-grinding also serves to remove any distortion which may have been introduced during the process of heat-treatment. For the rough-grinding operation, wheels of No. 40 grit are employed. On finish-grinding, the grit of the wheel varies according to the size of the balls. Wheels of No. 60 grit are used for all balls exceeding 5/16 inch in diameter, while for smaller balls wheels of 90 or 100 grit are employed. In all cases the machines are driven at the required number of revolutions per minute to give a surface speed of 4500 to 5000 feet per minute at the point where the ring wheel engages the balls.

The second installment of this article, which will appear in the April number of MACHINERY, will take up the process of ball manufacture at the time that the finished dry-ground balls are delivered to the tumbling department. This installment of the article will describe in detail the operations of tumbling or "oil-rolling," oil-grinding, burnishing, drying, polishing, inspecting and packing the finished balls ready for shipment.

* * *

BRAKE AND CLUTCH LINING

Fabric brake and clutch lining is made principally of cotton or asbestos, according to a paper read before the Association of Mining Electrical Engineers of Leeds, England, by J. Oswald of Glasgow. The cotton fabric has the higher coefficient of friction, 0.5 to 0.7, and is capable of absorbing much greater work, in foot-pounds per square inch, at a given pressure than the asbestos. The coefficient of friction rises with increased temperature and is practically unaffected by oil or water. The choice between cotton and asbestos is determined partly by the amount of heat that is likely to be generated; in all cases where 400 degrees F. is likely to be exceeded, asbestos should be used. Its coefficient of friction is 0.3. On account of its nature, the asbestos fabric is usually reinforced with brass wire, which makes it more expensive than cotton. Failures with fabric linings are due to the use of the wrong material, to failure to keep the fabric face clear of the opposing face when brakes are out of action, to failure to insure that the fabric is kept well home when applied, incorrect fixing of linings to the engaging media, and expecting too much from brakes that have been under-dimensioned by the makers for the duties they must perform.

* * *

It is estimated that the available water power in European Russia, including Finland, the Ural district and the Caucasus, is 10,000,000 kilowatts, or over 13,000,000 horsepower. Only about one-fortieth of this is now being utilized.

Successful Shrapnel Manufacture[1]

by Chester L Lucas[2]

Much has been said about the shortcomings of a few of the hundreds of American concerns that undertook munitions manufacture during the past two years and were unsuccessful in carrying out their contracts. But there is another side to the story, as is exemplified by those who have been highly successful. How the Westinghouse Air Brake Co. organized, equipped and managed for the production of 1,250,000 rounds of three-inch shrapnel and 1,500,000 additional time fuses, making a total of 5,250,000 parts, is described here. This article on management with horse sense is presented in the hope that the ideas will be of service to those who may be suddenly confronted with similar shell manufacturing problems.

THE problem of equipping for munitions manufacturing is in no way different from that of equipping for the manufacture of motor cars, cream separators, pencil sharpeners or any one of a hundred and one other products required in large quantities, unless it be that munitions work is attended by more or less rush and frenzy due to the nature of the product. The fact that the general public is greatly interested in any munitions activities, even to the point of inquisitiveness, helps to add to the general excitement. Shell manufacture, for instance, presents few really mechanical operations. The measure of success of such an enterprise is largely fixed, as in any other manufacturing proposition, by the way in which the working organization is perfected, the plant equipped and the work planned. The trouble with the shell manufacturers who have not been over-successful has seldom been in their mechanical practice, but in the personnel of the organization, the selection of the equipment and the method of procedure from the standpoint of management. In manufacturing any new product, there are certain preliminary stages that must be gone through if success is to be attained. The shell-making concerns who have succeeded have recognized this principle and have patiently gone through this period before attempting actual manufacture. The temptation to start prematurely is great, and is often increased by the pressure of the financial interests behind the organization. These men naturally are impatient to see things moving, even though they do not understand the mechanical difficulties to be surmounted. Moreover, the desire to "make a showing" and the insistent calls for deliveries augment the force that induces some managers to start manufacturing before they really know what they are doing. As in all such cases this premature start serves to complicate matters, manufacturing methods have to be changed as unsolved difficulties are encountered, resulting in much work having to be done over and a general upsetting of plans and schedules.

The keynote to the whole situation is found in the old adage, "First be sure you're right—then go ahead." There is nothing new in this principle, but it has proved to be true, as never before, by the lessons learned in the shell-making industry.

In view of these pitfalls to be avoided, it is gratifying that many of the concerns who took on contracts for munitions, especially shells, went at things in the right way, organized and equipped along the right lines and filled their contracts satisfactorily and on time. Much has been published about the mechanical operations of these plants, but little has been written of the details of organization and equipment for the work. While it is hoped that the demand for shells will not be increased, no one can predict how soon thousands of American manufacturers may be called upon to make shells for their own government. In the successfully handled contract described below may be found guiding points worth remembering.

Prominent among those who were successful in completing their shell contracts on time, is the Westinghouse Air Brake Co. of Wilmerding, Pa. The company's first order called for 1,250,000 complete rounds of 3-inch shrapnel, which meant that 1,250,000 each of brass cartridge cases, steel shells and time fuses had to be produced. The work was finished well within the time specified in the contract. Following this contract was another for 1,500,000 time fuses and this work was completed February 1, 1917. Two months and a half after signing the first contract the organization had been perfected, the equipment installed and production had commenced. At the height of the work 10,000 shells, fuses and cartridge cases were produced daily by the 1500 men on the day shift and the 1000 men on the night shift. Through the courtesy of A. L. Humphrey, vice-president and general manager, and O. W. Buenting, general factory manager of the company, these details of procedure in organizing and equipping for this work are presented.

One reason for the success of the work in this plant was the limiting of the work undertaken to just one size of shell. Many less successful shell contractors befuddled their work at the start by taking small quantities of several different sizes of shells. Each additional size increased the prospects for trouble many-fold.

Planning the First Steps

As soon as a definite decision was reached on what was to be manufactured, a conference was called of the mechanical heads of departments and engineers, and suggestions and ideas were asked for. After a day or two of deliberation another conference was called and these ideas and suggestions

[1] For information previously published in MACHINERY on the organization and management of munitions plants, see "What is the Matter with the Munitions Makers?", December, 1916.

[2] Associate Editor of MACHINERY.

"The machine tool builders and their salesmen were of great assistance in advancing good ideas"

were presented. With the suggestions as a basis, definite plans were adopted, and active preparation for the work began. The final plans were no one man's ideas but were a combination of ideas representing the best mechanical and executive brains in the organization.

Segregation of the shell work was an important factor in the success of the work. All the shell work was kept in one building of the plant and three distinct departments were organized to take care of the cartridge cases, shrapnel shells, and time fuses. A tool-room was provided for each department to make the tools and keep them in condition. In this way the toolmakers became specialists in the particular lines of tools for which they were responsible.

Personnel of the Shell-making Organization

An important factor that counted for much at this plant and one that some less successful concerns lost sight of, was the personnel of the organization. No new superintendents or foremen were engaged for the shell work. From the already successful organization making air brake apparatus, the new organization drew a few foremen, a large number of assistant foremen and leading hands, and took them into the shell-making department. The other way of building a body of shell-making executives would have been to hire men from outside. Such men would have been hard to get, even at high wages, because of the obviously temporary character of the work, and when secured, they would have been untried and of unknown ability. The company's own foremen were of known ability, and after the contract was filled would be even more valuable on their old jobs. The positions left vacant were filled by moving men upward in the line of promotion. As far as possible, the most important foremen were retained in the permanent organization to insure that the air brake production would not be interfered with.

Contrasted with this was the method of getting together the force of operators necessary to run the machines and work on the shell job. These were almost all new men hired through the employment office. If men from the air brake plant asked to go on the shell work they were permitted to do so, but were told that the job was temporary and if they went on the shell work they would have to take chances on re-employment after the work was over. As a matter of fact, not over 8 or 10 per cent of the old employes were transferred to the shell department. This number was just enough to give stability to the green men on the job.

On the fuse work, it was found that girls could be employed to advantage on many operations, such as burring, lapping, inspecting and assembling, because of their ability to do repetition work without tiring and their deftness on these small operations.

Equipping for the Work

The planning of the sequence of operations, the methods of tooling and the nature of the equipment was similar in most respects to that of many other shell-making concerns, and was directed by the general superintendent, assisted by the engineers and the designers on the staff. When getting ready for the work, many other shell manufacturing concerns were visited, and all the assistance possible was gleaned from every available source.

The machine tool builders and their salesmen were of great assistance in advancing good ideas for equipment, tooling, etc. Their experience on similar propositions in different parts of the country had given them an insight into the work that was not to be neglected. Of course the salesmen were looking for sales, but their assistance was gladly accepted if it appeared that their machines were best suited to the work, everything considered. No machinery was taken from the air brake plant; every machine used on the shell job was new.

In buying the machinery and other equipment for handling the shell work, two important points were constantly borne in mind. The first was to select only such machinery as would be useful in regular lines of manufacture after the shell business had passed. Of course, for operations like graduating or milling powder train grooves, special machinery was needed, but for turning, drawing and similar machining operations, standard machinery was used. Owing to this policy, the company is not now in possession of a lot of unsalable machinery. Already a large percentage of the shell-making machines has been absorbed into the air brake plant, and the absorption process is still going on.

"The metallurgists were kept busy determining what grades of metal should be used"

The second point borne in mind in buying equipment was to select as far as possible only such machinery as would do the work when run by operators of average intelligence. Skilled machine men were scarce; therefore the "brains were kept in the machines" as far as possible. This means that the simplest machines were not purchased, as they would have required skilled men to get exact duplication of the work. The machines selected

"—went over the specifications for the various parts, word for word, making sure that everything was perfectly plain"

were, as far as possible, of the automatic or semi-automatic type, which when once set up would produce accurate work in the hands of the average run of unskilled labor such as applied for positions every day.

The argument was presented by some manufacturers of single-purpose machines that one good sized shell contract would overwork any machine equipment to the extent that the machines would be "shot to pieces" by the time the contract had been completed. It was claimed that the wear and tear that the machines would receive at the hands of green operators, coupled with the pace that would be followed in getting out the order would wreck any machine tool. For these reasons, it was argued, high-class all-around machinery should not be bought, since it would be ready for the scrap heap after its shell-making season.

The fallacy of this argument is well demonstrated by the condition of the machines used on this contract. Machines pulled down for examination were found in good condition, in spite of the year-and-a-half of day and night service by operators taken from steel mills, farms and wherever else they could be found. This machinery was more costly than single-purpose machines, but the difference was more than made up by the reduction in the labor cost of producing the shells. Out of the hundreds of thousands of dollars worth of machinery bought for this contract not over 10 per cent is of the special or single-purpose class to the extent that it cannot be used in any other line of manufacturing. At least 25 per cent of the machinery has been absorbed in the railroad equipment plant and more is being taken in as needed.

"On the fuse work it was found that girls could be employed to advantage"

"Every shipment of material was held until lot samples could be taken and tested"

Chief Chemist and his Important Work

While the mechanical engineers were determining what machinery should be used and what tooling methods should be adopted for producing the various shell parts, the chief chemist and his assistants were also busy —fifteen hours a day. First, and one of the most important of the steps taken, was the checking of the specifications. These were studied by the chief chemist in person, who went over the specifications for the various parts, word for word, making sure that everything was perfectly plain. In many cases where the specifications were capable of being read in two ways, the obscure point was clarified by consultation with the inspectors. In some cases also the specifications stated that work should be done "with sufficient accuracy" or "in a suitable manner." The chief chemist made it his business to find out just what was meant by these phrases so that there would be no trouble when manufacturing actually commenced. Too much cannot be said of the wisdom of this preliminary work, as much trouble was thereby avoided, and when actual manufacturing commenced there were no annoying delays in finding out what had to be done to meet the requirements of the specifications.

The metallurgists were kept busy determining what grades of metal should be used, and samples from the mills were tested and the sources of supply thus fixed upon. In this connection, great care was taken that for every class of material two or more sources of supply were maintained. In this way production hold-ups from delayed shipments and shortage of stock were averted. Every shipment of material was held until lot samples could be taken and tested. When found O. K.—and not before—the shipment was allowed to enter the plant and go into production.

The testing of the shell steel and the determination of the necessary heat-treatments were important preliminaries of the metallurgical work. Tensile strength tests had to be made, and after the desired results were obtained, the exact procedure to be followed in heat-treating was arbitrarily laid down. The drawing brass for the cartridge cases was experimented with, actual tests in drawing were made and the most satisfactory annealing temperatures were selected. It will thus be seen that these important points were all settled before the time for actual shell-making had arrived.

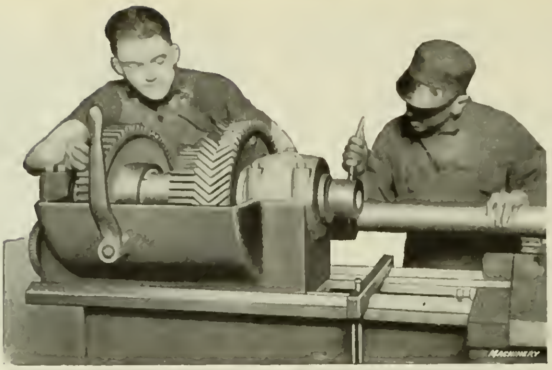
"—every shell was scleroscoped before and after heat-treatment"

While actual manufacturing was in progress the chief chemist still had plenty to do. Branch laboratories were installed at the points where help in maintaining correct conditions would be required, notably in the heat-treating and cartridge case departments. The assistants in these departments spent their time in making tests to assure that all was going well and in many cases went about looking for trouble. It was found, for instance, that oftentimes brass from two different shipments, although agreeing in analysis would not act alike in turning. Worked in the same machine with the same set of tools, one bar of brass would produce parts of slightly greater dimensions than another. After careful investigation it was found that the fault lay in the reducing treatment that the brass had received at the mill. When the brass was reduced too much between annealings it took on a harder temper and resisted the cutting tools to a greater degree, and the tools did not "cut to size." It then became necessary to take the heat-treatment up with the brass mill which thereupon adopted more exact methods in reducing and annealing so that the shipments of brass would be alike in temper. Causes

of trouble like this sometimes took longer to discover than to correct, but their elimination formed an important part of the metallurgist's duties, and contributed materially to the success of the shell work.

Keeping Peace with the Inspectors

Absence of friction between the inspectors and the production force was a noticeable feature of the work on the shell contracts at this plant. One reason for this was the definite instructions issued to the foreman of each department of the shell plant to meet all the inspectors' requirements—and to the inspectors' satisfaction. There was no room for argument, because in this shell plant "the inspector was always right." In exceptional cases, where the inspectors' requirements were deemed to be too severe, the matter was taken up by the factory manager and the inspector-in-chief, and quickly and amicably settled.



"Machines pulled down for examination were found in good condition in spite of the year-and-a-half of day and night service"

Over all the shell work was the chief inspector of the plant, who had assistants in every department. The limits for each dimension of all shell parts were arbitrarily set by the specifications of the contract. The limits set by the shell plant inspectors were kept well within those called for by the specifications, so that if the shell parts were made to the limits called for by the gages of the plant inspectors they would surely pass the more liberal gages of the final inspection.

Good gages and their maintenance were a great aid to successful work. These gages were made in the tool-rooms adjacent to the shell, case and fuse production departments, so that the toolmakers on each job became proficient in making the few types of gages needed for that particular department.

One of the pitfalls into which many shell contractors fell was in heat-treating. This trouble was partly due to the attempt to do the work without the necessary precautions being taken. In this plant, the experiments conducted by the metallurgists before production started helped to solve this problem. This preliminary work resulted in determining the exact heat-treatments before the first shell forging reached the plant. After production started, every shell was scleroscoped before and after heat-treatment. Some contractors have endeavored to "get by" with a scleroscope test on but one or two shells from each heat-treated lot, but the many poor shells that escaped undetected caused a great deal of trouble. Owing to the extreme care used in all inspection, and especially to the careful heat-treatment inspection, almost no shells were rejected from the entire lot of 1,250,000.

Hiring and Paying the Operators

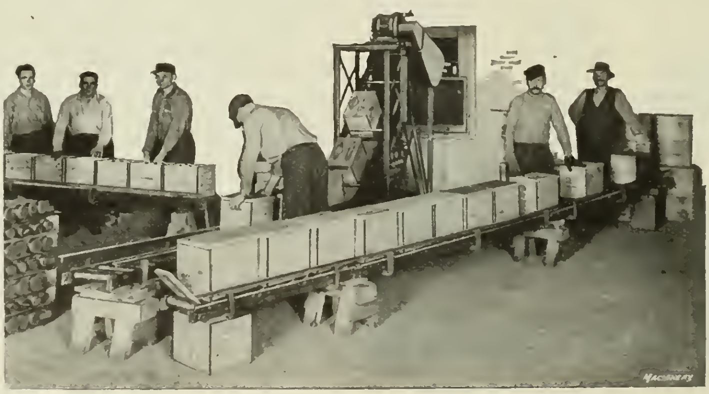
When the shell plant was completely equipped and ready for operation, the machine operators and other employes needed on the work were hired in especially for this job, as before stated. A small percentage of the regular working force of the railroad equipment plant was transferred to the shell plant merely for the purpose of giving stability to the working force. The machinery was new, the operations unfamiliar and the men green; therefore, at first the pay was by the day. As soon as practicable, however, piecework prices were set, based on the showing made while on day work, and the prices were maintained without change until the contract was completed. These prices were set high enough to enable the operators to make from forty to forty-five cents an hour on the average; in some cases proficient workers were able to exceed this average considerably. The piecework prices were not changed unless the methods of performing the work were changed. This positive setting of the prices and their maintenance were made possible because the start on day work afforded the opportunity to study the feeds, speeds and productions.

Many of the machine operators, especially at the start of piecework, had great ambition to turn out abnormal quantities of work and increase their earnings. The result was inevitable—the quality of the work suffered. After a few of these performances, the foremen were given instructions to check immediately a man who tried "to cut loose" at the expense of the quality of the work.

Considerable trouble was experienced in getting new men "down to earth" because the prevailing reports about shell-making wages in general brought applicants who thought that ten to fifteen dollars a day should be their average earnings. As a matter of fact, the piecework prices were set high enough to allow inexperienced men to make higher wages than they had ever earned before.

Shell Making without Impairing Air Brake Production

While this production of 10,000 complete rounds of shrapnel a day was going on, the railway air brake plant had to be maintained without sacrifice. The fundamental policy of keeping the shell work entirely separate and as far removed as possible from the railroad air brake department proved most wise. Another important point was that in selecting the organization to be used on shell work, the foremen and other executives were taken from such positions on the air brake work as would interfere the least with production. The foremen of the principal departments were undisturbed with few exceptions. By promoting many of the under-foremen and leading hands to positions of responsibility on the shell work, good results were secured, because these men were ambitious to make good in their new positions of authority and exerted every effort to be successful. The shell work was begun at a time when the railroad business was dull, and it seemed a mockery of fate that as soon as the shell work was well started the air brake business rapidly increased, and when the shell work was at its height the air brake plant was also busy. This shell contract, totaling 3,750,000 3-inch shells, cartridge cases and fuses, was completed well within the contract time of one year. The additional contract for 1,500,000 time fuses was also put through within the contract time of six months, and the work was carried on without allowing the air brake production to fall behind.



"—this shell contract . . . was completed well within . . . one year"

INDUSTRIAL PREPAREDNESS

BY A. B. HAZARD[1]

There seem to be varied and diverse opinions as to the probability of the United States being able to make a sufficient quantity of munitions in the event of war. In a recent issue of the Philadelphia *Evening Telegraph* of January 27, Howard E. Coffin of the Council of National Defense, states that it would take from five to thirty years to properly equip plants and manufacture munitions in sufficient quantities to supply our army and navy in case of trouble. In considering this statement it is well to remember that Mr. Coffin, himself has developed a large and extensive automobile plant in less than ten years and is considered one of the most rapid producers of automobiles in this country. We might also point out the accomplishments of the Ford plant, in Detroit, which in less than fifteen years has done far more difficult work than the production of munitions, both as regards accuracy, refinement and volume of production. It is true that there have been a number of failures of munition manufacturers, but they were few in comparison with the number who were successful.

I stated in an article published in MACHINERY, July, 1916, that there were in the United States at that time sufficient plants equipped with machinery that could be changed over to manufacture shells to turn out in thirty days 300,000 shells a day. That was a conservative statement. After carefully going over the conditions, I believe it would be possible to make half a million shells per day in this country with the equipment in use at the present time. I know of an instance where, in five months, a plant was equipped with shell-making machinery and turned out 3000 9.2-inch English shells daily. It should be possible to machine an armor-piercing shell of the same corresponding size in less time than a British high-explosive shell.

As for equipment, conditions are now perfected to such an extent that machines can be made in six or seven hours that are capable of performing both the internal and external machining operations necessary to finish shrapnel shells. It would take longer to ship the machines from the factory to the plant than it actually takes to build them. This is the work of but one concern. There are numerous other machine tool builders prepared to turn out large quantities of tools for the machining of shells. The smaller shells, six inches in diameter or less, could be machined from bar stock in far less time than they could be made from forgings, which is the practice now used for manufacturing shells for the Allies. There are a half dozen or more mills that could turn out bar stock and start shipment within four or five days from the receipt of orders. In summing up the conditions that obtain at the present time there is no reason why, within thirty days, we could not start shipment of the finished product in large quantities.

It is a fact that automobile manufacturers possess a limited number of machine tools capable of making munitions. A few scattered automatic machines in the different plants could probably be put together in an emergency and a large quantity of small shells produced. However, they would not be likely to be used, as these automatic machines have been improved to a great extent for making munitions and would be far more efficient than those now running in the average motor car plant.

As for high-explosive shells, together with the cases, primers, time fuses, etc., there are a number of manufacturers who are engaged in this line of work and would require but minor changes to modify their equipment for turning out these shells according to the government specifications. It might be stated further that there are numerous plants prepared to make different size shells and parts, all of which are, no doubt, listed and in the hands of the Council of Defense. As a matter of fact in from three to six weeks, shipment could be made in quantities far greater than would be needed by the army in case of an emergency.

There are other materials probably just as important that should be seriously considered by the Council of Defense. It would be advantageous to publish specifications in detail of the different commodities required by both the army and navy. This would educate the manufacturers in different lines, and would help them to prepare for the future. Then, again, this is the best time for standardizing such commodities as can be made exclusively in this country. This, in itself, would be a big saving of time. For instance, if manufacturers of trucks or other articles knew of a certain standard specification it would greatly facilitate their work. There is no reason to make a secret of these things, as there is no particular benefit to be derived from this policy. We have specifications of a great many articles used during the present war by the other countries that have given us valuable information and have done them no harm.

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TREND OF INDUSTRIAL BUILDING CONSTRUCTION

The present trend of industrial building construction is indicated by a recent investigation made by W. P. Anderson, president of the Ferro Concrete Construction Co. of Cincinnati, Ohio, and presented in a paper before the recent annual meeting of the American Concrete Institute in Chicago. The results of Mr. Anderson's investigation were drawn from inquiries made of the leading industries, manufacturers of all classes of metal goods, manufacturers of textiles, paper, leather, boots and shoes. Of the representative manufacturers who were requested to furnish data, 370 concerns contributed information covering 1230 buildings erected during the period covered by the investigation. These varied greatly in size, use and construction but all were used for industrial purposes. The returns year by year are graphically represented in the

Chart showing Trend of Industrial Building Construction

accompanying chart for the four major classifications—all wood, brick walls (steel frame), mill construction, and concrete construction. Of course the abnormal disturbances during 1914-1916 account for the great fluctuations in that period. But even up to and including 1913, the advance of concrete construction and the relative decadence of other types are distinctly noticeable. The comparative growth of the various types of building construction is most strikingly shown by comparing the periods 1905-1910 and 1911-1916. In the former, the returns cover 7,014,218 square feet of mill construction and only 5,152,579 square feet of concrete construction, but in the latter period the area of concrete construction jumped 327 per cent, to 16,926,152 square feet, while the mill construction showed a bare increase of about 10 per cent or 7,709,469 square feet. The estimated area for 1916 was used in making up all of these comparisons.

MECHANICAL DEFORMATIONS IN METALS

BY B. D. BALLANTINE[1]

It is interesting to know what changes take place in a metal when it is cold-worked, as, for example, when steel is cold-rolled or when brass is burnished. Sometimes it is exceedingly important for a machinist to know not only what effect a certain cold-working operation will have on the work he has in hand but also how this effect is brought about. In other words, he should understand something of the theory which governs these changes. By this knowledge he can oftentimes avoid annoyances that are likely to arise in regard to his work but that he cannot foresee if he goes at his work blindly. It is not the purpose, however, to give here a detailed outline of the theory, but simply to touch on its most salient features and to explain some of the everyday things that come up in connection with the cold-working of metals by the help of this theory.

When a metal has been strained beyond its elastic limit, allowed to rest for a short time, and then strained again, it is found to have a higher tensile strength than before and its elastic limit is also found to have been raised. This statement applies to metals in general, and especially to steel. The theory of this phenomenon is not simple and has not been absolutely established, but it has come to that stage where additional information strengthens rather than weakens it, so that it is now almost universally accepted.

When a cross-section of a piece of steel which has been subjected to strain beyond its elastic limit is examined under the microscope, there appears on each crystal a series of fine dark parallel lines that are more or less wavy. These are technically known as slip bands and are caused by a breakdown in the crystal, one part having slipped on another part and caused a slight displacement. In Fig. 1 are representations of two adjoining crystals, showing how they look before and after they have undergone strain. The steps *S* are where these bands occur. The average height of the steps is about 1/50,000 inch. The dark appearance of the slip bands is due to the reflected light in the microscope.

A number of elements exist in allotropic forms. For instance, pure carbon exists as diamond and as graphite, and sulphur exists as crystalline sulphur and as an amorphous sulphur similar in appearance to thick molasses. When brass or steel is burnished, the crystalline metal is converted into an amorphous form, which is pressed down into the tool marks. This amorphous metal flows into the minute cracks and crevices of the machined material practically as a molten metal flows and adjusts itself until it presents a smooth surface. The metal, when in this amorphous state, is harder,

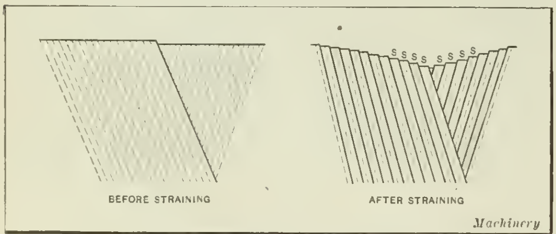

Fig. 1. Slip Bands of Adjoining Crystals

stronger and more brittle than when it is in the crystalline form, but it is more easily attacked by acids; in fact, so much more so that the original tooled surface can be restored by etching with nitric acid. The amorphous metal has a higher vapor tension also. When it is subjected to a high temperature in a vacuum it will sublimate off appreciably faster than in the crystalline form; it can be reconverted into the latter form, however, by being heated and then allowed to cool. This heat-treatment is known as one form of annealing and is the treatment used for softening brass.

When slip bands are created, a certain amount of crystalline metal is converted into the amorphous state, which flows around each slip band. Virtually all the metal at each slip band is changed in this manner into the amorphous condition. This acts as a cementing material, and, since it is harder and stronger than the original composition, the larger the number of slip bands created, the greater will be the amount of cementing material formed and consequently the harder and stronger the resulting material. Of course, if the thing is carried too far, ultimate fracture will result. The amorphous form is brittle, so when no available crystalline metal is left the metal loses its ductility, there is no more "give" to it, and it cracks. Everybody knows what the head of a well used cold chisel looks like, and so is familiar with the result of overstraining the metal. It must not be imagined, however, that all the crystalline metal is converted into the amorphous form. The process is carried on until a skeleton of the amorphous metal pervades the mass; a further carrying on of this straining operation will break down this skeleton.

The foregoing discussion leads to an interesting case. The fact is widely appreciated that a steel of fine grain is more

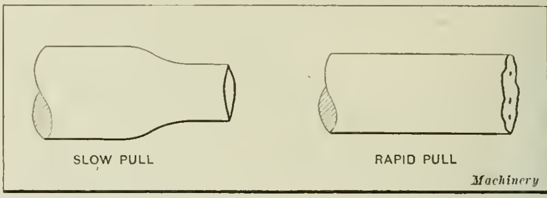

Fig. 2. Characteristic Appearance of Steel Bolt broken by a Slow and a Quick Pull

desirable than one of coarse grain because it is stronger. When molten steel cools and crystallization sets in, the nuclei of the crystals are first formed. As these crystals grow and as others form, they approach one another and a certain amount of molten steel is trapped, giving the crystals no more room to form. When this trapped material solidifies, it does so in the amorphous form. Consequently there is produced the condition existing in the preceding case, where the greater the amount of amorphous metal, the greater is the strength of the steel. As the amount of amorphous metal increases with the diminishing size of the crystals, a steel containing small crystals is stronger than one containing larger ones.

There is prevalent among machinists and metal workers a belief in the existence of the so-called "cold crystallization" of steel. The idea is that a steel originally of fine grain gradually assumes a coarse structure when it is subjected to continued alternate stresses and strains. No evidence to bear out this belief has been submitted to metalographists. A great many bolts and springs, broken after continued service, have exhibited what appears to be a coarse structure at fracture, but this does not warrant any such belief. The specimen will show its original grain if examined anywhere else than at the fractured surface. This coarse appearance at the break can be ascribed to other causes. Everybody has observed the behavior of a long piece of sealing-wax or of molasses candy. The stick can be bent almost double if a very slow and steady pressure is applied to it, whereas it will be broken off short if a sudden effort is made to bend it. Exactly the same thing is true of steel.

Fig. 2 shows the characteristic appearance of a steel bolt or bar when broken by a slow pull and when broken by a quick one. In the first instance, sufficient time has been given for slip bands to form, amorphous metal has had a chance to flow, and the result is a smooth break. In the second case, no such opportunity has been given for the amorphous metal to run and the fracture, which in any normal material always occurs through the crystals themselves, presents a ragged appearance in the absence of any filling-in material. But that is not all. When a bolt is subjected to alternate stresses and strains, slip bands will start to form. These will begin at a certain point and gradually spread from crystal to crystal. In the course of time the amorphous metal formed at these slip bands will be squeezed out by the intermittent pressure on the bolt and a minute crack will be formed. As the process

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is continued, the fracture will be extended until the unaffected portion of the bolt will be unable to bear the strain and breakage will occur. If these operations are carried on fairly rapidly, the steps caused by the slip bands, having had no chance to wear smooth by abrasion, will present a coarse crystalline appearance which has led to the mistaken notion that the metal has crystallized in coarse granules. If the process is carried out more slowly, the two surfaces, one on each side of the crack, will rub against each other, wearing each other down until they are smooth. Then when the bolt breaks, there will be a region on the fractured surface where this action has taken place that will appear rather smoother than the cross-section of that part of the bolt giving way last. This is only one instance of an illusion dispelled. There are many others connected with the science of metalography. As a rule, mankind does not go far out of its way to make discoveries unless compelled to. Urgent needs have fostered important discoveries and aided necessary developments. What the Civil War did for drop-forging in creating a demand for interchangeable gun parts in large numbers, what the present war is doing for the aeroplane, the automobile has done for the science of metalography; and the whole metal-workers' realm is affected.

* * *

ORNAMENTAL MACHINE SCRAPING OR FROSTING

The slides and ways of machine tools are scraped for two purposes: first, for correcting faults of machining, and second, for ornamenting the working parts. When correcting faults the scraper is used with a surface-plate to bring the flat surfaces to true planes. The practice has the merit of hardening the surfaces, removing the cast-iron dust and putting them in first-class condition to resist wear. As planers were improved and planer practice was developed, it was found that surfaces could be planed so smooth and true that scraping as a corrective process was no longer necessary. Of course it would be far from the truth to say that scraping still is not largely employed as a corrective process, but this is chiefly the fault of the machine tool equipment and operation. There is no valid reason why a lathe or planer bed or table cannot be planed so true that it will require no corrective hand work. The true function of scraping these parts should be to clean

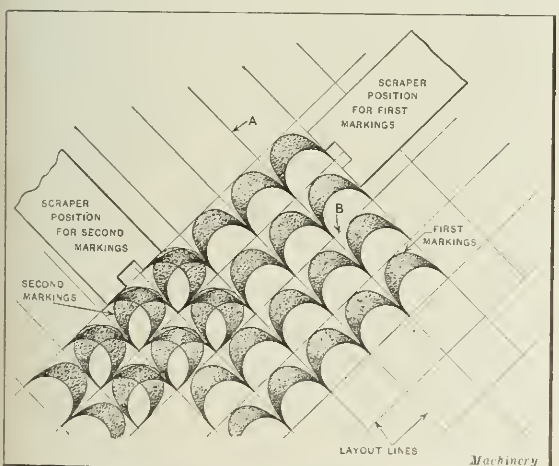

Fig. 1. Lund Method of frosting Machine Tool Slides

off the cast-iron dust, harden the surface so that it is in good condition to resist wear, and improve the appearance, if ornament is desired.

There are various methods followed in producing ornamental or frosted scraping; one that is simple, attractive and easy to produce is used by the Valley City Machine Works, Grand Rapids, Mich. The method was developed by Matthew Lund, vice-president and general manager, when he was employed as a mechanic in the plant of Bement & Miles, Philadelphia, Pa., years ago. The surface to be frosted by Mr. Lund's method is laid off as shown in Fig. 1, in squares measuring about ½ inch, and ¾ inch on the diagonal. The scraper used, shown in Fig. 2, has a notched edge; the width of the two points and the notch is ¼ inch each, the width over-all being ¾ inch. The lay-out lines are marked with a lead pencil, the lines showing black on the polished surface. The use of chalk on a finished surface is never advisable, as it is likely to remain in the pores of the metal and cause rusting years afterward. It is said to be practically impossible to get chalk out so that it will not plainly show effects long after the machine has been put in use.

Having laid out the surface to be scraped, the operator begins at a convenient spot, using the tool with a long pipe

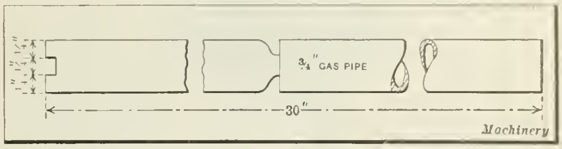

Fig. 2. Scraper used for producing the Lunar Markings

handle which rests on his shoulder. The tool is ground with a sharp chisel edge, and is not used as a scraper usually is, that is, to cut away the metal with a square corner. In fact, the function of the scraper is more of a marking tool than of a metal removing tool. The edges of the scraper are placed, say, on the line *A* with the left-hand side coinciding with line *B*. The tool is then given a sweep through a half circle ending with the left-hand side again next to line *B*. The results of the sweep are indicated by two lunar markings. This stroke is used progressively following the lay-out lines, and the markings are made rapidly. The second markings are produced in the same manner, but with the scraper held at right angles to the first position. The effect is pleasing, the work being regular and the light and shade effects all that could be desired for an ornamental frosted effect.

Of course it is understood that the surfaces scraped in this way have been proved beforehand with surface-plates and corrected when necessary by scraping in the ordinary manner. The marks of this scraping are eliminated by rubbing with emery cloth in a line parallel with the length of the ways. This leaves a surface in prime condition for the ornamental marking with the special tool.

Mr. Lund has instructed many mechanics in this method of ornamental scraping, and the practice has spread to other shops. It was instituted in order to secure uniform work from a number of operators, so that operator No. 23 working on the carriage of a machine, for instance, will finish his work in the same style as operator No. 50 who is working on the bed-plate. But it is also rapid; the time required to mark a surface a foot square in this manner is about one-half hour. Hence it is evident that the frosting work on a fair-sized machine tool need consume only a few hours. Of course we all concede that it is in a sense unnecessary, yet it adds greatly to the attractive appearance of a machine, and appearances count for a good deal in marketing high-class machinery in normal times. F. E. R.

* * *

Members of the Atkins Pioneers, men who have been associated with E. C. Atkins & Co., Inc., Indianapolis, Ind., for twenty years or more, celebrated the eleventh anniversary of their organization, with a banquet at the Spencer House in Indianapolis, Ind., Saturday evening, February 10, and a theater party at the Circle Theater. The Pioneers were organized in 1906, with sixty-two members, and the present membership is 121. John H. Wilde, the oldest member, who had a record of fifty-one years' continuous service, died last September. C. F. Aumann, the present treasurer of the association, is the oldest living member, having been in the Atkins service forty-seven years. Membership in the Atkins Pioneers is open to all employes. The object of the association is to promote sociability, loyalty and zeal for the business. The officers are W. O. Williams, president; C. S. Bronson, vice-president; C. A. Newport, secretary; and C. F. Aumann, treasurer.

MACHINERY

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MANUFACTURE OF STEEL BALLS

There is no other simple machine element that is regarded with more interest by those who know than a perfect steel ball; and it is with great satisfaction that we present in this number the first installment of a comprehensive article on ball manufacture. Steel balls suitable for high-grade bearings must be perfect spheres of hardened steel, highly polished; they must be without flaws or cracks, of uniform density and of high crushing strength. The hardness must be uniform and extend to the center. While the requirements are severe, they have been met in such measure as to make the highest grade balls an ideal product.

The machinery and processes employed in the manufacture of balls are unique, being peculiar to that industry alone. The ordinary turning and finishing processes of the machine shop cannot be employed for making balls, as they are too slow and costly and too inaccurate. Machining methods quite different must be used for manufacturing balls for bearings. Machines and methods have been developed which have put the making of balls on a tonnage basis, but, paradoxically, these machines are not in themselves of such exquisite refinement as to warrant the conclusion that the product will meet the most exacting requirements. As a matter of fact, ball making machines are crude, but they subject the rough forgings to peculiar abrasive and rolling actions, which tend to produce a truly spherical form. Not all balls produced are perfect—far from it; but by ingenious sorting and grading machines and sensitive gages the inferior grades are eliminated.

The importance of the ball making industry can hardly be over-estimated. Ball bearings are an essential feature of many modern machines, and the number using anti-friction bearings is growing. There is, perhaps, no feature of machine design that requires more study than the proportioning of bearings so as to give the longest life consistent with a minimum of frictional resistance. But, at best, the design of plain bearings is a compromise. Ball and roller bearings are steadily displacing them, as is shown by the millions annually produced. The factory whose practice will be described in these articles is now producing the equivalent of 25,000,000 one-fourth-inch balls daily, and will soon be able to increase its product over 60 per cent.

IMPORTANCE OF STANDARDIZATION

Perhaps the most valuable and enduring work of the American Society of Mechanical Engineers is the recommendation of standards of practice for engineers, such as the screw threads and boiler design standards. Standardization of practice means increased efficiency of production, less waste of material, and greater security. Howard E. Coffin, in an address delivered before a body of engineers recently, dwelt strongly on the need of standardization of aeroplane parts. He cited the case of one concern making screw machine parts for nearly all the aircraft built in the United States and Canada. One form of bolt is common in all the designs; but this bolt is requisitioned in eight different materials, several diameters, six styles of heads and fifty different lengths. This means that the one concern may be called on to produce several thousand different styles and sizes of one bolt, which might be used with equal satisfaction if standardized in one size and style.

The folly and waste of such practice is appalling. It is due largely to the reluctance of one designer to accept the figures and forms laid down by another, and to lack of appreciation of the savings effected by standardized practice. The intelligent, progressive and efficient engineer should be willing to accept the designs of others when reliable; acceptance is a step toward standardization.

We have had occasion several times to refer to the extraordinarily valuable standardization work accomplished by the Society of Automobile Engineers. This being a young society, unhampered by precedent and devoted to the interests of a comparatively new industry, has had a great advantage over the older societies. Its committees have risen to the occasion and by standardizing motor car details have saved the industry millions of dollars and set an example for other engineering societies to follow.

* * *

DELIVERIES OF MACHINE TOOLS

Price and delivery are very important items in any contract or order for machine tools. During the past two years, delivery has usually been a greater consideration than price. Some manufacturers who would not think of quoting a machine at $3000 with the intention of accepting the order and invoicing it at $4000 will deliberately name a delivery of three months and take the business with the full knowledge that they cannot hope to make shipment in less than four months. The latter practice is not so reprehensible as the former would be, but to deliberately name an earlier delivery date than can be met is morally wrong and financially short-sighted; it is harmful to the company indulging in such practice, and it gives the machine tool industry a bad reputation.

Some companies which consistently fail to maintain promised delivery dates do not do it with intent to deceive, but they do base their promises upon the best attainable deliveries if there should be no hitch at any point in the entire manufacturing schedule. Invariably something goes wrong, thus introducing more or less delay. With a proper production schedule, the machine tool builder should be able to predict very closely the date at which any given order can be filled—barring strikes, fires and accidents. One of the leading machine tool manufacturers has for some months been deliberately adding about 20 per cent to its shop production schedule when making promises of deliveries, knowing that the dates thus calculated can be easily anticipated. The result is that shipments, instead of being late, are made ahead of the promised dates. This has brought a number of unsolicited commendatory letters from customers who have received their machines earlier than promised, and much earlier than expected. It is building up good will for that company in the way of reputation for more than fulfilling obligations in the way of delivery promises.

If this practice should come into general use, no manufacturer would feel that he was losing business on this account, because all would be on the same basis. It would give the American machine tool industry, in general, a much more favorable reputation abroad; and those firms which first gain the reputation for meeting delivery promises will derive the most benefit.

THE ASSUMPTION OF RISK

BY CHESLA C. SHERLOCK [1]

The doctrine of law that a servant or employe upon entering certain classes of employment, assumes the ordinary risks and dangers of the employment is an important branch of the law of master and servant. Reaching into almost every branch of our industrial life, its importance can be comprehended only when one has realized how far-reaching our commercial and industrial world is.

It is a fundamental proposition that a servant assumes the ordinary risks and dangers of the employment in which he is engaged. The courts have even gone further and said that he also assumes the extraordinary risks and dangers that he knows and appreciates. And here is one of the most fertile fields for disagreement among the authorities. Just how far an employe assumes apparent risks, what risks are apparent and what are not, and the like, are questions that not only puzzle the most capable lawyers but the text writers and the courts as well.

Speaking in specific cases where the risk of employment was obvious, the courts have handed down a long list of conflicting and varying decisions. One court has held that an employe assumes all risks connected with the business with which he is employed, even though produced by the master's negligence, if he continues in the employment. A railway company is not liable for the killing of a conductor struck by a trolley pole while he is leaning out of a car running at high speed on a straight track at broad daylight at a place with which he is familiar, in order to ascertain a fact that he can learn by looking out from the rear of the car, since the conductor voluntarily chooses the negligent rather than the safe way.

As to employment that is obviously hazardous, the courts held, in a case where a salvage company was called upon to clear away the debris from a burning building, that one who engages in such work assumes the risk of injury from falling walls. It was also held in this case that "an employe of one engaged in salving property from the debris of a fire cannot hold his employer liable for injuries caused by falling walls; since, if the danger was obvious he assumed the risk of injury, and if it was not obvious the master did not violate his duty to use ordinary care to provide a reasonably safe working place." An employe sent to remove a pile of lumber assumes the risk of injury from its fall, because the lumber is covered with ice and defectively piled, where the defects are plainly obvious to him, notwithstanding they are due to the master's negligence.

These cases illustrate the tendency of the courts in instances where the facts show that the defect causing the injury was obvious, or must have been obvious, to the employe. In the case of defective machinery, appliances, or methods of work, a little different construction obtains. In a case where a nail projected above the floor in the immediate vicinity of a dangerous machine and a workman tripped on the nail and was thrown into the machine, it was held that there was no assumption of risk. This decision was based on a showing that the nail was habitually covered with litter, so that, as a defect, it was not obvious. However, when a servant remains, without necessity, under a heavy steel plate that is being hoisted in the air by means of a tackle, he assumes the risk and, if injured, cannot recover. One operating a lath machine has been held to assume the risk of injury from being thrown against the saws by the breaking of a stick or strip of lumber with which he undertakes to clear the chute carrying the sawdust from the machine.

An employe does not assume the risk of a device, installed by his master to lessen the risk of injury from the machinery at which he is required to work, being permitted by the employer to get out of order, unless he himself has notice of the fact that it is out of order. A servant who assumes the risk of getting his hand caught in a machine at which he is required to work may hold his master liable for aggravation of his injury by failure of a device installed to stop the machine in case of such accident to work, should his arm be drawn into the machine and crushed. A servant does not, by continuing to operate a machine that has not been protected by guards as required by statute, assume the risk of injury from violation of the statute. A servant does not assume the risk of injury from the master's violation of a statutory duty to guard set-screws. An inexperienced employe injured four days after his employment by an unguarded set-screw was found not to have assumed the risk of injury therefrom, although he knew of its existence, as the injury was due to the yielding of sawdust under his feet throwing him against the screw, the probability of which he might not have anticipated.

The defense of assumption of risk in its true sense in an action by the servant for injuries caused by the master's negligence has reference to those risks arising out of the negligence of the master that are known to, and the danger from which is appreciated by, the servant. A servant does not assume the risk of injury from the negligence of his master merely because he could have discovered and avoided it by the exercise of ordinary care; his assumption of such risk depends upon his actually being aware of and appreciating the danger. The test of "knowledge of danger" in determining whether an injured employe had assumed the risk is not the exercise of ordinary care to discover danger, but whether the danger was known to or plainly observable by the employe. A servant who knowingly engages to do what no prudent man ought to risk his life in endeavoring to accomplish cannot, if injury ensues, rely upon the law to throw around him the protection of a fiction that his employer impliedly undertook to take steps to minimize the hazard assumed, at least to the extent of making performance possible.

Where a servant discovers a defect in his tools or place of work that greatly increases his danger of injury and reports it to his master, he has not, by merely doing this, removed himself from behind the defense of assumption of risk. If the master promises to remedy the defect and on the strength of the promises the servant goes back to work, the doctrine of assumption of risk is still in force and, in case of injury, the servant cannot recover from the master for his negligence. Some of the courts, however, hold that where the master promises to remedy the defect before a certain time, as an inducement for the servant to return to work, he is liable up to the specified time; but that if the servant continues to work after that time the liability of the master ceases. If a master's promise to repair a defective machine is general or inferential as to the time of its performance, it runs for a reasonable time, and if not performed within such period, the servant assumes the risk of injury if he continues to operate the machine. To entitle a servant to take advantage of a promise by the master to repair the machine upon which he is required to work, the promise must have been the inducing motive which kept him at work and without which he would have quit.

The doctrine of assumption of risk by the servant not only applies to the master's negligence in the cases mentioned, but it applies to the negligence of fellow servants. It is a fundamental principle that fellow servants assume the risk of injury from one another in their common conduct of the master's work. Practically the same principles of law that govern in cases between master and servant hold in cases between a servant and a fellow servant. At least, it is safe to say they do in general principles, although there are distinctions in almost any phase of law that negative any attempt to state a broad general principle that will apply in all cases.

[1] Address: 408 S. & L. Bldg., Des Moines, Iowa.

* * *

Preliminary estimates by John D. Northrup, of the United States Geological Survey, Department of the Interior, indicate that the quantity of crude petroleum produced and marketed in the United States oil fields in 1916 was 292,300,000 barrels. This quantity is greater by 4 per cent than the corresponding output in 1915, which reached the record-breaking total of 281,104,104 barrels. Mr. Northrup estimates that 38 per cent of the 1916 total came from the Oklahoma-Kansas field, 30 per cent from California, and the remaining 32 per cent from the Appalachian, Lima-Indiana, Illinois, North Texas, North Louisiana, Gulf coast, and Rocky Mountain fields.

SHOP TRAINING FOR MACHINE TOOL SALESMEN

BY ALFRED A. BERKWITZ[1]

In recent years there has been a great deal written on salesmanship, and the subject has been considered from every angle. But one point is accepted by all writers; namely, that the salesman should have a thorough knowledge of his product. For this reason, most concerns send their technically trained young men to the factories for a varying period of time as a preparation for the sales department. There is no standard method of training in use among the different concerns. Some require the shop training before the men enter the sales offices; others prescribe a short term of office work before the men go into the shops. The writer is in favor of the latter method, because the salesman learns the methods of doing business, and, furthermore, at the end of this period knows just what he needs to learn while in the shops.

It is highly advisable that this shop training should be concentrated, and not too long. The average technically trained man does not take long to master as much of the shop practice and machine construction as he will need. Furthermore, since a salesman must know men as well as methods, he should be allowed considerable freedom while at the plant. The man who spends several weeks over a drawing-board detailing some gear or lever learns a certain amount, perhaps; it is certain, however, that he does not learn nearly as much as if he had spent the same length of time as recommended in the following. From the writer's experience as an instructor (secondary school and university), the method here outlined presents a logical means of obtaining the necessary shop training, in a concentrated manner.

After the salesman arrives at the plant, the first few days are spent in becoming acquainted with the various officials and inspecting the whole plant, in a general manner. Much depends on "getting in right" at the start. The serious part of the work then commences, and the first machine is taken up. Let us suppose that it is a boring mill. The writer frankly confesses that beyond the fact that a boring mill consisted of a revolving horizontal table and a stationary tool, to him the rest of the machine was simply a series of levers and covered boxes containing numerous gears, clutches, etc. A nearly completed mill in the shop should be chosen for the first inspection. At the outset, one fundamental principle common to almost every machine tool should be understood: the power applied to the machine is divided into two main branches, the driving of the tool or table, as the case may be, and the feeds. In the case of the boring mill, the power is traced from the belt or motor through the various speed gears and back-gears to the pinion which drives the table. The writer strongly recommends sketching these gear trains on a pad; the very act of putting a construction on paper helps to fix it in one's mind. In the same manner, the feed gearing is traced through from where it leaves the drive gearing to the final tool movement. If any part of the machine is inaccessible, the assembling benches should be visited and the desired part inspected in detail. In this way, a fairly good understanding of the function of each lever and clutch is obtained.

The next step is to hold an informal consultation with the designer of the tool. With his assistance, a number of assembly drawings of the machine in question should be selected from the files; ordinarily about four or five will be sufficient to show the general construction. It is advisable to choose only such drawings as will show the various parts of the machine assembled; too many detailed drawings are likely to cause confusion. These drawings should be gone over carefully with the designer and anything not thoroughly understood should be discussed. Blueprints should then be made and kept in the salesman's files for reference.

The question may arise as to the advisability of looking over these drawings before making the preliminary inspection of the machine instead of afterward. The writer believes that the latter method possesses several advantages over the former. In the first place, it is much easier to see a thing in reality than on paper. Then, in going over the drawings, the designer will usually refer to various parts of the machine, presupposing a slight knowledge of its construction on the part of the salesman. If he has not this knowledge, constant explanations are required which may be very annoying to the designer. On the other hand, if the main features are understood, it is much easier to grasp the inter-relation of the various mechanisms, especially if the tool is complicated. In addition, many good talking points on the various constructions can be obtained, since the salesman's attention is not absorbed by the mastering of details, and more time is had for generalization and for comparison with other makes of machines.

After the drawings have been studied, it is a good plan for the salesman to make a brief tour through the shop with the designer. By this means, every point discussed in the conference is brought home by actual inspection and the design of the whole machine is firmly fixed in mind. The concentrated study of that machine may now be considered as ended, though, from time to time, inspections will be made of various types in different stages of erection. Furthermore, it is an excellent plan for the salesman to have frequent chats with the men who operate these machines in different parts of the plant. Much valuable information regarding the output, mode of operation and special advantages may be obtained from them. This is of service if the salesman's prospect is a "mechanical" man—one who is appealed to from the operator's viewpoint.

As the salesman, both in his training and afterward, is brought in contact with numerous workmen, foremen, and designers, as well as other officials, the smoother and the more cheerful he makes his path, the better and more successful will be his results. Due either to experience or to prejudice, many foremen and designers who have worked up from the ranks have no use for a college-trained man. Although the greater part of this prejudice is unfounded, there are occasionally good causes for it. Most technically trained young men emerge from college with a large quantity of self-confidence, a good thing in itself. However, some are inclined to assume a condescending manner toward a man whose education has been obtained in the school of hard knocks. The latter are rather sensitive on this point and readily detect and resent any attempt to display superior knowledge. It is always well to listen to their side of the story, remembering that everything they state is from experience; if they are wrong, it is usually possible, by using a bit of tact, to show them the correct solution or method. If they are correct, their methods should be warmly commended; a word of praise here and there is a great lubricating agent. The average modern workman has a profound respect for education. Anyone who is interested in his welfare is his friend.

After a machine has been studied in the foregoing manner, it is a good plan for the salesman to accompany the inspector on his final tests. Much can be learned from him. He usually has had extensive experience and possesses a veritable storehouse of anecdote and history concerning various machines and their development.

Much the same procedure is followed with each machine, although, after becoming more experienced, the salesman can carry on the study of two or even three machines simultaneously. However, it is better to concentrate on one machine at a time, if the available time will permit. Along with his practical training, the salesman should keep up an extensive technical reading in all lines. A knowledge of present conditions and of the trend of improvement and development in his field is of great importance. A further aid is the inspection of any outside plants within convenient distance. On these visits the salesman becomes acquainted with the conditions which his machines have to meet, the methods of manufacture, and the requirements upon the machine-tool builder. He also learns the demands of the users of machine tools. He should transmit this information to his shops, and if he suggests any improvement of value, it should be carried out. Frequently, though, a salesman will offer a machine with certain attachments which are of little service to the user but are a source of trouble to build. If the salesman knows his machines thoroughly and also his own factory conditions, he can often guide the purchaser in his demands.

[1] Sales Engineer, Niles-Bement-Pond Co., 111 Broadway, New York City.

GAGING AND INSPECTING THREADS—2

DEVICES FOR TESTING LEAD OF TAPS AND SCREWS

BY DOUGLAS T. HAMILTON [1]

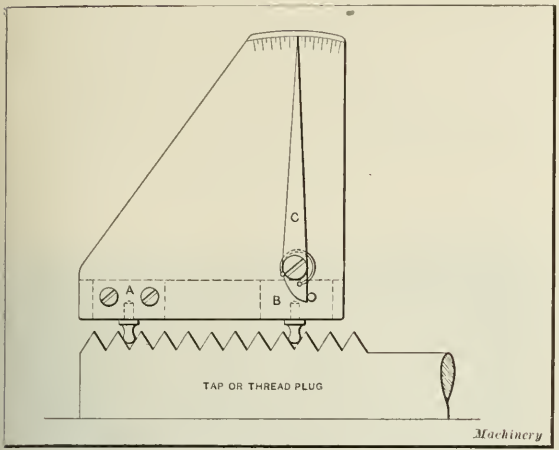

Fig. 16. Simple Device for testing Lead of Taps and Screws

WHILE the pitch of a screw or gage bears a definite relation to the pitch diameter, these two elements are generally tested separately, although, as will be subsequently described, devices are made for testing both at the same time. This is only done, however, when it is desired to make parts, such as screws, etc., interchangeable, and not when producing gages.

Simple Device for Testing Lead of Screw Threads

Fig. 16 shows a simple device which is used as a comparator for testing the lead of taps and screws. It consists of a fixed block *A* and a sliding block *B* held in a frame as illustrated. The blocks are provided with pointers having ball points. The sliding block operates an indicating needle *C* which, on a magnified scale, indicates the error in lead. The manner in which this instrument is used is as follows: The position of the pointer on the scale is noted when the instrument is brought in contact with a standard plug that engages the ball point; the free block *B* adjusts itself to the thread into which its point enters and carries with it the needle *C*. Next the tap or screw to be tested is placed in position against the device. If the lead of the screw or tap is correct, that is, if it is the same as the standard, the pointer will occupy the same position on the scale as it did when brought in contact with the plug. If the tap or screw is long or short in lead, the pointer will show the amount by its movement either to the right or to the left. The circular arc of the scale is generally graduated to read to 0.001 inch.

Indicating Comparator for Testing Lead of Taps and Screws

A somewhat more elaborate device for testing the error in lead of taps and screws is shown in Fig. 17. In this, one ball point *A* is fixed and is mounted in slide *B*, which is operated by a knurled-head screw *C*. This ball point *A* may be screwed into any of the holes *D* which may be ½ inch apart. The other ball point *E* is inserted in a movable block *F* mounted on ball bearings. This block is connected, through lever *G*, with the indicator or sensitive gage *H*, which is so arranged and graduated that each thousandth inch can be easily read. When the standard plug is placed against the device, the ball points enter between threads the same as in the device previously described, and slide *B* is adjusted by the knurled-head screw *C* so that the indicator points to zero. When the screw or tap to be tested is placed against the ball points, any error will then be apparent by the motion of the needle.

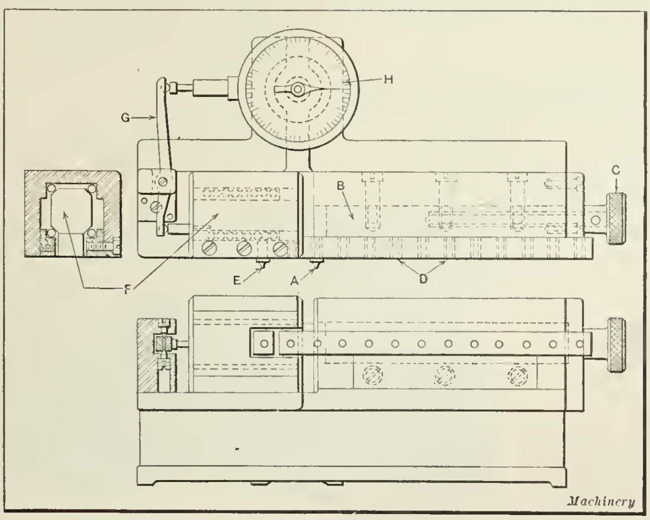

Fig. 17. Indicating Comparator for testing Lead of Taps and Screws

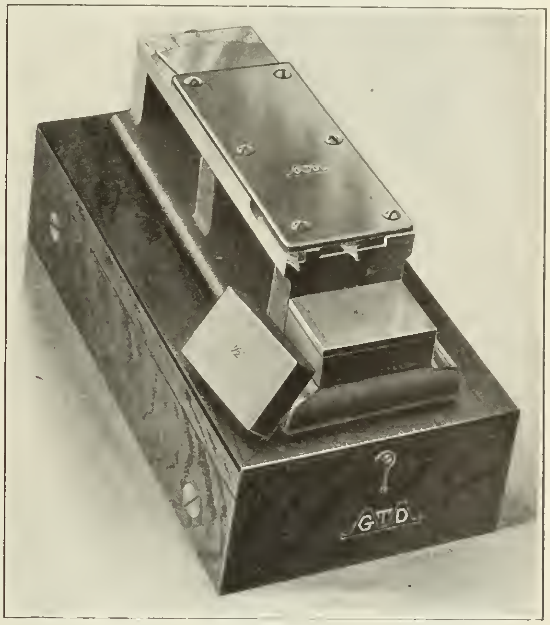

Fig. 18. Wells Bros. Rapid Screw and Tap Lead Tester

Wells Indicator for Testing Lead of Screws and Taps

A simple but effective device for testing the lead of screws and taps is shown in Figs. 18 and 19. This device is made by the Greenfield Tap & Die Corporation, Greenfield, Mass., and as shown in Fig. 18, comprises a base carrying one fixed and one movable pointer. These pointers are made to enter the threads of the screw, as shown in Fig. 19, the indicator previously having been set to zero by means of a reference plug. In using this device, the screw is simply pressed against the points and any deviation from the correct lead is shown by the indicator in thousandths inch. A set of steel blocks furnished with this device permits of the rapid testing of any size screw. The blocks vary in thickness, thus en-

[1] Address: Fellows Gear Shaper Co., Springfield, Vt.

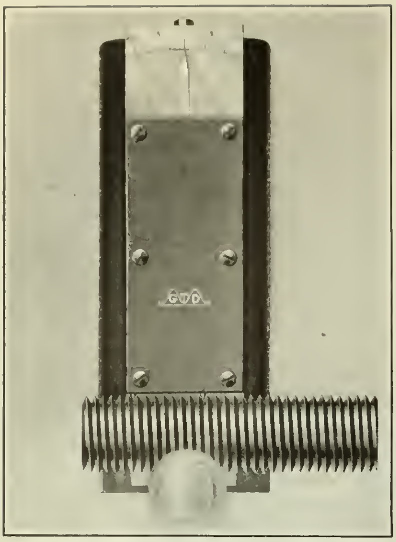

Fig. 19. Indicator shown in Fig. 18 in Use testing Lead of Screw

abling the screw to be placed at the proper height so that the points will come in the center or on the axis of the screw. The points are removable so that they can be replaced when they are worn.

Wolfe Dial Indicator for Testing Lead of Taps

A dial indicator known as the Wolfe indicator, which is particularly adapted for testing the lead of taps, is shown in Fig. 20. It can be used for testing any screw or tap having a length of one inch or more, and an accuracy of 0.0002 inch is said to be easily obtained. The dial of the indicator is graduated to read to thousandths inch and has a range of 0.024 inch on each side of the zero mark. This instrument has two ball points *A* and *B*, which are brought into contact with the thread to be tested; point *A* is movable and point *B* stationary. Point *B* can be unscrewed from its socket and screwed

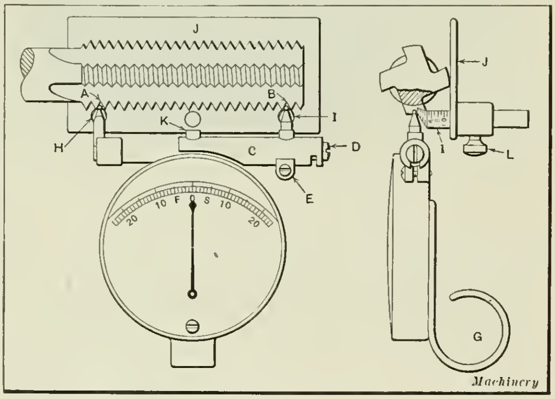

Fig. 20. Wolfe Indicator particularly adapted for testing Lead of Taps

into the socket *K* when a testing range of one inch is desired. Point *B* is held in a sleeve *C* that can be adjusted by screw *D*, the sleeve being held in position by clamping screw *E*. The loop or handle *G* is used for holding the indicator.

In addition to the indicator proper, a centering gage provides a means for enabling taps, screws, etc. to be tested on the center line, thereby insuring the required accuracy. This centering gage can be used on taper as well as straight taps and has a capacity for diameters ranging from ¼ to 1½ inch. The adjustable points on the centering gage are graduated in thirty-seconds of an inch and they may be held in position by thumb-screws *L*.

As the illustration shows, this centering gage also has a main plate *J* against which the piece being tested is held. When using the centering gage the graduated points are set out from the plate *J* at a distance equal to the radius of the tap or screw to be tested. Thumb-screws *L* are then tightened, thus holding the points in the adjusted position. The tap or screw is next placed in the centering gage and is held down on plate *J* and against the points. The indicator, of course, is held in the hand with the second finger through the loop *G*. The gage is brought so that the stationary ball point *B* enters the thread and rests on the flat end of point *I*. The movable point *A* enters the thread and rests on the flat part of the point *H*. The indicator will then show whether the thread is "fast" or "slow" in thousandths inch. If the thread is accurate, the needle will remain at zero. If it is "fast," the pointer will move in the direction of *F*; and if "slow," it will move in the opposite direction.

Lead Test Indicator

Figs. 21 and 22 show a thread test indicator used in the Pennsylvania Railroad shops for testing staybolts, taps, and lead-screws. This instrument comprises a standard on which is pivoted a sensitive spring pointer *H* and a stationary pointer *J*. The latter is mounted on a bar *K* which may be adjusted minutely lengthwise by screw *L*. The indications of pointer *H* are read on segment *M*, the support of which may be adjusted, through the circular dovetail slot, about the center of the pivot of *H* to bring the reading to zero. This adjustment is effected by screw *N* and clamped by screw *O*. Spring stop-screws *P* limit the extreme movement of the needle.

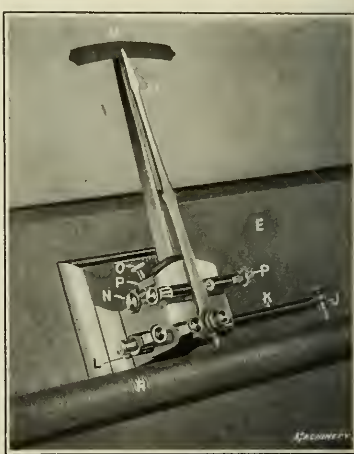

Fig. 21. Lead Test Indicator having Wide Application

In use, the points are adjusted to span a certain number of threads and the instrument is pushed up against the screw to be measured until the measuring points are firmly pressed into the thread. Scale *M* is then adjusted until the indicator points to zero. The instrument is then moved from one place to another along the thread and if the needle points to zero in all positions the thread is uniform.

Another use of this tool is in finding the amount by which the threads are longer or shorter than the true pitch. By this test, the indicator is first set to zero on a reference screw of known accuracy; the screw to be tested is then put in place and measurements are taken at various points along its length. The readings on the dial show whether the pitch is long, short, or regular and by how much. The indicator can also be used for measuring the size of thread at or near the pitch line. The indicating points are balls and various sizes are provided to suit the different pitches and shapes of threads. An

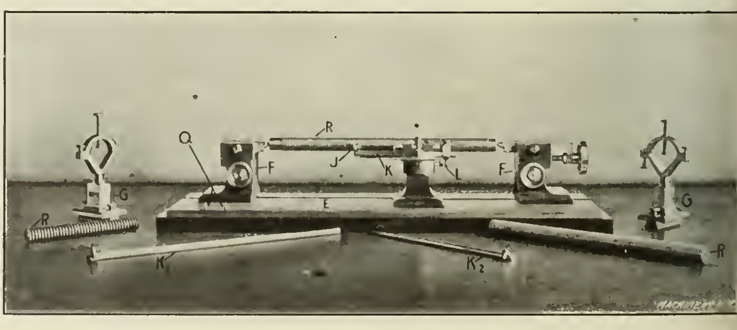

Fig. 22. Indicator shown in Fig. 21 in Use testing Lead of Long Screw

extra set is shown at Q in Fig. 22. Various model screws for comparative measurements are also shown at R, and bars of various lengths for carrying the fixed indicating points are shown at K_1 and K_2. The whole arrangement makes the instrument practically universal in application, since base-plates of any length may be used and the centers or yokes fastened to them at the points required.

Testing Included Angle of Thread

Fig. 23 shows a simple device for testing the included angle of a thread. This consists of a special base carrying two center supports, and a rear support or slide for holding cone-pointed inspection rods.

The procedure followed in using this device is to place the plug to be inspected on the centers, and then locate one of

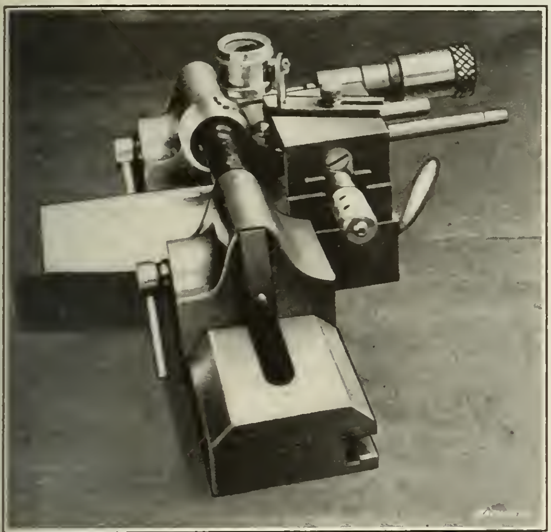

Fig. 23. Device for inspecting Included Angle of Thread

the cone-pointed rods with the carefully ground and lapped point in the space between the threads. A sheet of white paper, for illuminating purposes, is then placed on the base, as shown, and the thread viewed through the magnifying glass. If it is desired to determine just how much the angle is off, rods having points ground to included angles of 60½ or 59½ degrees are used, the angle depending on the pitch of the thread and the tolerances permitted. Usually, however, the thread is tested for "light", and if the cone point does not bear evenly on the angular sides for the depth of the thread it is not passed. By using the two points, which are spaced exactly one inch apart, it is also possible to test the lead with this device.

Limit Working and Inspection Thread Gages

Most of the devices described in the foregoing are somewhat limited in their application and will not be found suitable

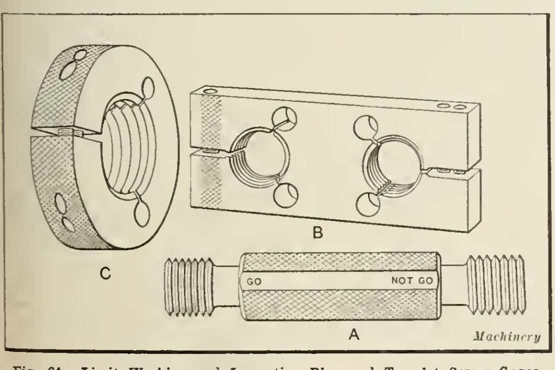

Fig. 24. Limit Working and Inspection Plug and Templet Screw Gages

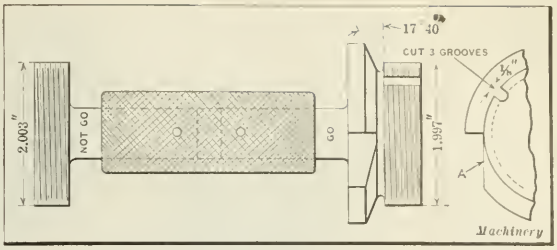

Fig. 25. Double-end Limit Plug Gage having Beveled Shoulder for inspecting Chamfered Thread Hole

when a large number of threaded parts are to be produced within certain limits of tolerances. As a general rule, gages are designed to handle one diameter and pitch of thread. The most common form of limit thread gage is shown in Fig. 24. For threaded holes, a limit plug gage A having two threaded ends, one of which is made to enter the hole and the other not to enter (when the work is satisfactory) is used. For external threads, such as screws, etc., a templet, as shown at B, having "Go" and "Not Go" holes, is used; or for the larger sizes two rings, as shown at C can be employed. The chief objection to these gages is that they do not indicate what element of the thread is in error. For many classes of work, however, they fill all requirements; especially when the necessary care is exercised in producing the tools used in cutting the threads.

The general practice is to use the double-end templet B for sizes up to one inch in diameter; the "Go" end is knurled. For sizes over one inch, two rings, as shown at C, are used. These gages are adjusted to the plug A and are set by means of interlocking screws, which cause the three lands to converge to a common center. For inspecting the U. S. standard

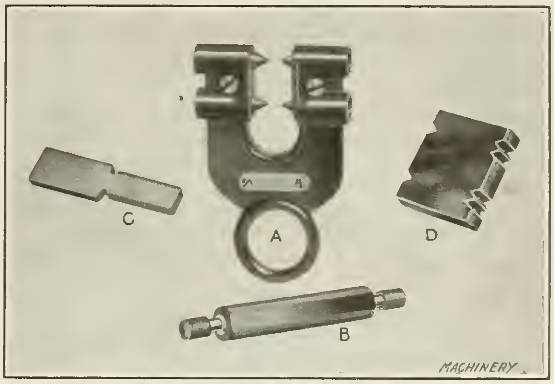

Fig. 26. Limit Snap Gage and Setting Plugs

thread, the threads in the ring and plug have flat tops—one-eighth the pitch—and sharp V-bottoms to clear fine chips, dust, and dirt, and also to insure a bearing upon the angular sides of the thread.

In cases where the threaded bushings, sockets, etc. are made with a chamfered mouth, the "Go" end of the plug gage, as shown in Fig. 25, is made with an enlarged shoulder, the front face of which is beveled to the angle required. This shoulder is then cut away, as shown at A, to provide a means for inspecting the accuracy of the angle. The threaded part has three grooves to collect fine chips and dirt.

Limit Snap and Plug Gages for Threaded Work

A limit snap gage for threaded work, which is manufactured by the Greenfield Tap & Die Corporation, is shown at A in Fig. 26. This gage is used for testing the pitch diameter of screw threads, and is provided with hardened cone points, carefully ground to the angle of the thread wall. The points are not placed directly opposite each other, but are offset an amount equal to one-half the pitch. The cone points are adjustable and are set by locking screws, which are sealed by the inspector after he has checked the gage. B shows a setting

plug that is similar to the plug shown at A in Fig. 24 and is used for sizes up to ¼ inch. C is used as a setting plug for sizes from ¼ up to 3 inches; and D for sizes from 3 inches up.

Fig. 27 shows the snap gage illustrated at A in Fig. 26, held in a stand and used for the rapid inspection of screw threads. This illustration shows clearly the advantages of this gage. At A, the screw being tested is too small and has passed both sets of points; at B, the screw is too large and will not pass the upper or "Go" points; while at C, the screw is just right, as it has passed the upper points and is hanging on the lower ones.

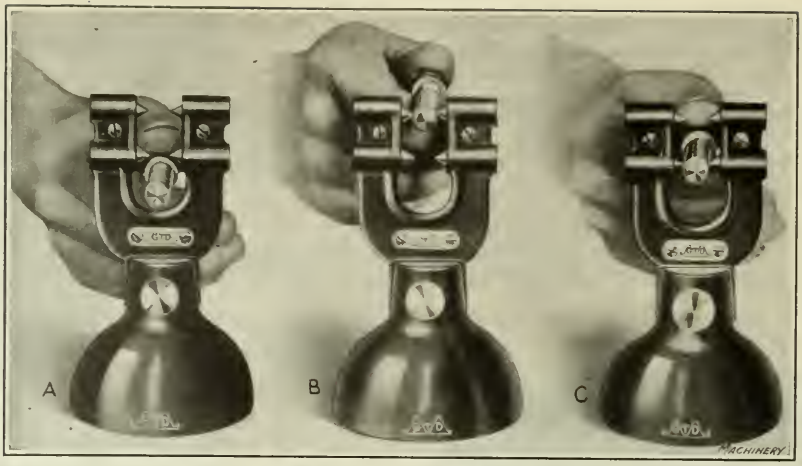

Fig. 27. Applications of Limit Snap Gage shown in Fig. 26

Limit Snap Gages for Testing Lead and Pitch Diameter

While the cone points in the gage shown at A in Fig. 26 are set off an amount equal to one-half the pitch, they do not cover a sufficient number of threads to detect errors in lead.

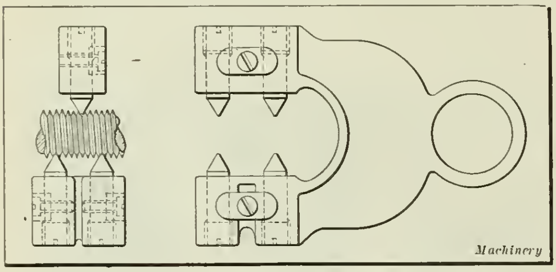

Fig. 28. Limit Snap Gage for testing Lead and Pitch Diameter

A modification of this gage is shown in Fig. 28. This is provided with two sets of three points, making six cone points in all. The points held in the lower jaw of the gage are spaced approximately ½ inch apart, depending on the pitch of the thread, and the upper points are offset from a line located equidistantly between the two lower points an amount equal to one-half the pitch. By the use of this gage it is possible to detect errors in lead which would prevent the screw and nut from going together as they should.

Another gage of the snap type, which inspects both the lead and the pitch diameter of a screw thread is shown in Fig. 29. This gage comprises a frame carrying three conical points B, C and E, which are accurately ground to the required angle; the extreme ends of the points are removed so that the points will contact with the sides of the thread. Points B and C are fixed in the lower jaw of the gage, so that their center distance is equal to an exact number of threads representing twice the length of a nut of corresponding diameter. The third point E is held in the upper jaw and is midway between the lower points. All three are set to a known standard. Located opposite the point E is a point F having a flat face A, which is adjusted so that the small cylinder D (which is of such diameter that it will touch the sides of the thread half way down its depth) will just enter the thread of the screw when made to the minimum pitch diameter. In testing, if the screw enters between the points, and the "Not Go" plug D does not, the screw is within the required limits for pitch diameter; any error in pitch is compensated for by the necessary reduction in pitch diameter.

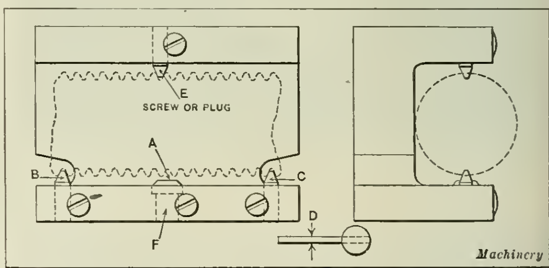

Fig. 29. Another Limit Snap Gage for testing Lead and Pitch Diameter

Indicating Gage for Inspecting Lead and Pitch Diameter

When the volume of work to be inspected warrants the additional expense, an indicating gage is to be preferred to one of the rigid snap type. A satisfactory indicating gage for testing the lead and pitch diameter of screws is shown in Fig. 31. This gage comprises a cast-iron base A to which is attached a fixed jaw B; the movable jaw C is attached to a slide D. Jaws B and C are each provided with two carefully ground and lapped vee projections, which fit in the threads of the screw being tested. The extreme ends of the points are removed, so that the projections will contact with the sides of the threads. The projections on blocks B and C are located exactly one inch apart and one set of points is offset from the other an amount equal to one-half the pitch of the thread being inspected. Slide D is kept in the forward position by an open-wound spring, and block C is withdrawn from contact with the work by handle E. Thus the pressure on the work being tested is that exerted by the spring that holds the slide in the forward position. When being inspected, the work is placed on the hardened and ground block F.

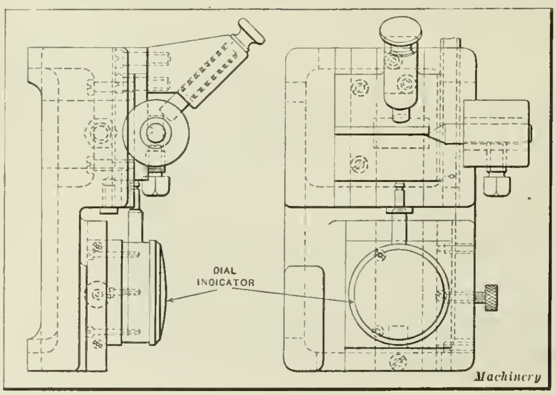

Fig. 30. Fixture for testing Lead of Opening Die Chasers

The indicating mechanism comprises two levers G and H. The short end of lever G contacts with the flattened face of a plug I on slide D.

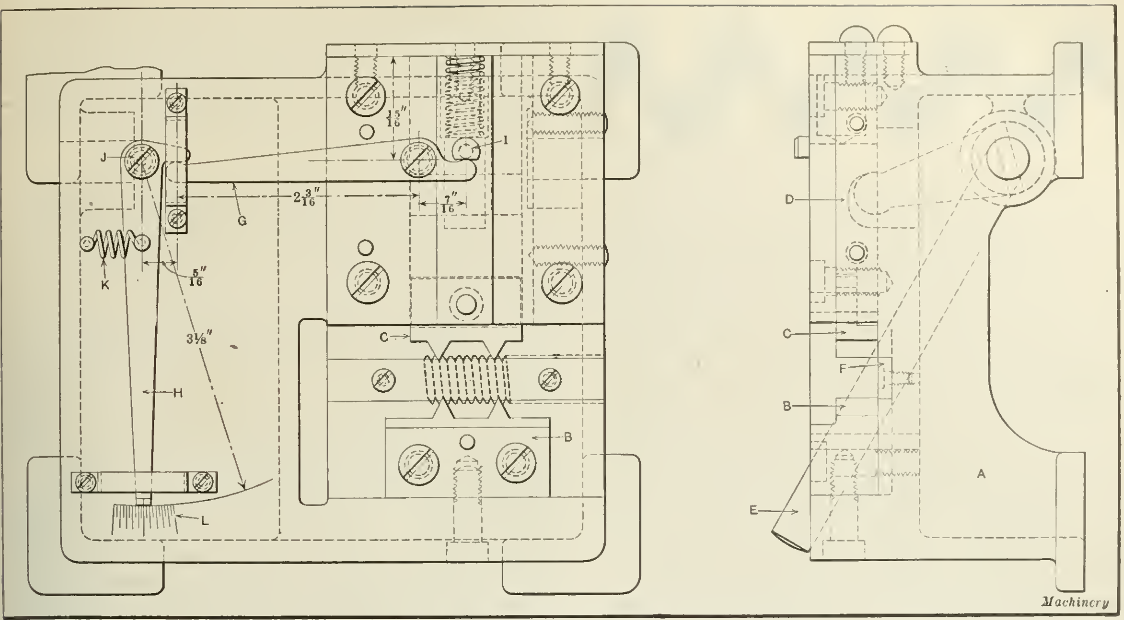

Fig. 31. Indicating Gage for inspecting Lead and Pitch Diameter

Lever H is fulcrumed at the point J and is kept in contact with the long arm of lever G by a spring K. The ratio of the two levers, or the multiplication of the error, is 50 to 1, so that the marks on scale L (which are spaced 0.05 inch apart) represent an error in the diameter of the work of 0.001 inch. With this device it is easy, therefore, to detect errors as fine as 0.00025 inch, although for the average run of work, this degree of refinement is unnecessary.

Inspecting Die Chasers

The extensive use of opening die-heads for the production, in large quantities, of commercially accurate screws, has necessitated, in many plants, the use of fixtures for inspecting the chasers in order to insure that the pitch is within the desired degree of tolerance; also, in straight chasers, that the threaded face is correct in relation to the rear face. One simple but effective device for testing the lead of die chasers is shown in Fig. 30. This fixture was designed for testing the lead and registration of Geometric and Modern die chasers. It consists of a base carrying several slides that give the required movement and an indicator for testing the chaser. A chart is prepared for checking up the registration of the starting teeth on the chaser.

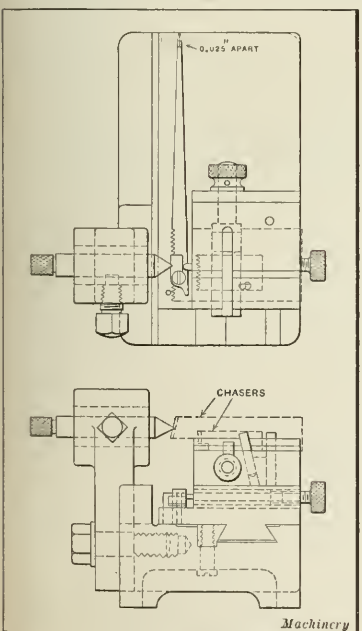

Fig. 32. Fixture for testing Straightness of Opening Die Chasers

In use, the chaser is located by the same slot that locates it in the die-head and, as shown in the illustration, is held in place by a spring plunger pressing upon it at an angle of 45 degrees. The top slide is located by a pointer which is held on a bracket, and meshes with one tooth of the chaser. The spindle of the dial indicator bears against the end of this slide. To test the chasers, No. 1 is set at zero on the dial indicator, and then the chart is used to determine if the other chasers are correct in relation to the first by noting the position of the needle on the indicator as each chaser is put in place.

Fig. 32 shows a fixture for testing the straightness of Geometric and Modern die chasers. In this case the chaser is also mounted on a slide, and a pointer, in connection with a multiplying lever, is used to indicate the distance from the rear face or slot to the pitch line of the chasers. The slide is adjusted to bring each tooth successively in line with the pointer, and then the movement of the indicating lever is noted. This lever is kept in contact with the slide so that any change in the position of the slide for the various teeth in the chaser is multiplied by the indicator. The lower slide is adjusted to bring the pointer in line with the various teeth of the chaser while they are being tested.

Microscope for Measuring Screw Thread Gages

The micrometer caliper with various types of ball and cone points is satisfactory for testing the average screw thread. However, it is not sufficiently fine for testing accurate gages. The Schuchardt & Schütte precision measuring and screw testing microscope, shown in Fig. 33, is intended for making accurate measurements of small objects, and it is particularly adapted for measuring and

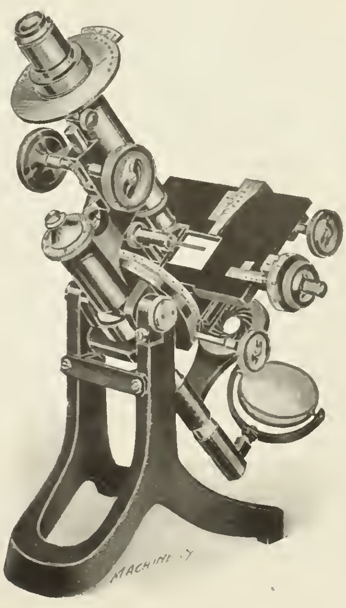

Fig. 33. Schuchardt & Schutte Microscope for measuring Screw Threads

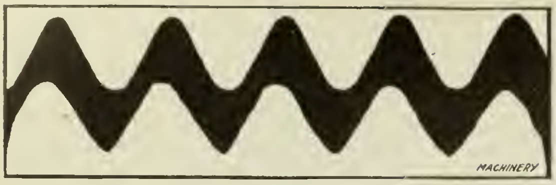

Fig. 34. Comparison of a Screw Thread (Below) and a carefully drawn Screw Thread Outline

checking micrometer screws, dividing scales, standard gages, and a variety of other precision work. The accuracy that can be attained with this machine is such that the length and pitch of a screw can be determined to within 0.00004 inch, the depth of the thread to within 0.0004 inch, and the angle of the thread to within 5 minutes. In making any or all of these measurements, it is not necessary to change the position of the screw or gage after it has been set.

Fig. 33 shows the instrument set up with a small screw in the chuck. In the field of the microscope are two cross-hairs which are used as reference points. In measuring the pitch of a screw, the vertical cross-hair is first brought exactly over the slope of the thread, and readings are taken. A screw is then manipulated to move the object across the field of the microscope until the cross-hair comes in visual contact with the slope on the next thread, and the readings are again taken. The difference between these two measurements represents the pitch of the thread. In measuring the depth of the thread, the horizontal cross-hair is first brought into visual contact with the top of the thread, and the readings are taken. The work is then moved until the horizontal cross-hair reaches the bottom of the thread, and the reading again noted. The difference between the two readings is the depth of the thread.

The field of the microscope can be rotated to provide for measuring the angle between the slope or sides of the thread. For making such measurements the field is rotated to bring one of the cross-hairs into contact with one of the angular sides of the thread, and the readings noted. The field is then rotated until the same cross-hair comes in contact with the opposite angular side of the thread. The difference between the two readings represents the included angle of the thread within an accuracy of five minutes. The object under examination may be inclined to the optic axis of the instrument and the angle of inclination determined. As the object remains in the same plane as the axis of rotation, it is not thrown out of focus by the inclination of the instrument.

Projection Method of Measuring Screw Threads

A method of inspecting screw threads which up to the present time has not been extensively applied, but which for certain purposes (especially laboratory use) can be used with success, is the projection method. This consists chiefly in comparing a screw gage to be tested with a carefully drawn diagram magnified about fifty times. The gage to be tested is mounted on a suitable fixture, and is then illuminated by the aid of a small arc lamp and condenser. Carefully arranged lenses are then used to throw a magnified image of the thread on the chart or screen, and observations made on the diagram. The lenses should be chosen to produce a uniform magnification over the entire field, and distortion should be eliminated. As the screw carries a diagram of the thread which is magnified fifty times, it is an easy matter, as shown in Fig. 34, to compare the image projected with the correct thread profile. In Fig. 34, the image has been lowered somewhat to increase the depth of the shadow, and it can be seen that the thread on the gage is comparatively rough and incorrectly formed in places. Another method of comparison is to project, simultaneously, the image of an accurate screw placed beside the one to be examined. The difference between them is easily detected. This method applies to male gages and screws only, as it evidently would be impossible to project the thread in a ring gage or nut in this manner.

Conclusion

In closing this review of the methods of gaging and inspecting screw threads, it must be admitted that this subject is far from being satisfactorily settled. There has been, however, an awakening on the part of manufacturers to the advantages of gaging methods properly applied and there is no doubt but that this subject will receive a great deal of study and investigation in the next few years. It is to be hoped that the results of these investigations will be published for the benefit of manufacturers in general.

* * *

ELECTROPLATING GAGES FOR WEAR

One of the serious problems of interchangeable manufacture is the maintenance of gages. Obviously a gage, whether external or internal, begins to wear with the first piece gaged, and wear is continuous with use. The question is what limits shall be put on gage wear which, when exceeded, will require them to be returned to the tool-room for readjustment? If the limits established are very narrow, the cost of inspecting gages and restoring them to their original condition will be very heavy; and on the other hand, if the limits are wide, the gages will eventually become so worn that their usefulness as a means for maintaining standards will be lost.

The electroplating process presents a means by which gages may be restored to their original condition at a minimum cost. The process may be used also as a check on the wear by which any user will be apprised of the fact that the gage has worn below standard. Suppose a hardened steel plug gage is electroplated with a copper film 0.00005 inch thick. The total increase in diameter of the plug gage is then 0.00010 inch. Suppose we establish this as a limit of wear of the plug gage. Then the limit approximately is reached when the copper film is worn through and the hardened steel becomes visible.

The restoration of the gage to the original size is merely a matter of suspending the gage in the electroplating bath a certain number of minutes, the time depending on the thickness to be deposited, the voltage and other factors affecting the deposition of the copper. All these factors may be accurately determined and the electroplating battery may thus be employed as an accurate means of building up to exact size.

The objection to this system that doubtless will be urged is that copper is a soft material and wears rapidly, but a *thin* film of copper deposited on hardened steel wears comparatively slowly, as experience has demonstrated. The scheme is one that is worthy of earnest attention of gage-makers, toolmakers and others concerned with the manufacture, use and maintenance of gages used in interchangeable manufacture.

* * *

COMMON SALT FOR PRESERVING WOOD

BY MARK MEREDITH[1]

Many methods are in use for preserving wood and preventing it from rotting. Most of these, such as chloride of zinc and the sulphate of copper treatment, are comparatively expensive, and are applicable therefore only to the better classes of wood; moreover, they can only be used by the large industrial works, and are not suitable for private use. It has now been discovered that ordinary common salt is an excellent substance for impregnating wood and for preserving it against decay. The effects of the action of common salt on wood were first noticed at the Great Salt Lake in Utah. It was observed that the sleepers of a railway line which was continuously washed by the very salt waters of the lake needed no renewal, and after forty-three years were in a far better state of preservation than oak sleepers impregnated with expensive chloride of zinc after fourteen years, when the latter required renewal. In consequence of this discovery, numerous and comprehensive experiments have been made to ascertain the effect of salt impregnation of wood, and it is reported to have been entirely satisfactory. It has been determined that a solution of common salt kills all the bacteria of decomposition and prolongs the life of the wood for practically an unlimited period. The discovery should have a tremendous effect on the wood industry, especially in connection with ships, railways, house-building, etc.

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DIE-FORGING TROUBLES[1]—1

FIELD FOR DIE-FORGINGS AND METHODS OF MAKING TO AVOID COMMON TROUBLES

BY JOSEPH HORNER [2]

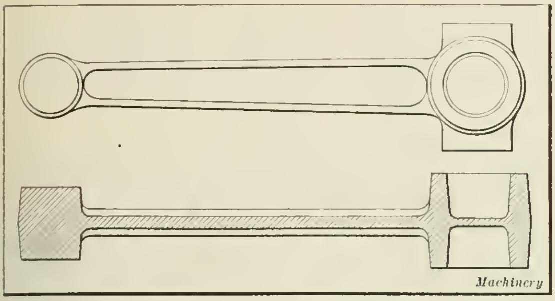

Fig. 1. Automobile Connecting-rod which illustrates Differences in Dimensions of Adjacent Parts

NOTWITHSTANDING the vast extension in the practice of die-forging during recent years, the results, in some cases, have caused disappointment. Many of the forgings have been found unreliable, likely to fracture, inaccurate while expensive, and lacking in the qualities of hardness, strength or toughness. Nor do these results cause much surprise to men familiar with the behavior of the ferrous metals and alloys. Many of these troubles arise from either ignorance or neglect; yet the purchasers are largely to blame for they often compare prices only. Sometimes the stampers are men who have not had the earlier and valuable training of working smiths; in other cases the heat-treatments suitable to the carbon and alloy steels are neglected.

Because it is always possible, under a hammer of sufficient power, to stamp any shape whatever from a white-hot piece of metal, the practice has grown of stamping many intricate and disproportioned shapes from a solid lump without the preliminary bendings, upsettings and fullerings that the smith performs at the anvil. Often this treatment is correct and economical, but frequently certain factors are ignored, such as fiber, proximity of heavy and light sections, deep ribs, sharp bendings and parts tied to each other without freedom to shrink. The smith at the anvil does not overlook these factors because early in his training he learned that such neglect will cause failure. Besides, he works largely in wrought iron, and wrought iron is just a bundle of fibers—crystals elongated by rolling—sometimes mixed with layers of dirt and scale, and the difference in strength with and across the grain amounts to several tons per inch. The same is not true of mild steel, though some fiber is developed by drawing, and in pieces where strength is required, direction of fiber should be taken into consideration.

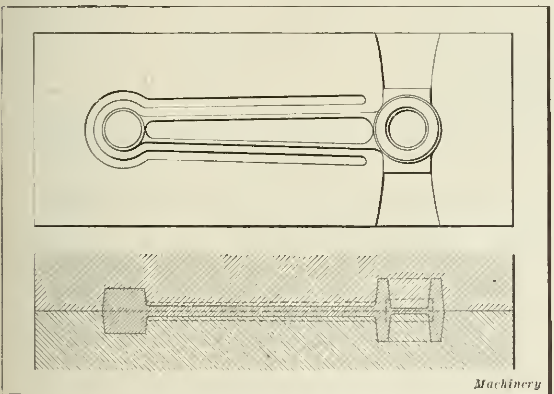

Fig. 2. Dies for forging Connecting-rod

Another cause of trouble is the large and rapidly growing use of the numerous kinds of alloy steel. There is no lack of information concerning the heat-treatment of these, but this treatment is frequently ignored, being regarded as a matter of lesser importance or one which involves too much trouble and labor. Alloy steels which are suitable for one class of forgings are unfitted for another.

Comparison of Forgings of Malleable Cast Iron and Steel Castings

Much the same conditions obtained when malleable cast iron and steel castings were first used. Adjacent parts were improperly proportioned, the effects of shrinkage stresses were not sufficiently appreciated, and heat-treatment (annealing) was imperfectly done. As a result both malleable iron and cast steel were tried and then discarded for a long season. Nor has the prejudice against steel castings been wholly removed. There seems to be no difficulty in obtaining heavy steel castings that are sound and to dimensions, but relatively few firms have equipped themselves to provide small castings, of a few ounces or pounds weight, that are sound, have minimum allowances for machining, and are of correct uniform thickness and homogeneous throughout. Firms who must have these may find it profitable to install a small converter plant, and by experimenting, find the solution of this problem. There are many parts now commonly forged, of which levers are typical examples, for which sound steel castings would be as suitable; perhaps more so in some cases, because castings possess greater rigidity.

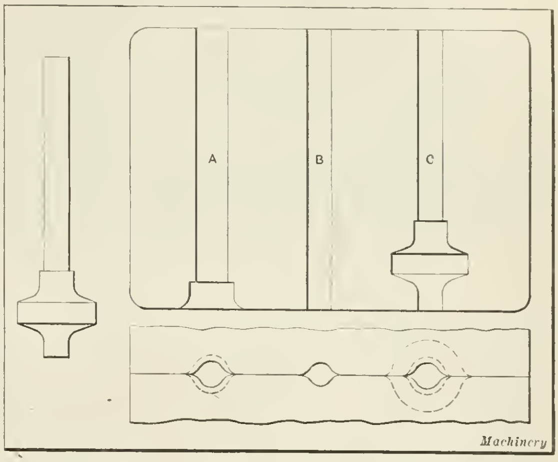

Fig. 3. Valve Stem Fig. 4. Dies for forging Valve Stem

The subject of forgings versus castings is a live one. Forgings are frequently more homogeneous than castings; that is, they are free from blow-holes, a matter of much importance when tooling has to be done. Hard spots and blow-holes play havoc with delicate tools. Besides, cored castings are very likely to turn out with unequal and variable thicknesses and this increases the difficulty and cost of machining. This lack of uniformity in thickness is of great importance because of

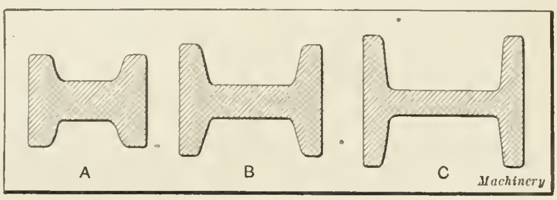

Fig. 5. Stages of Lever Forging

[1] For information on drop-forging previously published in MACHINERY, see "Impressions for Bosses on Drop-forgings," November, 1913; "String Drop-forging," December, 1912; "Dies for Drop-forging a Crankshaft," October, 1912; "Making Duplicate Drop-forging Dies," August, 1911; "Drop-forge Die Sinking," July, August, and September, 1911, and articles referred to in connection with the first installment.

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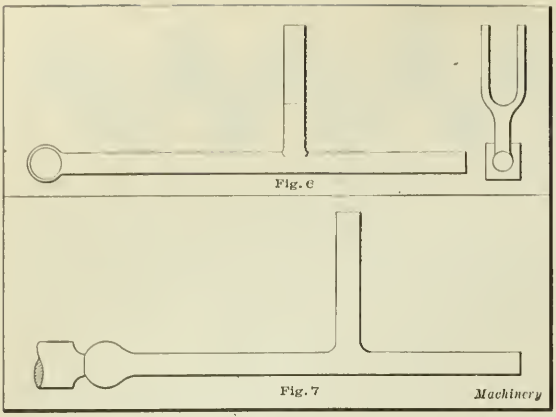


Fig. 6. Making a Wrought-iron Rod with Fork at Right Angles
Fig. 7. Completed Steel Rod

the growing practice of holding pieces of repetitive work in jigs and fixtures. The facility with which this is done is hindered by variations in the dimensions of the pieces. This trouble often determines a decision in favor of forgings over castings. In addition, when dimensions are variable they are uncertain. Corresponding parts that are thicker in one casting than in another, require tedious readjustments of give-and-take settings. These are expensive to make and are fre-

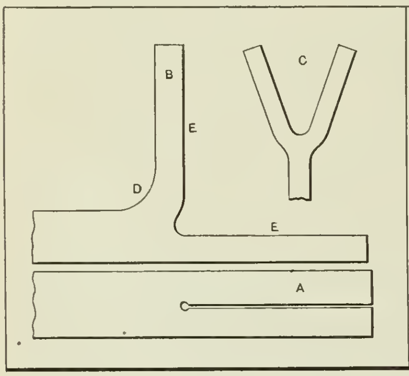


Fig. 6. Making a Steel Rod with Fork at Right Angles

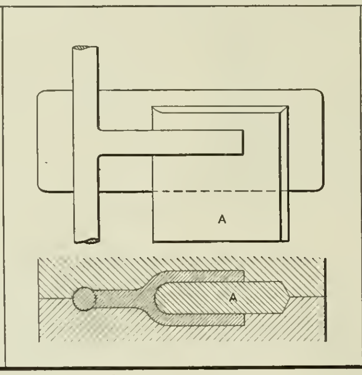


Fig. 9. Dies for Forked Part of Rod

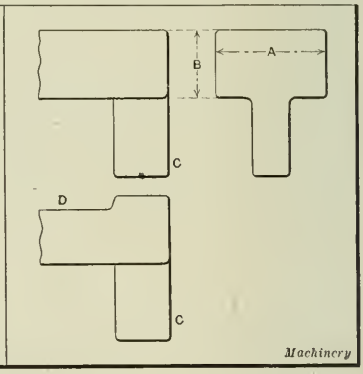


Fig. 10. Forging Boss from Rectangular Rod

quently rejected, after some of the tooling has been done.

Malleable cast iron suffers by comparison with cast steel, because its tensile strength, rigidity, and hardness are lower. It is therefore not a desirable material to use for levers, or indeed for any parts that are subjected to severe stress and wear. But it is suitable for hubs and for axle-gear cases and similar parts. Good malleable castings are the result of a careful grading of iron, in the first place, and an equally careful annealing. It is for this reason that deliveries must always be delayed from three to four weeks after the castings have been turned out of their molds.

Die-castings have not competed seriously with forgings, or with castings in steel and in malleable iron. Being made of soft alloys, they are not suitable for parts that require much strength or are subjected to rapid wear. They are cast to fine limits of dimensions and are beautifully finished, but until they can be produced in the harder materials they cannot compete with die-forgings.

Troubles Due to Difference in Dimensions of Adjacent Parts

Considerable fault has been found with some classes of die-forgings, but a study of the reasons for the defects will show the evils that ought to be avoided. The study, however, should begin with the ordinary products made from mild steels, for the difficulties are accentuated when alloy steels are used.

The principal troubles that arise, and that are fruitful in evil results are, first, large differences in the dimensions of adjacent parts, deep sections, and acute changes in direction, as sharp bends or offsets. In a sense these are related to each other, because in each case the proper treatment is related to the character of the material being molded. When heated to nearly the welding temperature, steel is plastic; that is, it flows and takes the course of least resistance—develops something of a fibrous character. Yet it offers internal resistance to forces acting upon it, and is over-stressed if these forces are excessive. Some of the lesser stresses may be removed by subsequent annealing, but they may be of too violent a character to respond fully to such treatment. The anvil smith understands these facts and brings his practice into harmony with them. He cannot well injure a forging that is being shaped on the anvil, but harm may easily result under the blows of a power hammer or the squeeze of a press. The injury, therefore, which metal often suffers in mechanical forging is seldom inflicted at the anvil.

In many instances where welding would be the method selected as suitable at the anvil, the article is stamped solidly and weldless under the drop-hammer. This is often better for the forging, particularly when it is made of steel, which does not weld quite so reliably as iron. But on the other hand, to stamp from the solid may result in the production of a weak forging because of short fiber. This, though a nearly negligible fact when mild steel is being used, is of importance when wrought iron is under treatment; indeed with the latter material, slender parts must often be bent and forged or else attached to adjacent parts with welds.

Differences in the dimensions of adjacent parts may seriously

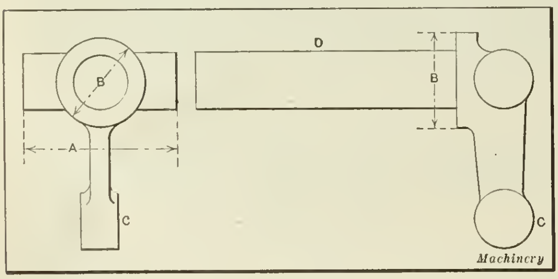


Fig. 11. Rectangular Bar that is rough-forged with Steam Hammer

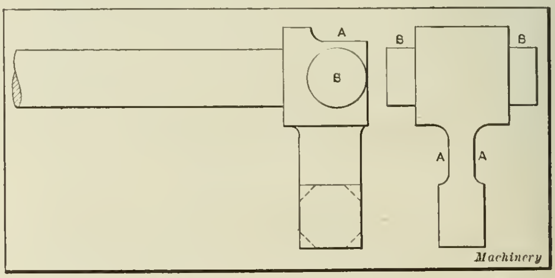


Fig. 12. Rough Forging partly brought to Form with Fullers and Swages

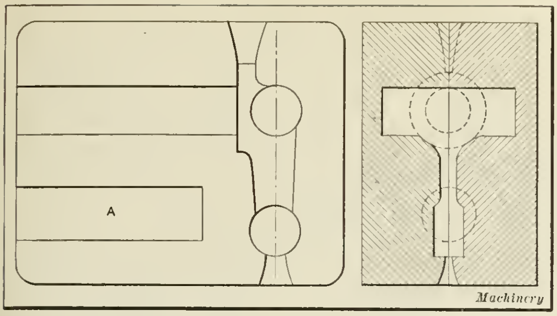


Fig. 13. Finishing Dies for Piece shown in Fig. 12

diminish the strength of forgings in which they occur. Take, for example, an automobile connecting-rod, Fig 1, which has two solid lumps at the ends, connected with a relatively slight web or shank. The web must be reduced—drawn down from a lump which is somewhat larger than the dimensions of the larger capped end. This forging is also typical of many double-ended levers and similar objects, and when the material is of a fibrous character, its quality is improved by the work done upon it at a white or a full red heat. When such articles are produced at the anvil, the thin connecting web is reduced gradually, without suffering injury, by the gentle operation of fullering. When a power hammer is available, the fullering is often done under that, the tup taking the place of the sledge. In each case the reduction is gradual and the metal is not stressed.

In marked contrast with this are the results obtained by stamping the same article from a solid lump between dies in one operation. A large quantity of metal is suddenly displaced from the web portion, flowing out into gutters and setting up intense stresses in the places where the thinner metal joins the heavier. This trouble might be avoided by adopting the methods of the smith and making the process a gradual one. This can be effected either by employing more than one pair of dies or by doing some preliminary work at the forge. Each is equally suitable, but when a hammer is available it performs the work more rapidly than the anvil tools. The preliminary reduction can be made by the employment of a fullering tool held in the hand, and moved over the lump on the anvil and struck by the tup; or breaking-down dies may be used; or a very rough reduction can be made in the finishing dies, recesses having been cut in the sides for this purpose. The last method is quicker than fullering with a round-faced tool and cheaper than separate dies for breaking down. This roughing down is done at the side of a die in order to have room for the spreading out of the displaced metal. The forging, after breaking down, is still a mere shapeless lump of metal, but it has undergone its maximum amount of reduction. It may then be finished in the die impressions which impart its final outlines.

When the connecting web is plain instead of recessed, a good plan is to pass the forging through two sets of dies, divided in planes at right angles, the roughing dies being jointed through the axis of the bosses and the finishing dies in the central planes of the bosses and of the web. This increases the cost of the dies, but it improves the product and leaves less metal to be removed by trimming.

Forging Hole in End of Connecting-rod

Another problem in the making of a connecting-rod is the forging of the hole in the big end. The part which is to become the cap is forged solidly along with the big end bearing, and a hole is punched to avoid the cost of drilling and boring through solid metal. Punching this hole displaces a large amount of material and is another possible source of weakness. In roughing out the head, its dimensions measured across are left rather less than those of the finished head to allow for the enlargement which results from punching the hole. As shown in Fig. 2, this is done with punches, which form a part of the dies themselves, standing up for nearly one-half the thickness of the boss from each die. They must not meet or there would be no space left for the fin from the hole, which must occupy the space between the halves of the punch. The operation of punching squeezes the surrounding metal outward to fill the die and to form the outside parts of the big end. Another method of forming the hole is to lay the end in a bolster and punch the hole all the way through with a punch that will clear itself. The punch may be gripped in a withe or laid on the forging and driven through by the tup.

When work is enlarged by punching in dies, the metal is stretched and may be opened out, which is not good for it. To avoid this, the allowances should be so proportioned that the outward pressure exerted by the punch will be counteracted by the sides of the die so that the metal will be subjected to pressure between the punch and the die. It is better that an excess of fin should be thrown out in this operation than that the metal should barely fill the die when finished.

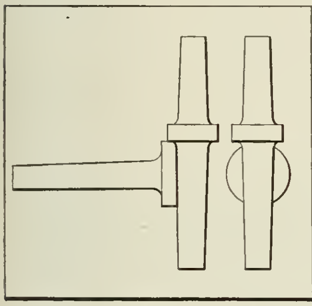


Fig. 14. Forging for Steering-axle Arm

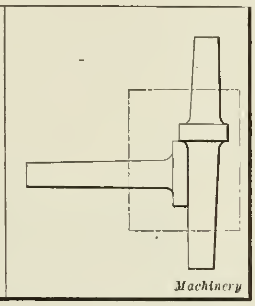


Fig. 15. Relative Sizes of Forging and Material used

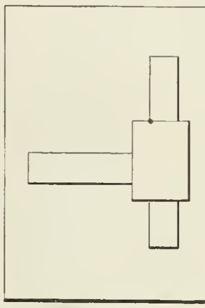


Fig. 16. First Reduction in forging Steering-axle Arm

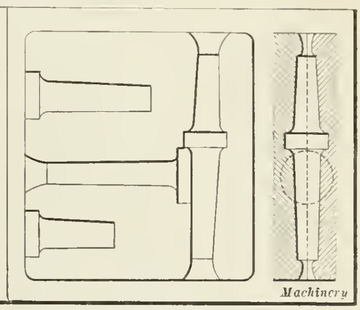


Fig. 17. Dies for forging Steering-axle Arm

When the best results are desired—exact dimensions, freedom from stress, and good finish—the forging should be finished in a second pair of dies. The connecting-rod forging must be first put through stripping dies to remove the fins, reheated, and restamped in the finishing dies. Unless large numbers of rods are being ordered, it is almost better not to punch the holes, but leave the end solid to be drilled, which simplifies the dies, as no projections for the holes are needed.

Forging Articles with Deep Sections

The case of articles having very deep sections, such as large bosses and ribs, is nearly parallel with that of articles having

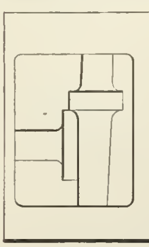


Fig. 18. Dies for Formative Work

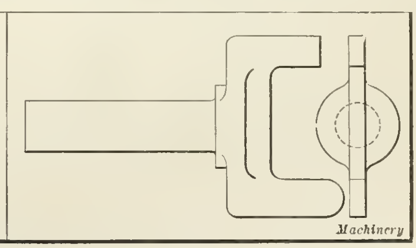


Fig. 19. Forked Forging on which Breaking-down is Necessary

heavy and light sections adjacent. In each case, the metal is distressed by severe work done upon it unless the drawing is done gradually. Bosses on levers and on deep forgings, such as hubs, are troublesome to draw at one heat. In the case of levers the web should be fullered down on the anvil or under the hammer as a preparation for the finishing dies. The reduction can be done either with a fullering tool or in a breaking-down die, the choice depending generally on the number of pieces required.

The larger the dimensions of the forging, the more necessary is the preliminary reduction. In small articles the omission of a preliminary reduction does not matter much, because the smaller mass of metal flows more readily than the larger one, though the relations of thick and thin parts in both small and large castings may be alike. Yet, in good practice, the smallest articles which have much discrepancy in adjacent dimensions are treated in two or more die impressions at one heat in the same dies—breaking down, finishing, and stripping. On the other hand, only a portion of a large forging may be finished in dies. The bosses only may be thus treated, with a small length of the web adjacent, the remainder of the web being finished with a flatter, or under the plain tup of the hammer. A large volume of heavy work is done in this way. Much of this work is also being done in the forging press.

The valve stem shown in Fig. 3 requires preparatory reduction if the valve and stem are formed in one forging; being a small piece it can be dealt with at one heat in one pair of dies. The stem and valve head are roughed down in two successive swaging recesses A and B, Fig. 4, leaving the valve

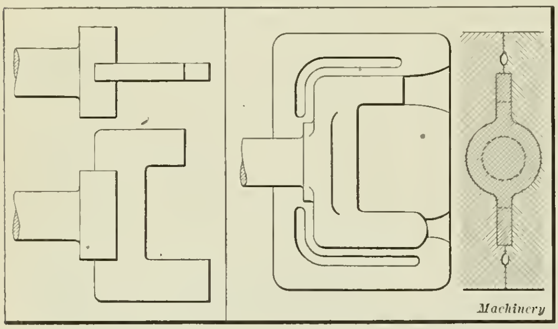


Fig. 20. Work shown in Fig. 19 after First Drawing

Fig. 21. Dies for making Forked Forging shown in Fig. 19

portion thicker or thinner, according as the intention may be to enlarge or reduce its diameter in the final finishing impression C. No stripping dies are necessary in this case. The fin is eliminated as soon as it is formed by rotating the forging in the dies. This is readily done by forging from a bar long enough for the other end to be used as a porter.

Deep ribbings on webs of levers, Fig. 5, are another source of trouble. Being made, as these levers must be, from a flat bar of simple rectangular section, the pressure required to produce the shape is very severe. To attempt to impart the final section in one heat would necessitate raising the metal to a temperature that might injure it and shorten the life of the dies. If the work is done in successive stages, as shown at A, B, and C, no damage will result because the reduction and the formation will be so gradual. This is the principle applied when rolling steel beams and channels.

Forging Pieces with Sharp Bends

Acute changes in direction, as sharp bends, are found in a large number of forgings. Obtuse angles are tolerable and right angles are bad, but acute angles are a danger. Yet even these last entail no risk if the forgings are made in the correct manner. The controlling factors are the kind of material used, the methods of formation, and the use of connecting radii.

It is always well to regard this class of forgings from the point of view of the smith working at the forge in wrought iron. His method is either to bend adjacent portions or weld

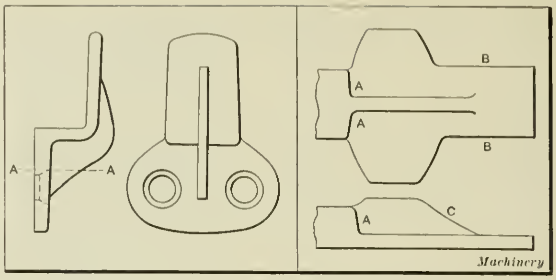


Fig. 22. Hatch Cleat to be forged

Fig. 23. Metal when reduced by Hammer

them; rarely does he attempt to cut out such articles from the solid, regardless of the direction of the fiber. He may do so when dealing with mild steel. He does this partly to preserve the fiber intact in the longitudinal directions, to lessen his labor, and to economize material. But none of these reasons appeals with much force to the die stamper, who is therefore disposed to stamp many articles from the solid which an anvil smith would bend or weld more slowly and more laboriously. As a result, levers with sharp bends are frequently untrustworthy in service. The characteristics of malleable materials are not appreciated so fully by the die stamper as they are by the smith.

On the other hand, steel will endure bendings of a much more severe character than wrought iron will, but it is less reliable than iron when welded. Between these two evils the stamper must take his choice. Aside from unusual cases, welding should be regarded suspiciously in steel, but it is not always unavoidable, and is not so risky in the mild steels as it is in the high-carbon and many of the alloy steels.

In each of the following examples of forgings with sharp offset pieces, a smith working at the anvil would generally adopt welding methods; in steel this welding would not be adopted. The rod shown in Fig. 6, having a fork extending out at right angles, is one of those jobs that may be made with or without a welded joint. The use of this joint would unquestionably be the better method for a forging made in wrought iron. Then the rod can be easily made by preparing the forked piece and uniting it to the rod either with a scarfed joint or a vee. A slight preliminary upsetting of the end to be scarfed would be required and a slight enlargement, by upsetting, of that portion of the rod in the vicinity of the weld. The same method might well be adopted in the case of mild steel. But another way, and one in which welding is avoided, is to fork and bend from a straight piece of rod, as indicated in Fig. 8. The method entails a considerable amount of reduction, but that is a negligible matter when it is done under a power hammer. The bar selected must be large enough to permit of the formation of the two parts E of the fork. These prongs are divided with a hot set, as shown at A, and opened out to a right angle as at B, leaving a good radius behind at D. The piece bent round is then divided similarly, and opened out, as shown at C, and hammered to approximate shape on a form. The rear part of the rod is drawn down next, nearly wholly on one side, either by fullering or directly between the tup and anvil as far as the boss portion, which is left nearly the original size of the bar as shown in Fig. 7.

The forging, however, need not be completed wholly in dies; being of considerable length, the dies would be inconveniently

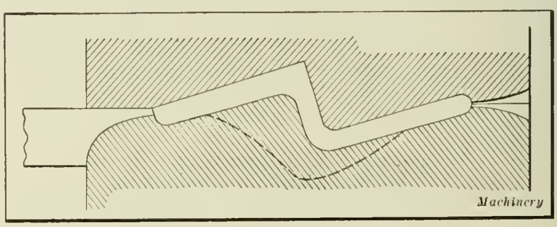


Fig. 24. Dies for dummying Hatch Cleat

massive. It is enough to finish the central part in dies, Fig. 9, and the bossed end in another pair, leaving the stems to be completed neatly in common swages. The top die is removed in the upper part of Fig. 9.

By proceeding in this way, the continuity of the metal is preserved without doing more injury to it than steel can endure. The special precautions which are necessary are to avoid too quick a bending at *D*, Fig. 8, and to punch a small hole when splitting down, as at *A*. Even though a keen angle may be required in the finished forging, it must not be formed in the first place. A large radius or fillet must be left, and the larger the safer; it is easily obliterated in the subsequent forging operations. If this precaution were always taken, there would be fewer complaints of the fracture of forgings of this kind.

This preliminary work is more readily done on the anvil than in dies, and the die-forging, if the numbers justify the outlay, should be performed in two sets of dies, thus relieving the finishing dies of the rather large amount of reduction that would otherwise be necessary. By concentrating the work in one pair, the metal is stressed rather severely and the forgings are of unequal dimensions and variable weights, because the amount of fin squeezed out is

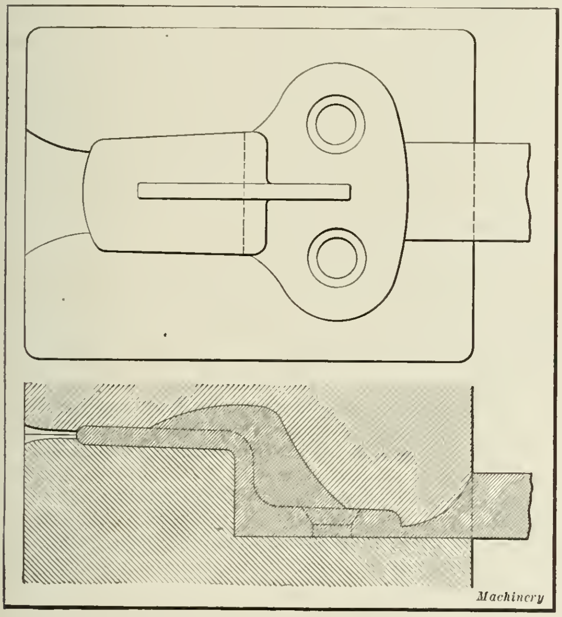


Fig. 25. Dies for finish-forging Hatch Cleat

unequal, as the joints of the dies are thrown apart to variable distances by the fin, which cools and sets quickly. Though this fin is subsequently stripped the forgings are left of greater depth than they would have been if the dies had closed on the joint. But the method to use also depends on the degree of accuracy with which the preliminary work has been performed. In cases, like Fig. 9, where there is a forked end, the fork must be molded over a form block *A* let into the dies. If the fork is of small dimensions, it is generally better to forge the part solid and slot or mill it out in the machine shop.

In the case of a forging like that shown in Fig. 11, where the metal is rather heavy in the locality of the large boss, it is always better to take a rectangular bar large enough to draw down from than to select a smaller one and upset it. The latter method should be avoided when practicable, because it tends to open the fiber. For drawing down, the shape of the original piece, whether square or cylindrical, is of no particular moment, the point being to reduce smaller sections from large ones. In the present case, the forging is made from a piece of metal which need have no particular relation to the finished work. It is best taken, as in Fig. 10, about as thick in one direction as the distance *A* over the bosses, and

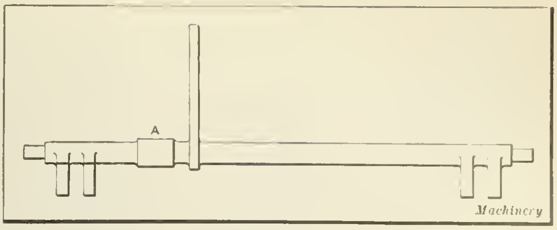


Fig. 26. Weigh Shaft

in the other wide enough to include the boss *B* and the arm *C*. Its length must be sufficient for the stem *D*.

The rough dummying may be done under the steam hammer between tup and anvil, bringing the lump first into the shape shown in the upper part of Fig. 10, and then into that shown in the lower part. Material is drawn down to one side *C* to form the arm, and set down on the other side *D*, after which the stem is drawn out and rounded roughly. The roughing out is continued to form the outlines in Fig. 12; this is done with fullering tools at *A* and with swages at *B*. After cutting off the angles with a hot set, the forging can be finished in dies. These dies are shown in Fig. 13. The recess *A* is used for bringing the stem nearly to the correct size and outline before the final forging in the main recess. The extension of the stem serves as a porter bar, which is severed subsequently with a hot set. The open end of the die permits of the extension of the stem as its diameter becomes reduced. The fin formed at the other portion is squeezed out through the gutters shown. A stripping die may be made or the forging can be taken out by the porter bar and the fin knocked off and replaced for finishing at one heat.

Forging Shapes by Making Large Reductions

The steering-axle arm forging, Fig. 14, is one that would be bent or welded by an iron smith. But as pieces of this kind are always made in steel, and generally in one of the alloy steels, the question of direction of fiber is negligible. Bending and opening out might be done in steel in this case, but it is hardly practicable, because of the collars about the central parts. It is better to take a cubical lump and effect the shaping by reduction. The relation of the lump to the forging is indicated in Fig. 15, and the first stage of reduction in Fig. 16. This reduction is effected without any help from dies, being done directly between tup and anvil, followed by top and bottom swages that impart the circular outlines to the stems. Further reduction is effected in the supplementary recesses in the dies, Fig. 17, following which the entire forging is finished in the main recess. Or if the dimensions of the dies are undesirable from lack of hammer power, only the more difficult formative work need be done, Fig 18, leaving the stems to be finished in tapered swages.

The forging shown in Fig. 19 is made with some preliminary breaking-down from a piece of rod considerably larger than the diameter of the boss. From this, the forks and the stem are produced by drawing. The general plan is shown in Fig. 20. The material is drawn down at the sides and at the front, forming a plain extension large enough to include the horns. The superfluous metal is cut out with a hot set. At the rear,

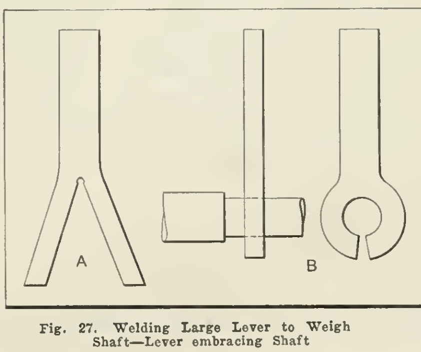


Fig. 27. Welding Large Lever to Weigh Shaft—Lever embracing Shaft

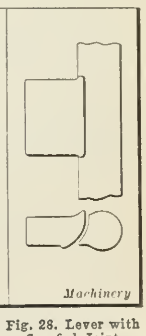


Fig. 28. Lever with Scarfed Joint

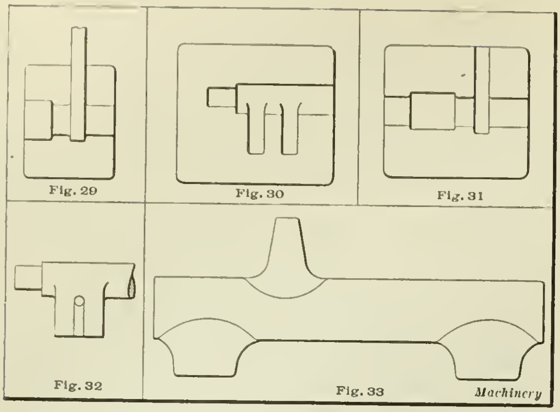


Fig. 29. Dies for forging Lever of Weigh Shaft
Fig. 30. Dies for forging Ends of Weigh Shaft
Fig. 31. Dies for forging Large Lever and Enlarged Part of Weigh Shaft
Fig. 32. Removing Metal from Interspace at End
Fig. 33. Forging Steel Weigh Shaft

the stem part is swaged down. Finish can now be imparted in dies to the boss and forks, leaving the stem to be finished in common swages. The dies are plain, as shown in Fig. 21. Stripping dies may be made, or the forging can be pulled out by using the stem as a porter, the fin being knocked off, and the forging returned for finishing. In neither of these examples is injury done to the material, nor is there any risk of incipient cracks nor of faulty welds.

These preliminary reductions need not all be done at the anvil; all the fullering is performed much more rapidly under a power hammer. One or two minutes will suffice for any of the fullerings here mentioned, and the forgings will generally then be hot enough to be put through roughing dies, if such are used, and stripped, but a second heat will be required for finishing.

Forging Awkward Shapes

The hatch cleat shown in Fig. 22 has no great differences in adjacent dimensions, but the shape is an awkward one to forge by hand under the steam hammer. It is properly a job for drop-forging, which offers no especial difficulties; but the dummying may well be done, without help from dies, under the power hammer. It includes two processes, roughing out the two parts at right angles—the plate and rib—and beginning the bending. The best way to make this cleat is to take a bar or a lump having a cross-section about equal to that of the total area across the widest part *A–A* of the forging and spread the metal out under the hammer, as shown in Fig. 23. The bar should be turned about at right angles under the hammer to deliver a few blows on the flat part and on the rib alternately, spreading both out with a reduction of thickness. This can be done, without any aid, by laying the bar toward one side of the anvil, so that the corner of the tup and adjacent edges will strike in the corners *A*, where the reduction begins. Simultaneously, the sides *B* will be narrowed—not by cutting but by drawing down under the hammer—and the slope of the rib at *C* also imparted similarly, the forging being turned about rapidly so that all the reductions will be made alternately and in succession, in one heat.

Two dies that may be used for this purpose are shown in Figs. 24 and 25. The first is better for facility of forging, but it will not form the screw holes, which the second will do. As an alternative, the first may be used for dummying only, leaving the finish and the holes to be done in the second. The top die is removed in the upper part of Fig. 25.

Forging a Weigh Shaft

The weigh shaft, Fig. 26, is a job for welding if made of wrought iron; if made of steel it may be welded or forged. Welding may be used in the case of mild steel, but if the piece has a large carbon content, and with some alloy steels, welding is not desirable. Then the alternative entails a large amount of drawing down. This is a problem that arises often in shops where hammer power is limited. A smith knows almost as if by instinct, how much his hammers are capable of doing, just as a man working at the anvil only, knows the limits set to hand work with fullers and swages. Insufficient power often causes the adoption of methods that would not be followed or even considered if more power were available. It often means the selection not of the best possible method but of the most practicable. Heavy reductions, though not impossible, are tedious and expensive if done at the anvil or under light hammers. The alternatives to reduction are, then, upsetting, which is limited to small areas, and welding, which is the chief alternative and practically the only one. As long levers with offset pieces are a common type the methods outlined are suitable for work in iron and in steel, both those employing welds and those dispensing with them.

In the method which is best adapted to include welding, a rod of the same diameter as the shaft is taken and the lugs and the lever are welded to it. The slight enlargement at *A* is made by taking a short heat there and upsetting, the bulbous formation that results being reduced in swages. The pins at the ends can be reduced in swages.

The strongest way in which to weld the lever is to make it embrace the rod, as shown in Fig. 27. A scarf, butt, or vee weld should not be used as the surfaces in contact are narrow and it is not desirable to encroach into the rod. An encircling weld gives a large surface; it was formerly much used in welding the webs of wrought-iron cranks to the shafts and pins. To make this weld, the lever is cut and forked, as shown at *A*, and bent around the shaft, as at *B;* a welding heat is then taken over the section and the joint closed with a hand hammer or in swages. The necessary reduction and finish are imparted in swages or dies, which should be made especially to embrace the entire section, force the sides together, and complete the outlines without leaving any correction to be made later.

The short levers near the ends can be welded on, each pair of levers as one piece to be subsequently divided in a slotting machine or with a saw running down to a drilled hole. A scarfed joint, shown in Fig. 28, is most suitable for this place and is preferable to a vee or a butt. The bar must be slightly fullered over the area to be welded, and the lump for the lever will be slightly upset or spread out by fullering in the manner employed in connection with weld joints.

If dies are used for imparting finish, two only need be made, one for the central part—that about the lever, Fig. 29—and one for the two ends, Fig. 30. If the dies shown in Fig. 31 are employed, the preliminary swaging of the enlarged part can be omitted, since the dies embrace the whole of that part of the shaft. The same pair of dies made for one end of the shaft, Fig. 30, will serve for the other. They are shown with the forks out instead of leaving them solid for the machine shop to deal with. This is the better method when dies are used. The metal can be removed from the interspace, in the smithy, by punching a hole at the bottom, as in Fig. 32, and cutting down to it with a hot set; but a neater and less severe method is to punch or drill a hole and saw down to it. If the hole is to be punched, it may be done at the same heat as the welding, using a hand punch with a withe.

If such a shaft is made in steel, which is not so well suited for welding, Fig. 33 shows how it may be made from a solid bar, but at the expenditure of a large amount of labor in reduction. A bar of large dimensions is fullered down heavily at three sections, which correspond with the long lever and the two pairs of forked levers. The distances these are apart are so estimated that when the shaft is drawn down they will occupy roughly their centers on the finished shaft. Consequently, as exact accuracy is not possible, the fullered portions are left as roughed in Fig. 33, until the shaft is brought to its proper diameter and length. Then the formative and corrective work is done upon the lever parts. The amount of formative work entailed is large. Much of it must be done with fullering tools, though some truing is done with sets. More will be saved then by making the final correction in dies similar to those already shown. Roughing and finishing dies may be employed, or one pair of dies with one or two removals to knock off the fin.

Removal of Fins

In all examples of the class of forgings just mentioned, the quantity of fin removed is very large, so stripping dies are desirable. If the attempt is made to forge without roughing dies, the fins must be knocked off with a hammer as they are formed or the forging removed to the stripping dies, and then returned to the forging dies once or twice before the work is completed. In this case, the forging may have to be reheated.

Fins are not only unavoidable but, in moderation, they are desirable because they prevent the damage to the dies which would result from the violent collisions of their faces. They form an elastic cushion between these faces. If expressed in large quantities, as must happen in some forgings or sectional parts of forgings, they are removed once, twice, or three times in successive reductions until that left is very thin. If a thick fin is left at the final correction, the forging will be too thick and over weight. This is often a cause of complaint against drop-forgings and is objectionable because it increases the labor of tooling and interferes with the practice of tooling in fixtures when that method is adopted.

Only when objects are wholly cylindrical in section can fins be reduced as soon as they are formed, by rotating the work in the dies between the hammer blows. In all other cases the forging remains in one relation to the dies and the fin is squeezed out in the joint without being reduced at all. Consequently some spaces must be provided into which the fin will flow. As the faces of the dies at the joint must make actual contact, the provision for the fin is made in a direction away from the jointing edges of the dies. It often comprises a joint, sloped to receive the accumulation of fin. As this leaves only a narrow margin of actual joint faces, the gutter is often preferred. This is a good method to adopt when large amounts of fin are being squeezed out. The gutter is brought moderately near the edges of the die, leaving narrow flat faces between it and the die, and also beyond it.

Associated with these methods, or independent of them, is the common practice of sloping away the faces at the joint where the forgings terminate at ends or at sectional parts. This permits of the flow of metal in large quantities without any obstruction. Enough of an opening must be left for the superfluous metal to get away freely, without too sudden chilling and setting. The same provision often serves for severing the forging from a porter bar, the narrow zone of metal serving like a nick to break off the forging from the porter. The thinning of the fin, generally at the front edges, also enables the stripping to be done easily. It is often knocked off with hammer blows, though stripping dies are better and should be used when the quantity of forgings is large.

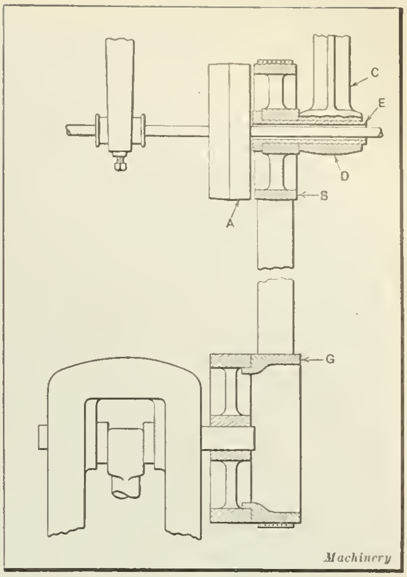
To allow a large quantity of fin to be expressed from forgings is not considered good practice, but there are many exceptional cases where it should be done, especially in the case of very irregular and awkward shapes. It may be true economy when the alternative would entail a large amount of formative work at the anvil, or under the hammer with fullering tools, sets, and swages.

* * *

PRESS-ROOM LINESHAFT IDLER PULLEY

The bugbear of most press-rooms is the throwing off of power press belts to stop the press while the tools are being changed or when the press is not to be used for some time. Where the state law does not forbid it, it is often the practice to throw a power press belt off both the pulleys, and tie a knot in it, allowing it to hang from the lineshaft. This is dangerous, and unsightly as well. In states where the law forbids this practice, a clutch is generally employed. This may or may not be satisfactory, according to the kind of clutch used, and the equipment is rather expensive.

At the plant of the Frank Mossberg Co., Attleboro, Mass., the idler pulley construction illustrated was developed and is being used with marked satisfaction. In view of the difficulty experienced with an ordinary loose pulley on the constantly revolving lineshaft, this improved pulley construction was designed. The pulley *A* is of the ordinary split type and is fixed to the lineshaft. Besides the regular lineshaft hanger shown, another hanger *C* is introduced which is provided with a cap *D*. The cap clamps the split bushing *E* on which the loose pulley *B* is mounted. Pulley *B* is also of split construction. About 1/8 inch clearance between the split bushing *E* and the lineshaft is provided, thus relieving the lineshaft of the pull of the belt when idle. A ring *G* is attached to the flywheel of the press which forms a pulley of sufficient width to permit shifting the belt to the "off" position. The split construction of all the parts in this idler pulley permits it to be erected or taken down without dismantling the lineshaft. V. B.



Press-room Lineshaft Idler Pulley

* * *

OUR COPPER INDUSTRY

With the entire output of the first half of this year sold some time ago, copper producers are working every available source of supply to the limit. As a result, the production of copper in the United States is 700,000,000 pounds a year more than it was in July, 1914. Then the metal was mined at the rate of 1,700,000,000 pounds a year and was sold for 13.75 cents a pound. At the beginning of this year, it was produced at the rate of 2,400,000 pounds a year and was sold for 35 cents a pound, though the average price for the year was 27.2 cents a pound. Because of this increase in value and in production, nineteen of the largest copper companies in the country paid $77,500,000 more in dividends in 1916 than they did the year before. This increased value also made it possible to work sources that could not be properly developed two years ago.

While in time of peace only about one-tenth of the copper produced throughout the world is used for the manufacture of war materials, at least three-fourths of the present immense production is used for war purposes. In addition, the 100,000,000 pounds annually produced by Germany, Austria, Turkey and Serbia are used in the war. However, should the war suddenly end, the demand, and hence the price of copper, would not immediately drop. Europe has been completely stripped of its copper. All cooking utensils, electric equipment, etc., of this metal have long ago been used in the manufacture of materials of war. These must be replaced as soon as possible. Besides, the various nations require large amounts for manufacturing purposes. In 1913, Germany and Austria imported 500,000,000 pounds of copper from this country, while it is estimated that 2,000,000,000 pounds will not meet our own demands this year. But a determined effort will be made to reduce the price materially. Committees have been organized in several European countries to devise ways and means of caring for their needs on an economical basis after the war. These organizations, with government co-operation, are planning to buy their metal at prices favorable to themselves or to restrain buying if prices are not suitable.

* * *

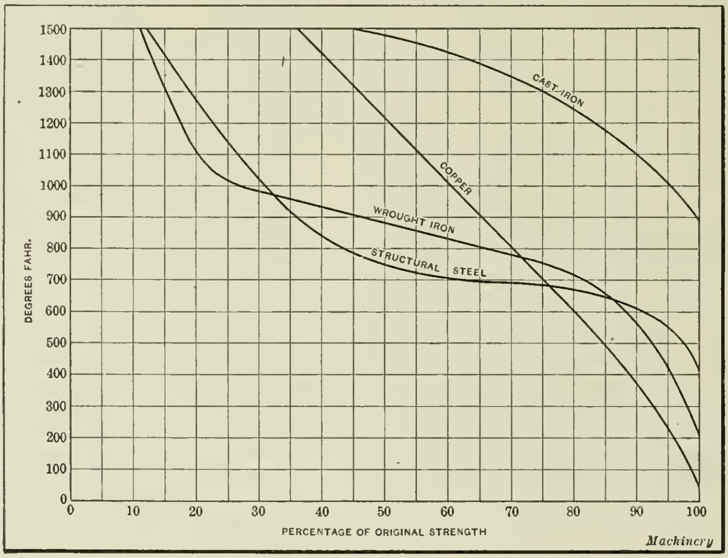
High-class marine oil engines at the present time command a price of from $60 to $65 per horsepower. Figured on a pound basis, they sell at about 40 cents a pound net weight.

EFFECT OF TEMPERATURE ON STRUCTURAL MATERIALS

BY E. N. PERCY [1]

During the last two or three years, the structural designer has been called upon to design apparatus intended for the extremely difficult combination of pressure and high temperatures. Such designs include retorts, autoclaves, and distillation apparatus. As a matter of fact, power machinery is nowadays so standardized that only in manufacturing apparatus does the designer find a field for trained creative work. The variations in the strength of materials due to change of temperature have been fairly well investigated and made available for the engineer, but as most pressure work has been done at low temperatures the designer has not found it necessary to consult these authorities. With the advent of superheated steam at high pressures and the treating of chemicals under pressure and high temperatures, as in the dye industry or the manufacture of condensation products for electrical purposes, it is sometimes necessary to work under such conditions that the factor of safety ordinarily used is necessarily lowered.

The accompanying diagram shows the curves of strength for different materials under varying temperatures. The data for these curves have been averaged from experiments made by various authorities in different parts of the world. It will be noted that cast iron withstands heat the best; the strength has a tendency to increase up to 900 degrees F., after which it decreases at a fairly uniform rate until its melting point is reached. The use of cast iron for the heat chambers of hot-bulb engines operating at a bright orange heat, that is, in the neighborhood of 1800 degrees F., is well known. These engines usually operate at a maximum compression pressure of about 60 pounds and several checks by the writer indicate that the factor of safety averages 3 to 4 and in some cases is as low as 2.



Strength Curves of Copper, Iron and Steel

The strength of structural steel increases slightly up to 400 degrees F., and then decreases rapidly until 800 degrees is reached, where it has about 40 per cent of its original strength. From this point on the decrease is fairly uniform until its melting point, in the neighborhood of 2000 degrees F., is reached. Wrought iron weakens at lower temperatures than structural steel. It follows the same general laws, but shows a somewhat greater strength throughout after rising above 650 degrees F. The strength of copper decreases from the beginning, at a uniform rate, until its melting point is reached.

These data are modified by surrounding conditions in each particular design. For instance, with cast-iron retorts it is practically impossible to get a tight casting in the average foundry, and the making of cast-iron retorts, gas benches, and autoclaves for high-temperature work is now monopolized by a few foundries who make a specialty of this type of casting. As a rule, some material is added to the iron to make it more fluid so that it will mold in a more homogeneous form. Wrought iron and steel tend to oxidize rapidly under high heats. This tendency is combatted, to some extent, by the various processes of covering with protective, non-oxidizable substances, such as aluminum, porcelain or lead. Copper oxidizes badly at high temperatures and can only be used for special types of high-temperature work. Alloys of copper with tin or zinc are particularly objectionable because the tin and zinc tend to separate, leaving a porous copper that rapidly breaks down. Every practical man knows that brass "rots" when heated. Tobin bronze and similar compounds of copper will withstand fairly high temperature without deterioration, and may be forged or subjected to other heat processes.

The industrial world at present is in need of a thorough and detailed investigation of the strength of various structural materials at high temperatures, also of methods of protecting structural materials from chemical attack. At the present time it is not possible to realize certain valuable laboratory processes because apparatus to withstand the chemicals cannot be manufactured on a large scale.

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* * *

USES OF SLIDE-RULE

BY E. J. GIBSON [1]

When making calculations on the slide-rule, it is often convenient to be able to set the runner accurately to a mixed number containing a common fraction. The prevailing practice is to refer to a table of decimal equivalents and set the runner as nearly correct as can be determined by the eye. This finding of the decimal equivalents can be eliminated in many cases and the runner set accurately by a simple rule that requires but a short mental calculation.

Multiply the integral by the denominator of the fraction and set the slide so that the product on the C scale is over the integral on the D scale. It will now be found that the graduations on the C scale divide the preceding integral space on the D scale into as many parts as the denominator of the fraction. Commencing at the integral, pass the runner over as many of the divisions as there are in the numerator of the fraction, and the runner is accurately set.

Example—Set the runner to 5 13/32. As 5 × 32 = 160, set 160 on the C scale over 5 on the D scale. Note that 192 on the C scale is over 6 on the D scale, thus dividing the space between 5 and 6 on the D scale into thirty-two parts. Commencing at the figure 5, move the runner over 13 of these divisions and it is set accurately to 5 13/32.

Sometimes it is desired to convert the final result of a calculation into a mixed number. This can be done by simply reversing the process.

Example—What is 2.89 expressed in the nearest sixty-fourths? As 2 × 64 = 128, set 128 on the C scale over 2 on the D scale and it will be found that 2.89 = 2 57/64, very nearly.

* * *

Times have changed since Ruskin wrote: "He who works with his hands only is a mechanic; he who works with hand and head is an artisan; and he who works with hands, head and heart is an artist," but the central thought is as true today as when it was written. The operator who runs a machine without thought is a mechanic in the degraded sense of the word—he is virtually a part of the machine, and will so remain until he learns to use his head.

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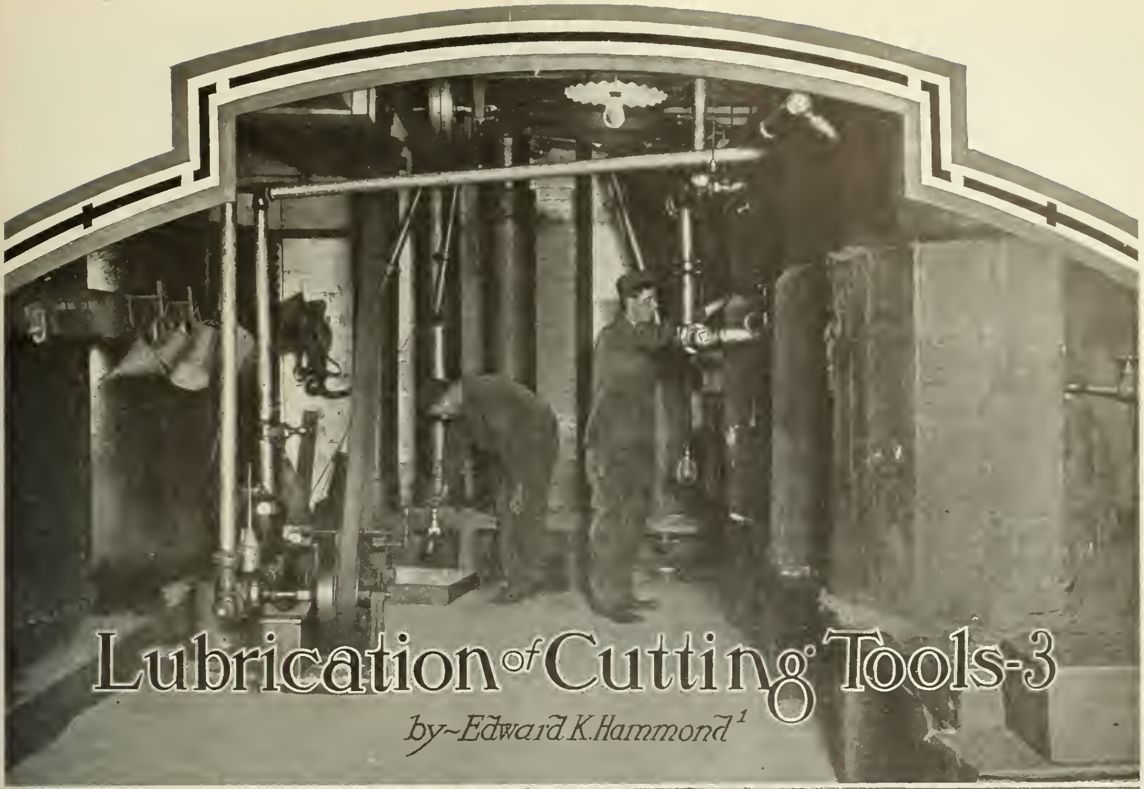

Lubrication of Cutting Tools—3

by Edward K. Hammond[1]

It has been the experience of manufacturers using large numbers of screw machines and other machine tools on which a lot of cutting oil is required that the operators of these machines are likely to be troubled from sores on their hands and arms. This trouble has become serious in some shops where cases of infection of small cuts and scratches have resulted in employes losing considerable time and, in some cases, in the amputation of hands or arms. The introduction of employers' liability laws has stimulated investigation of this subject, and it is now believed that these cases of infection are due to the presence of disease-producing bacteria in the oil; to overcome trouble from this source various methods of sterilization have been developed. Chief among these are sterilization by heat and by introducing a germicide into the oil or cutting compound. There is a wide diversity of opinion in regard to the development of bacteria in oils or cutting compounds and the possibility of securing valuable results by sterilization. This fact is indicated by the contradictory results obtained by different investigators, to which reference will be made.

Sterilization by Heat

When the oil or cutting compound is sterilized by heat, the practice is to have a smaller tank connected with the storage tank into which the oil can be pumped. This tank is usually provided with a coil through which steam may be passed to heat the oil, and after this has been done the steam is shut off and cold water passed through the oil to reduce its temperature to that at which it should be returned to the work to give the best results. The following is a report of tests conducted on mineralized lard oil, which show, first, that it is possible to develop bacteria in oil, and, second, that sterilization at a temperature of 140 degrees F. is an effective means of removing such bacteria.

We divided the oil into four portions that were passed through the process of filtration which we use. After being filtered, these four portions were treated as shown in Table I. The counts were made after incubation of forty-eight hours at 37 degrees C. There was no growth in the portion heated at 140 degrees F. after incubation for forty-eight hours at 37 degrees C. Another portion of the oil was heated at 140 degrees F. for twenty minutes and incubated for twenty-four, forty-eight, seventy-two, ninety-six, and one hundred twenty hours. At every twenty-four hours of incubation, the oil was examined for growth, and at the expiration of one hundred twenty hours no growth appeared. You will note that the original dirty oil showed a bacteria count of 24 per cubic centimeter and that the three samples that were heated for twenty minutes at a temperature of 80, 100, and 120 degrees F. were not properly treated to kill all bacteria, but that treating the oil at 140 degrees F. seemed to free the oil from bacteria.

In order to check up this last treatment, samples of the oil that had been treated at 140 degrees F. were set aside and allowed to incubate for twenty-four, forty-eight, seventy-two, ninety-six, and one hundred twenty hours. These samples, which were examined after every twenty-four hours, showed no trace of bacteria, and it is safe to assume that if after one hundred twenty hours no growth appeared, all the bacteria had been killed. Our chemist claims that the heat-treatment at 140 degrees F. for twenty minutes is enough to kill all the most common bacteria, such as the streptococci and other bacteria which cause infection of flesh wounds, as well as tuberculosis bacteria.

The results of the preceding test seem to show conclusively that bacteria can develop in mineralized lard oil and also that sterilization by subjecting the oil to a temperature of 140 degrees F. is the means of killing these bacteria. In conducting any form of scientific research, it is never safe to place reliance upon results obtained in individual cases; in

TABLE I. RESULTS OF STERILIZATION TEST

Time Heated, Minutes	Temperature, Degrees F.	Bacteria per Cubic Centimeter[1]
20	80	22
20	100	15
20	120	7
20	140	0

Machinery

[1] Note: The oil before treatment contained 24 bacteria per cubic centimeter.

[1] Associate Editor of Machinery.

order to draw general conclusions information must be obtained from a great variety of sources. It is entirely possible that while this method of sterilization would prove effective for some oils, it would be totally inadequate for other oil mixtures and cutting compounds. It is also possible that elimination of bacteria might be due to a change in composition of the oil after being used and not to the sterilization process to which it was subjected.

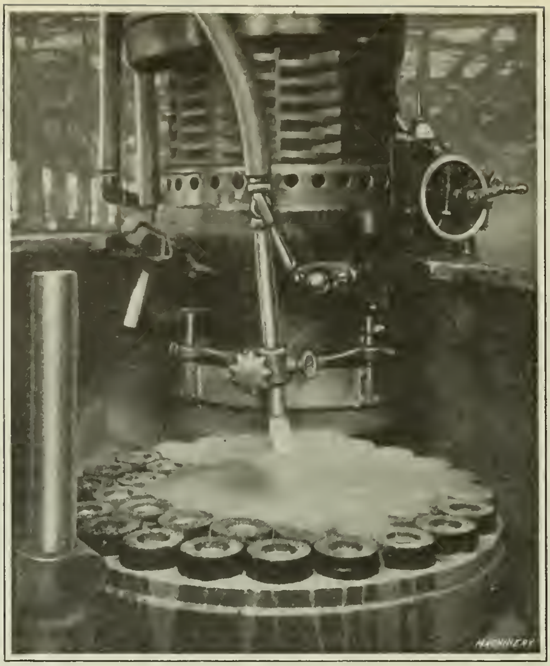

Fig. 60. Delivering Coolant to Wheel on Blanchard Surface Grinder

That such a possibility exists is emphasized by the result of research work recently conducted in a prominent laboratory with the view of furnishing a well-known manufacturing firm with exact information as to the causes of infection of cuts on the hands and arms of men operating machines where a large quantity of oil or cutting compound is used. These investigations have not yet been brought to a definite conclusion, but they have progressed far enough for the investigators to be able to state that after being placed in use any oil mixture containing petroleum undergoes a change in composition which results in producing a powerful germicide in the oil, thus rendering it absolutely sterile. It is the view of investigators in this laboratory that many cases of infection of cuts that are attributed to bacteria carried by oil are actually caused by bacteria that find their way into abrasions of the skin from dirty towels and an infinite number of other sources. It has been suggested that if such a change in composition results in making an oil absolutely sterile, the development of bad sores on the hands of machine operators may be due to any of the following causes: (1) The oil may have a slight soluble action on brass parts of the machine or brass products and thus form a verdigris which causes infection of cuts. (2) Certain aldehydes or other products are formed in the oil, and these cause trouble when they get into cuts or other abrasions of the skin. (3) The presence of free fatty acids in the oil causes trouble in the same way. In the two latter cases it is also assumed that these aldehydes or acids find their way into the stomach and cause nausea, lack of appetite, and other indispositions from which some industrial workers suffer who operate machines on which a lot of oil or cutting compound is used. That such contradictory opinions as those just cited are expressed today shows that the subject of oil sterilization is still in what may be called an experimental stage. The subject is one of great importance, and it is to be hoped that definite conclusions will soon be reached that will enable oil to be treated in a way that insures workmen against danger from bacteria, if this really constitutes a source of infection.

Oil mixtures containing cottonseed oil and other vegetable oils become rancid after being in use for some time, and this is due to the development of certain molds and bacterial growths. Investigations conducted up to the present, however, tend to show that these are not of disease-producing types and so should not be the cause of infection.

Sterilization by the Addition of Germicide

The sterilization of cutting oils and compounds is still in the process of development, and some manufacturers are now experimenting with the use of carbolic acid, formaldehyde, creosote oil, and other germicides. Small quantities of such chemicals are added to the oil, and a little thought will make it evident that such additions have an important advantage over sterilization by heat in that they are circulated through the pump, pipe line, machines, and back to the storage tank, thus having an opportunity of keeping the entire system in a sterile condition. In one well-known manufacturing plant it is the practice to add one ounce of creosote oil to each twenty-five gallons of cutting compound used in the factory. Similarly, a well-known firm of oil refiners recommends the addition of 2 per cent of carbolic acid to oils or cutting compounds. Carbolic is a weak acid, so far as its action on metals is concerned, and this addition would not result in damaging the machine bearings or the finished work; this acid is also one of the strongest germicides known to science, and such an addition ought to prove helpful in freeing oils and cutting compounds from bacteria.

Fig. 61 shows, in diagrammatical form, the arrangement of a complete Richardson-Phenix oil filter and sterilizer. Dirty oil from the machines enters the system through pipe *A* and passes through the series of chip baskets, baffle plates, magnetic separators, and cloth filters described in the February number. It then passes to pump *B*, which delivers the clean oil to the machines in the factory. It will be seen that the main pipe line is provided with a pressure relief valve at *C*, so that the pressure at which oil is delivered to the tools will not exceed that which has been found most effective. This is an important point, because experience has shown that in order to work at maximum efficiency either an

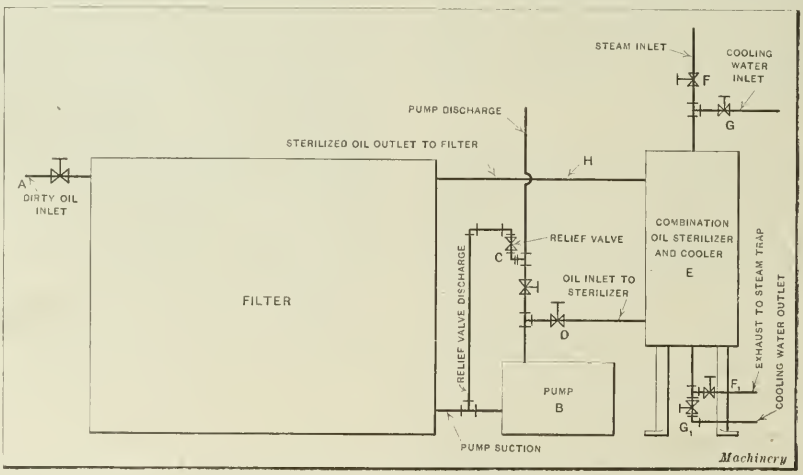

Fig. 61. Diagram showing Arrangement of Filter, Pump and Sterilizer as applied in Central Station Practice of Richardson-Phenix Co.

oil or cutting compound should be delivered at exactly the pressure that will enable it to remain in contact with the work instead of having a tendency to rebound. The fluid which escapes through pressure relief valve C is returned through a by-pass pipe to the suction chamber of the pump.

Sterilization of oil at a temperature of 140 degrees F. is recommended once every ten days, and when this treatment is necessary, all the oil in the piping and machine pans is allowed to drain down into the filter tank and sterilizer. Oil is pumped through valve D into sterilizer E, which, it will be seen, is connected with a double pipe line at both top and bottom to provide for passing either steam or cold water through the coil in the sterilizer. After having passed through the sterilizer the oil is carried through a by-pass pipe that carries it back to the filter tank and thence through the filter units back to the sterilizer. This circulation of oil is continued until all the oil in the system has reached a temperature of 140 degrees F.; the oil is kept at this temperature for twenty minutes. Incidentally, repeated passing of the oil through the filter also gives it a thorough cleaning. While the oil is being heated, valves F and F_1 are opened to permit steam to pass through the coil in the sterilizer, and after this has been done, these valves are closed and valves G and G_1 are opened to allow cold water to flow through the coil, thus cooling the oil for subsequent use. Circulation of the oil through the filter and sterilizer is continued while it is being cooled.

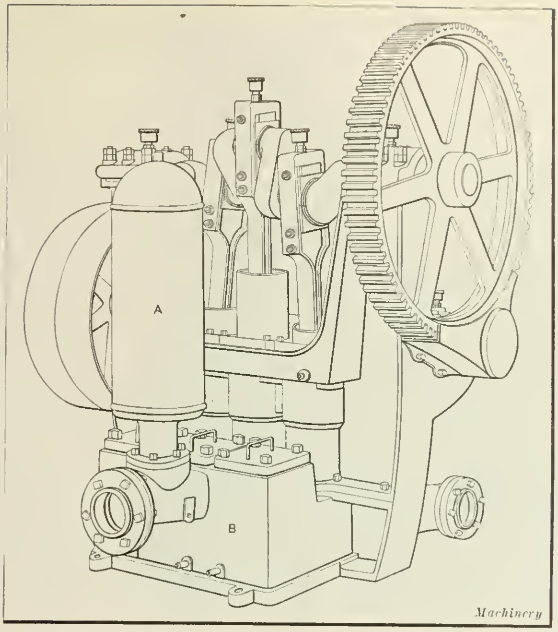

Fig. 62. Single-action Triplex Plunger Pump made by Goulds Mfg. Co.

The systems of filtering and distributing oil described can be highly endorsed, but whether the system of sterilization is effective is a question. In order to sterilize effectively there are two points that must receive careful attention, *i. e.*, all the bacteria must be killed, after which the sterilized oil must be placed in a container which has also been sterilized in order to keep it free from germs. Even though the temperature of 140 degrees is high enough to insure the killing of all bacteria in the oil, it is doubtful whether this would be permanently effective, owing to the fact that the sterilized oil is circulated through pipe lines and machine pans that have not been sterilized. Those who are familiar with the growth of bacteria know that they develop at a rapid rate, and so, even if all bacteria are killed in the oil treated in the sterilizer, the return of this oil to the unsterilized pipe line system would give an opportunity for the development of bacteria long before the lapse of the ten-day period. Many bacteriologists would also be inclined to question the efficacy of sterilization at 140 degrees F., as it is generally conceded that a much higher temperature is required to insure thorough sterilization. A lower temperature may be sufficient to kill existing bacteria, but the spores from which bacteria develop, which correspond to seeds of plants, have greater vitality than the fully developed bacteria, and it only requires a few hours for these to develop into bacteria.

Pumps Used in Central Station Practice

Pumps used for distributing oils and cutting compounds from central stations are usually of either the plunger or centrifugal type, and each of these has points in its favor. The following gives a brief description of the reciprocating or plunger type of pump and of the centrifugal pump.

Reciprocating or Plunger Type of Pump

Fig. 62 illustrates a single-acting triplex plunger pump built by the Goulds Mfg. Co. These pumps are ordinarily driven by individual electric motors, as shown in Fig. 63, which also illustrates the Richardson-Phenix filter used for purifying lard oil in the factory of the Marlin Arms Corporation, New Haven, Conn. The pumps are geared down so that the pump speeds vary from about 40 to 60 revolutions per minute. When delivery of a large volume of lubricant is required, pumps with three plungers are used in order to secure uniformity in pressure and rate of delivery, the results obtained in this way being shown diagrammatically in Fig. 64. In Fig. 62, A is an air chamber against which the pressure is developed, the air acting as a cushion to absorb shock and help to maintain the pressure at a uni-

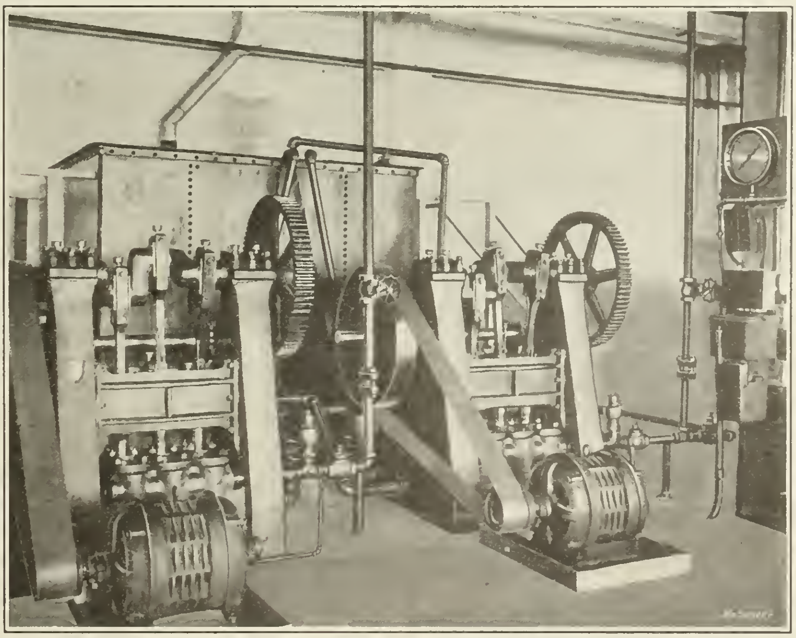
Fig. 63. Goulds Triplex Plunger Pump and Richardson-Phenix Oil Filter in Plant of Marlin Arms Corporation

form level. In case *B* are contained inlet and discharge valves for each of the cylinders. Pumps of this type are made in sizes ranging from 8¼ by 10 inches down to 4 by 4 inches, with capacities from 30 to 400 gallons per minute. Any desired pressure may be maintained by means of a by-pass and pressure regulating valves that can be set to give the required pressure. Table II gives capacities of plunger pumps for various cylinder diameters and lengths of stroke.

Centrifugal Pumps

The operation of centrifugal pumps is based upon the action of centrifugal force. Pumps of this type are usually run direct-connected to an electric motor, as shown in Fig. 65, and oil or other fluid comes to the pump through a suction pipe. In starting the pump it is usually necessary to prime it, or in other words, to fill the suction pipe and pump casing with fluid. The impeller consists of a wheel with passages formed in it in such a way that the fluid enters from the suction pipe at points near the center of the impeller and is expelled from the periphery into the volute chamber. This volute chamber connects the pump with the delivery pipe. Various arrangements are used for priming pumps, one of the most convenient of which is to use a foot-valve in the suction pipe and have a pipe connection with the delivery pipe so that by opening a valve the suction pipe and pump casing may be filled. In other cases hand pumps are used to raise the fluid in order to fill the suction pipe and pump casing.

Centrifugal pumps have one important advantage where lubricant is delivered to all machines from a central distributing station in that they may be designed to deliver lubricant at a specified pressure at the tools, and when this pressure is reached the pump will continue to "churn" without increasing the pressure. Large centrifugal pumps are usually built according to specifications of the purchaser and are arranged to develop a given pressure. Where pumps of this kind deliver lubricant to tools on several floors and it is required to have the same pressure on all floors, the usual method of procedure is to design the pump to deliver the required pressure on the top floor; on lower floors where there is less loss of pressure due to a smaller static head and friction loss in the line, gate valves can be used to throttle down the pressure so

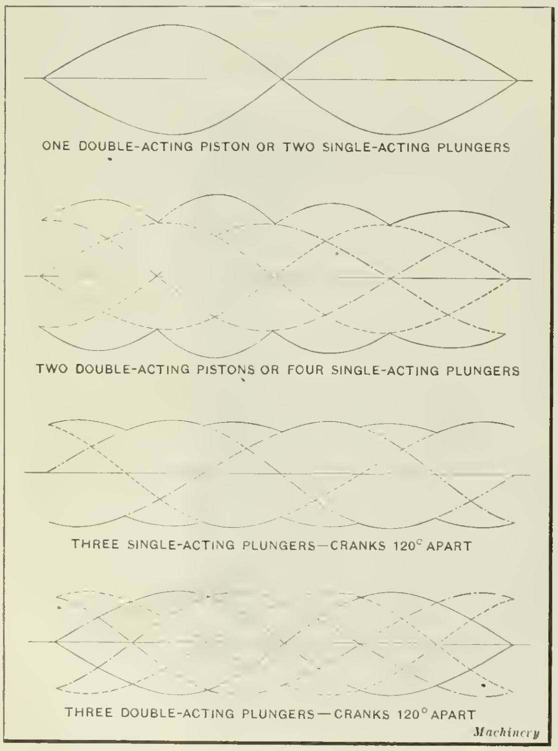

Fig. 64. Diagram illustrating how Plungers of Multiple-plunger Pump tend to neutralize Variations of Pressure in Different Cylinders

TABLE II. CAPACITIES OF RECIPROCATING PUMPS[1]

Diam. of Cyl., In.	Area, Square Inches	Length of Stroke in Inches: 2	3	4	5	6	7	8
		Capacity per Stroke in Gallons or Decimal Parts Thereof						
½	0.196	0.002	0.003	0.003	0.004	0.005	0.006	0.007
⅝	0.307	0.003	0.004	0.005	0.007	0.008	0.009	0.011
¾	0.442	0.004	0.006	0.008	0.010	0.011	0.013	0.015
⅞	0.601	0.005	0.008	0.010	0.013	0.016	0.018	0.021
1	0.785	0.007	0.010	0.014	0.017	0.020	0.024	0.027
1⅛	0.994	0.009	0.013	0.017	0.022	0.026	0.030	0.034
1¼	1.227	0.011	0.016	0.021	0.027	0.032	0.037	0.043
1⅜	1.485	0.013	0.019	0.026	0.032	0.039	0.044	0.051
1½	1.767	0.015	0.023	0.031	0.038	0.046	0.054	0.061
1¾	2.405	0.021	0.031	0.042	0.052	0.063	0.073	0.083
2	3.142	0.027	0.041	0.054	0.068	0.082	0.095	0.109
2¼	3.976	0.034	0.052	0.069	0.086	0.103	0.121	0.138
2½	4.909	0.043	0.064	0.085	0.106	0.128	0.149	0.170
2¾	5.940	0.051	0.077	0.103	0.129	0.154	0.180	0.206
3	7.069	0.061	0.092	0.122	0.153	0.184	0.214	0.245
3¼	8.296	0.072	0.108	0.144	0.179	0.215	0.251	0.287
3½	9.621	0.083	0.125	0.167	0.208	0.249	0.292	0.333
3¾	11.045	0.095	0.143	0.191	0.239	0.287	0.335	0.382
4	12.566	0.109	0.163	0.218	0.272	0.326	0.381	0.435
4¼	14.186	0.123	0.184	0.246	0.307	0.368	0.429	0.491
4½	15.904	0.138	0.207	0.275	0.344	0.413	0.482	0.551
4¾	17.721	0.153	0.230	0.307	0.384	0.460	0.537	0.614
5	19.635	0.170	0.255	0.340	0.425	0.510	0.595	0.680
5¼	21.648	0.187	0.281	0.375	0.469	0.562	0.656	0.750
5½	23.758	0.206	0.309	0.411	0.514	0.617	0.720	0.823
5¾	25.967	0.225	0.337	0.449	0.562	0.674	0.787	0.899
6	28.274	0.245	0.367	0.489	0.612	0.734	0.857	0.979

Machinery

[1] Note: Figures are for one single-acting cylinder. For single-acting triplex pumps multiply by 3. For single-acting duplex pumps multiply by 2, etc.

that it will be the same as on the top floor. The same practice is used with other types of pumps; but in the case of plunger pumps it is necessary to have a pressure-control valve and by-pass, as previously mentioned. In addition to their application for distributing lubricants from a central station, centrifugal pumps are employed on grinding machines and other machinery for pumping cutting compound to the wheel and work.

Positive Pump Pressure and Gravity Oil Feeds

Two systems are in general use for delivering lubricant from a central station to machines in the shop. One of these consists of pumping the purified lubricant up to a storage tank at the top of the building from which it flows by gravity to the machines on different floors. The other is to pump lubricant direct to the different machines. Each system has its advocates and each seems to have certain points in its favor. The claim is made for the gravity tank system that a uniform pressure is obtained for the oil, without fluctuations due to pulsation of the pump. It is also pointed out that should the pumps fail, there is a supply of oil in the gravity tank that will carry the machines for a limited space. This may be a point of some importance, but the claim made in regard to variations of pressure due to pulsation is not so important, as will be seen by reference to Fig. 64, which shows how each cylinder in a triplex pump, which is one type commonly used for this service, tends to neutralize variations in pressure in the other two cylinders, so that the combined effect is a close approximation of normal pressure.

Regardless of whether a gravity tank or direct-pump delivery is employed, it is necessary to keep the pressure of lubricant delivered to machines on different floors as nearly uniform as possible, and this result is secured by having valves placed in the pipe lines on each floor or supplying individual valves at each machine. For average work, the pressure in the pipe line is usually maintained at from 28 to 30 pounds per square inch. The valves at the machines can be adjusted to throttle down the pressure to exactly the required amount. In cases where a variety of machines on the same floor call for delivery of lubricant at different pressures, it is common practice either to have a number of valves in different branches of the pipe line leading to the different classes of machines or to provide an independent valve on each machine.

Return of Oil to the Central System

After flowing over the tools and work the lubricant is col-

lected by the usual means provided on machine tools and returned through drain pipes to troughs in the floor. These are covered with boards that may be lifted to give access to the trough, when this is necessary, the arrangement being shown in Fig. 66. The troughs are usually about 6 inches wide by 1 foot deep, the size depending on the amount of lubricant to be handled, and it may be mentioned that troughs are used in place of pipes to prevent the system from becoming clogged by chips or through gumming of oil. In buildings with concrete floors these troughs may be placed in the concrete, but if machines are carried on wooden floors the drain pipes can pass through the floors and discharge into galvanized-iron troughs suspended from the ceiling of the room below. An advantage of having all the oil handled from a central station is that it reduces fire hazard, as no oil is kept in the base of the machine and the small quantity adhering to chips is insufficient to support a fire. The oil storage and filter can be located away from the main building or put in a fireproof compartment.

Fig. 66. Cover lifted from Drain Trough in Floor, showing Means of Access in Case Trough becomes clogged

Planning a Central Distributing and Purifying Plant

In planning to install a central station for the distribution and purification of oils and cutting compounds, information should be given concerning the number, size, and make of the various machine tools which are to be supplied with lubricant, the average and maximum number of machines that will be operating at one time, the kind of oil or cutting compound used, and the volume of lubricant which it will be desired to circulate per hour. In addition, information should be given concerning the different metals that are to be cut. In many instances it is possible to make use of the existing oil-storage and piping systems and simply add filters and sterilizers to make the system automatic.

Limitations of the central station for delivering oils and cutting compounds are the high first cost of installing such a system and the possibility of trouble arising that would interfere with the delivery of lubricant to the shops, thus causing loss of time and damage to cutting tools. The liability of difficulty from this source is materially reduced by installing one or more reserve pumps. Another criticism of the central distributing station is that a heavy additional expense is involved if provision is made for delivering different kinds of oils and compounds to various classes of machines in the factory. The advantages of the practice of distributing all cutting oils and compounds from a central station are as follows: provision of clean oil, possibility of returning oil to the tools at a low temperature, sterilization of the oil to prevent infection, reduction of fire hazard, longer life for cutting oils and compounds, saving of labor in handling oil, saving of oil wasted in handling, improvement of sanitary conditions in factory, and continual stirring of soluble compounds which insures uniformity of solution.

Filters and Trucks for Transporting Oil

In some cases where it is undesirable to install a system of piping for the distribution of oil to all machines from a central station, the oil may be purified by passing it through a system of strainers and filters similar to that illustrated in Fig. 47 in the February number. For this purpose separate straining and filtering outfits may be built with a capacity for handling any desired amount of oil or cutting compound. One of these small units, built for use in filtering kerosene in the factory of the Hess-Bright Mfg. Co., Philadelphia, Pa., is shown in Figs. 67 and 68. When an equipment of this kind is employed trucks are used for conveying oil to machines in the factory and for returning used oil to the filter. Fig. 69 shows an excellent truck for handling work of this kind. It will be seen that it has two compartments, each of which has a capacity for 160 gallons. The truck is taken around through the shop and dirty oil is pumped out of pump reservoirs on machines into the "dirty-oil receiving tank." After this reservoir has been cleaned (if necessary), a fresh supply of oil is pumped in from the "clean-oil tank" in the truck and the dirty oil is then taken back to the filter. A truck of this kind does away with danger of spilling oil on the floor.

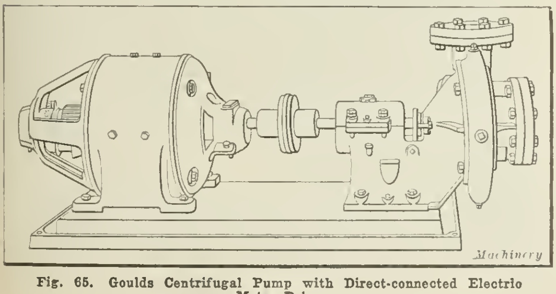

Fig. 65. Goulds Centrifugal Pump with Direct-connected Electric Motor Drive

Methods of Conducting Shop Tests

In many shops where facilities are not available for determining the relative value of different oils and cutting compounds, dependence is often placed upon the judgment of the shop superintendent or foremen, and this is likely to prove unsatisfactory from one of two causes. When this practice is followed, the man who determines what oil or cutting compound to use will often base his selection upon ideas formed at the time he learned his trade, and these may be badly out of date. The judgment of such a man is likely to lead him to specify lard oil or a mixture containing a high percentage of lard oil for use on many classes of work where satisfactory results could be obtained with a cheap soluble oil compound. On the other hand, a man who is inclined to economize may carry this to the extreme and specify an oil or cutting compound which may be bought at a low price, but which will prove costly through failure to keep the cutting tools in good condition or through tendency of the oil to gum, turn rancid, etc., making it unfit for use after a short period of service.

Testing Oils and Cutting Compounds

In the purchase of oils and cutting compounds, as in the case of all equipment and materials used in machine shops, the points of vital interest to the buyer are first, the quality

of service which he will obtain, and second, the length of time for which the lubricants will continue to render this service. The most obvious way of securing information on these points is to conduct running tests on machines and lubricate the cutting tools with the oil or compound which the purchaser has under consideration. In this way he may obtain information on the following points: (1) The efficiency of the oil or cutting compound as a lubricating or cooling medium, as determined by the length of time that the tools "stand up" between grindings. (2) The amount of service obtained before the supply of oil is exhausted through loss from splashing, being carried away on chips, and similar causes. (3) Ability of the fluid to radiate heat rapidly, as determined by noting the uniformity of temperature indicated by a thermometer suspended in the reservoir. (4) Freedom from acids or alkalies, as indicated by lack of tarnish produced on a polished metal disk immersed in the fluid for several hours. (5) Cost per running hour. First cost only becomes a matter of importance after the user has satisfied himself that the lubricant is capable of giving satisfactory service on his work. The following describes current practice in conducting shop tests on oils and cutting compounds.

Method of Conducting Shop Tests

In conducting shop tests the aim should be to operate the machine and cutting tool as nearly as possible under conditions that will exist in actual manufacturing. The best plan is to select a piece of work on which the tool can be run for at least one week, and before starting work, care should be taken to see that the machine is properly lubricated and that the reservoir, pump and piping are thoroughly cleaned to remove all the lubricant previously used. Attention should also be paid to the cleaning and lubricating of all bearing surfaces and slides before the machine is loaded for test. If the oil or cutting compound is to be given every opportunity of producing satisfactory results, it is not sufficient to allow it to simply flow onto the top or side of the tool; the feed pipe should be arranged in such a way that a copious stream will be carried to the tool point and the surface of the work being machined in order that both tool and work may be properly lubricated and cooled. Care in grinding the cutting tools is of equal importance because the test must be conducted under conditions equal to the best that can be expected in actual manufacturing operations. Improper grinding of the tool not only results in the generation of more heat, but also in rapid destruction of the cutting edge; and failure to provide means for the delivery of the required volume of lubricant is an obvious injustice to the manufacturer of the lubricant who is endeavoring to show what his product is capable of doing. Many good cutting compounds have been condemned through failure to provide a proper arrangement of feed pipes and to have the tool properly ground.

When the machine reservoir has been properly filled with oil or cutting compound care should be taken to see that this lubricant remains uniform throughout the test; this is particularly important in the case of emulsions made from soluble oils and water. Attention to this point will be of assistance in figuring the running cost per hour or the cost of lubricant for producing a given quantity of work. In a test of this kind with different oils and cutting compounds the following data should be taken: (1) Total running time; (2) time spent in grinding tools; (3) time consumed by delays and in making repairs; (4) condition of tool at start; (5) deterioration of tool; (6) speed and feed employed; (7) number of pieces of work produced; (8) number of gallons of lubricant in reservoir at start; (9) number of gallons of lubricant in reservoir at finish of test. In this connection it may be mentioned that oil ought to be reclaimed from the chips produced and this amount measured and deducted from the quantity of lubricant put in the machine reservoir to start the test. These data will enable an intelligent comparison to be made of oils and cutting compounds from which the purchaser can select those best suited to his requirements.

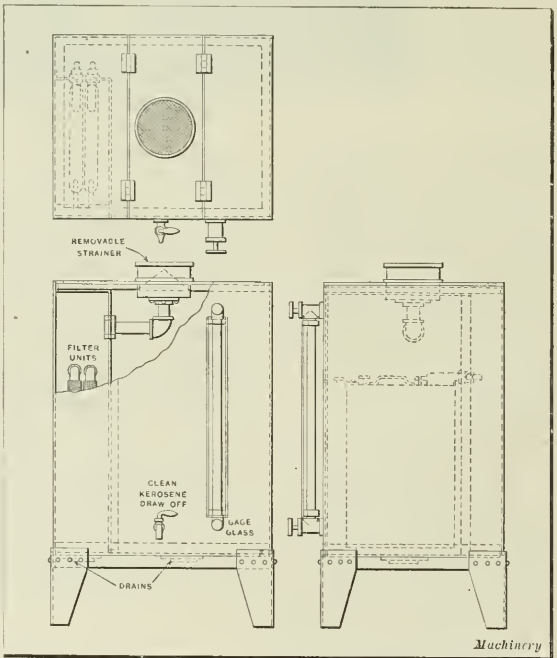

Fig. 67. Richardson-Phenix Filter used with Transfer Truck; this Illustration shows Filter used in Plant of Hess-Bright Mfg. Co. for purifying Kerosene Oil

Simple Methods of Testing Quality of Oils

Scientific testing of oils and cutting compounds calls for the use of somewhat elaborate apparatus and in order to secure accurate results the man making such tests must have received training as a chemist. Where data are required on the properties of a given oil or compound and the plant has not the facilities of a chemical laboratory, it will be desirable to send samples to a consulting chemist who will conduct an investigation for a moderate fee. At the same time it is desirable for shop men to be able to make a few elementary tests on oil which will give information concerning its probable value for the service required.

Acidity—A simple method of determining whether or not an oil or cutting compound contains free acid consists in suspending a piece of polished sheet copper in the oil for a period of two weeks. The presence of acid is indicated by corrosion of the polished metal surface, making it somewhat dull in the presence of even slight traces of acid. If the oil is pure the copper will be bright after being removed from the oil.

Mineral Oil—A good test to ascertain whether mineral oil is pure and has been carefully refined consists of dropping a small quantity of strong sulphuric acid into the oil; this will have no effect on the color if the oil is pure, but if fatty material is present the oil will become discolored.

Animal and Vegetable Oils—Mineral oil and rosin oil are sometimes used as adulterants for expensive animal and vegetable oils. Mineral and rosin oils differ from other oils in many respects, especially in their appearance when examined by reflected light. Mineral oils show a greenish tinge or "bloom" when examined by reflected light, but when seen by transmitted light, this bloom disappears and the true color of the oil is seen. Rosin oil has the same characteristic except that the bloom is blue. This bloom is due to the familiar phenomenon known as "luminescence," *i. e.*, the property of becoming luminous when exposed to the sunlight. To test animal or vegetable oils for the presence of mineral or rosin oil, place a sample of the oil in a four-ounce bottle and view it by reflected light; the presence of any bloom indicates these impurities. By suitable treatment in the process of refining, oils can be "de-bloomed" so that the characteristic luminescent appearance is not seen when viewed by ordinary reflected light; but when such oils are viewed by reflected light from an ordinary enclosed arc light, the char-

acteristic appearance will be noted. This test will reveal the presence of minute traces of mineral or rosin oil. Attention is called to the fact that many so-called "mineral lard oils" are sold which consist of mixtures of lard oil and petroleum, and these will naturally show the presence of mineral oil when subjected to this test, but the purchaser who is paying for pure lard oil or other pure oils of animal or vegetable origin, does not want to pay a high price for a product that has been adulterated with cheaper oils.

Turpentine—The most common adulterants found in turpentine are mineral oils although wood turpentine and rosin spirits are sometimes added. A simple test for purity of this material is to drop it onto a piece of white paper which is allowed to stand in the air until the turpentine is evaporated. The presence of other oils is indicated by a stain left on the paper; if the turpentine is pure, no discoloration will appear after it has evaporated.

Lard Oil—Lard oil is sometimes adulterated with cottonseed oil, and the presence of over 10 per cent of this adulterant may be detected by adding a solution of silver nitrate which will cause it to darken considerably through the formation of metallic silver. This is a simple test performed by merely adding the oil to a test tube containing an equal volume of alcoholic solution of silver nitrate and heating the mixture in a gas flame. The silver-nitrate solution is made by dissolving 1 part of silver nitrate in 200 parts of 95 per cent alcohol and 40 parts of ether.

Testing Fluidity of Oils

Oils and cutting compounds are consumed through various causes, among which may be mentioned carrying away by chips; loss by oxidation, gumming or turning rancid; leakage from trucks or other forms of conveyors; and spattering from machines. The first two causes of loss are due to inherent properties of the oil and must be guarded against by tests; losses from the latter causes can only be prevented by the exercise of care and the provision of proper means for handling lubricants and preventing them from being thrown from the machines.

When oils have constituents that are easily oxidized or likely to gum, it not only results in loss of oil but also in trouble through clogging pipes, which retards the action of slides and other machine members, and prevents the oil from flowing freely to the point of the tool and work. Oxidation results in the formation of a black sludge in the oil and also in the formation of a tenacious skin or gum, trouble from these sources being particularly marked in the case of some vegetable oils and lard oil of poor quality. In addition, oxidation and gumming reduce the fluidity of the oil and cause an excessive amount of oil to be carried away with the chips. The same is true of oils having too high a viscosity, and with such oils it may be found good practice to add

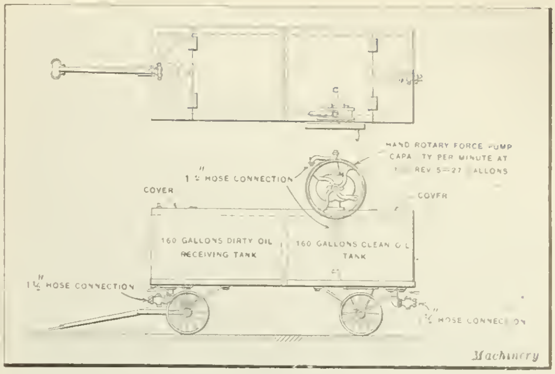

Fig. 69. Truck used for removing Dirty Oil from Machines and substituting Supply of Clean Oil

kerosene oil or some other "thinner" to make them run more freely.

Fig. 70 illustrates a practical test to determine the probable loss of oil through retention by chips. A funnel is lined with flannel and two pounds of fine chips is placed in it. Four ounces of oil is then poured through the funnel and allowed to drain into a second measure; after allowing sufficient time for the oil to drain, the amount in the second measure will indicate how much has been retained by the chips. Tests of this kind should be conducted with new oil and also with oil that has been in use under actual working conditions for some time. In some cases it may be found that the new oil runs through in a satisfactory manner, but that after being used for a time the fluidity will have been seriously reduced. This is particularly true of oils that give trouble through gumming or oxidation, and of poor grades of mineral lard oil in which the lard oil has a tendency to become thick and separate from the mixture so that it is easily retained by the chips. Even when great care is taken in the operation of centrifugal chip separators to recover oil from chips the loss will be quite heavy with oils of this kind, and in making the test for fluidity, oils that do not run freely through the funnel should be viewed with suspicion and should not be accepted if the best results are expected.

In plants where oils are tested in the chemical laboratory stress is likely to be laid upon the results obtained by saponifying the oil by boiling it with an alcoholic solution of caustic potash. This is the chemist's name for the process of making soap from animal oil, and in interpreting the results of his investigation he may fall into the error of recommending the oil having the highest saponification value, unless he is a man who has a thorough knowledge of the requirements that must be met to obtain satisfactory results from cutting oils. If so, he will know that a mixed lubricant containing a large amount of animal oil—which gives a high saponification value—does not necessarily give satisfactory results. This is due to several reasons: it may be that the animal oil is of poor grade, so that it tends to oxidize and gum rapidly; it may be too thick to run freely to the tool and work; or it may give trouble through failure to radiate heat rapidly, etc. While laboratory tests are of great importance in determining the properties of lubricants, their results should not always be relied upon until they have been carefully studied and compared with the results obtained with the oils under working conditions.

Laboratory Tests on Oils and Cutting Compounds

While information obtained by practical shop tests gives information of direct value to the manufacturer who uses cutting oils, there are a number of tests conducted in the laboratory which yield information concerning the chemical and physical properties of the oil that are of value in determining what its probable efficiency will be when used in the shop. The tests most commonly conducted on oils used for lubricating and cooling metal-cutting tools are for determining the following properties: specific gravity, viscosity, flash point, fire point, and cold point.

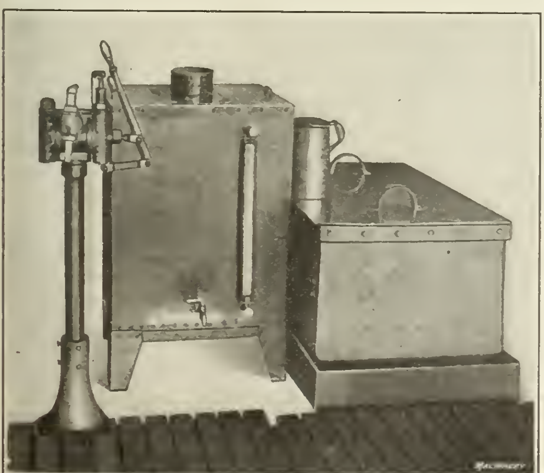

Fig. 68. View of Kerosene Oil Filter shown in Fig. 67, set up in Hess-Bright Factory

Specific Gravity

Specific gravity is defined as the ratio of the weight of a given volume of fluid under test to that of the same volume of water. Water has a specific gravity of 1 and all oils and cutting emulsions have specific gravities less than that of water. The specific gravity of an oil in some instances may serve as an indication of its purity, as different oils have characteristic specific gravities by which they can be recognized. The most accurate determination of specific gravity is made by means of a pycnometer, two types of which are shown at A and B in Fig. 71. The type shown at B is used for obtaining the specific gravity of asphalt and oils of high viscosity; with these materials trouble would be experienced in cleaning the type of pycnometer shown at A, which is the one most commonly used for obtaining the specific gravity of such fluids as oils and cutting emulsions. In making a test, the pycnometer is carefully washed and dried, after which its weight is determined on a chemical balance. It is then filled with distilled water, care being taken to have the water fill the capillary tube in the stopper, after which the combined weight of the pycnometer and water is determined to obtain the weight of this volume of water. The pycnometer is then once more dried and filled with oil, after which it is again weighed to obtain the weight of the oil. The specific gravity may then be easily calculated by dividing the weight of the oil by the weight of the water. It is essential that all weighing be done at a standard temperature, which is 15.5 degrees C. (60 degrees F.). If any weighing is done at another temperature the results must be converted to the standard temperature, because the specific gravity varies with changes of temperature.

Determination of specific gravity by means of the pycnometer is a slow process, and for commercial work sufficiently accurate results may be obtained in other ways. At C is shown a Westphal balance used for this purpose. The fluid to be tested is placed in the container and the plummet suspended from the right-hand end of the balance beam is immersed in the fluid. It will be seen that the beam is graduated and carries a counter-poise, the position of which is adjusted on the beam so that the balance comes to rest with the point at the left-hand end opposite the point on the frame. The specific gravity of the fluid is then read direct from the graduation on the beam that comes under the counter-poise.

Another rapid method of determining specific gravity, and one which is commonly used, is by means of a Baumé hydrometer, a number of which are shown at E. This consists of a plummet which is weighted at the lower end so that it floats vertically in the fluid to be tested; the depth to which the hydrometer is immersed depends upon the specific gravity of the fluid. As the specific gravity is dependent upon temperature, it is necessary to specify the temperature at which the determination is made. For this purpose some of the hydrometers shown are provided with thermometers. In the case of those that do not have thermometers, it is necessary to determine the temperature with a separate thermometer dipped into the fluid, and make the necessary correction, or to avoid this, oil may be tested at the standard temperature of 60 degrees F. Baumé gravity may be converted into specific gravity by using the following formula:

$$\text{Specific gravity} = \frac{140}{130 + \text{Baumé gravity}}$$

For very accurate work, however, the following formula should be used:

$$\text{Specific gravity} = \frac{141.5}{131.5 + \text{Baumé gravity}}$$

Viscosity may be defined as the tangential force per unit area divided by shear per unit of time; this property represents a measure of internal resistance in the fluid and indicates the magnitude of forces tending to retard a rapid flow of the fluid. It will be evident from this that oils used for the lubrication and cooling of cutting tools should not have too high a viscosity because this would prevent their rapid flow to the point where cooling or lubricating action is required. The viscosity of distilled water is taken as the standard against which the viscosity of other fluids is compared; and owing to the change in the fluidity of oils which takes place with variations in temperature it is obviously necessary for the determination of viscosity to be made at standard temperatures in order that comparison may be made with the viscosity of water at the same temperature.

Viscosity is determined by an instrument known as a "viscosimeter," of which there are a number of different forms. The Saybolt universal viscosimeter was recommended by the American Society for Testing Materials and has been adopted as a standard in the United States. In England the Redwood viscosimeter is the standard, and the Engler meter has been adopted as a standard by the Germans. The Saybolt viscosimeter is shown set up in Fig. 72. At A is shown the top of a small container into which is poured the oil to be tested, and surrounding this container is a water bath the temperature of which is raised to the degree at which the test is to be made. Temperatures of 70, 100, 130, and 210 degrees F. are standards for the determination of viscosity (70 degrees on the Saybolt viscosimeter is practically obsolete; some oils deposit paraffin at this temperature and interfere with the test); the temperature to use depends on the viscosity of the oil, high temperatures being used for oils of high viscosity and low temperatures for oils of low viscosity. In stating the viscosity of an oil, information must also be given in regard to the temperature at which the test was made. The temperature of the water bath is raised by an electric heating element B, which is immersed in the water until its temperature has been raised to the required degree, as indicated by thermometers C and D. This heating element is then dipped into the bath or removed, as the case may be, to maintain the required temperature.

The oil to be tested is poured into pan E and passes from this through strainer F into container A in the viscosimeter. This container extends through the bottom of the water jacket, and has a small lower opening fitted with a stopper. Beneath this opening is a glass receiver G, which contains sixty cubic centimeters when filled to the graduation line at the neck. In conducting a viscosity test, the stopper is removed from the bottom of container A and oil is allowed to flow into receiver G until it is filled to the graduation line, the time in seconds required to do this being noted by means of a stop watch, and expressed as a number with the temperature, *i. e.*, Saybolt viscosity of 200 at 100 degrees F. When the "specific viscosity" is desired, the same test is conducted with water in place of the oil, and the viscosity of the water

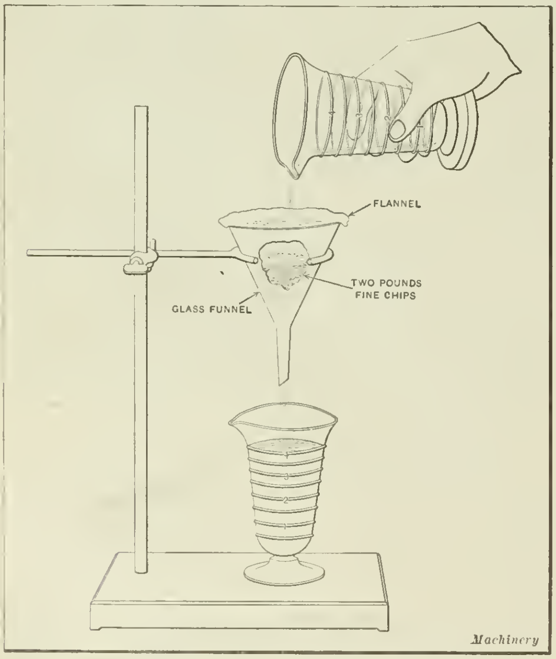

Fig. 70. Simple Method of testing Amount of Oil carried away by Chips

or the time required to run sixty cubic centimeters into receiver *G* divided into the time required for the same amount of oil gives the "specific viscosity."

$$\text{Specific viscosity} = \frac{\text{Viscosity of oil}}{\text{Viscosity of water}}$$

Flash Point

The flash point of an oil is the temperature at which sufficient vapor is given off to develop a temporary flash or flame when ignited by a taper or some other convenient means. The use of oils with a low flash point should be avoided, owing to the danger of their starting fires. This is particularly true in the case of automatic screw machines, etc., where kerosene is sometimes used to thin the oil to the required consistency, and where a large volume of oil is exposed in the pan. Determination of the flash point is commonly made in the Cleveland open cup apparatus illustrated in Fig. 73. This consists of a cup *A* filled with oil, in which is immersed an accurate thermometer *B* for measuring the temperature. The oil is heated by a Bunsen burner *C*, so the temperature will rise at the rate of ten to twelve degrees per minute, and with each three to five degrees rise in temperature the small gas taper *D* is applied by passing it horizontally over the surface of the oil. In most laboratories this test is made by applying the taper with each rise of five degrees F., but the American Society for Testing Materials recommends applying the taper after each rise of three degrees F. When the flash point is reached there will be a slight explosion at the surface of the oil, showing that the oil vapor is ignited, and the temperature indicated by thermometer *B* represents the flash point.

Fire Point

The fire point of an oil is the temperature at which the oil will continue to burn when a flame is applied to its surface. The determination of this temperature is made in the Cleveland open cup, shown in Fig. 73, used for ascertaining the flash point. The two tests are made together; that is to say, after the flash has been determined the temperature is raised still further with application of the taper at intervals of three to five degrees F., until the point is reached where the oil continues to burn when the lighted taper is applied to its surface. It will be evident that after passing the flash point there will be a momentary ignition of oil vapor each time the taper is applied to the oil, but this must not be confused with the fire point which is not reached until the temperature is sufficiently high to maintain a flame on the surface of the oil when it is ignited. The fire point of oils suitable for lubricating and cooling metal-cutting tools ranges from 30 to 65 degrees F. above the flash point, the average difference being 40 degrees F.

Cold Point

Oils become more viscous as they cool and finally solidify. Those with too high a cold test should not be used—especially in cold weather—because they are likely to give trouble by failing to run freely to the tools and work and by clogging up supply pipes, etc. In the case of lubricants containing oils refined from crude petroleum, cooling first causes the paraffin particles to solidify which gives the oil a cloudy appearance. The committee on lubricants of the American Society for Testing Materials has applied the terms "cloud test" to the temperature at which this takes place and "pour test" to the temperature at which the oil can just be poured. Both of these come under the general heading "cold test."

Fig. 74 illustrates apparatus for determining these temperatures; it consists of a bottle about 1¼ inch inside diameter and 4 or 5 inches high which is filled with oil to a depth of about 1¼ inch. A special cold-test thermometer is inserted through the cork, having colored alcohol and a long bulb which is immersed in the oil. The bottle of oil is placed in a container filled with cracked ice, and when the temperature of the oil is near the expected cloud-test point the bottle is removed for each two degrees drop in temperature and the oil inspected; when the lower half becomes opaque, the thermometer reading is taken as the cloud-test temperature.

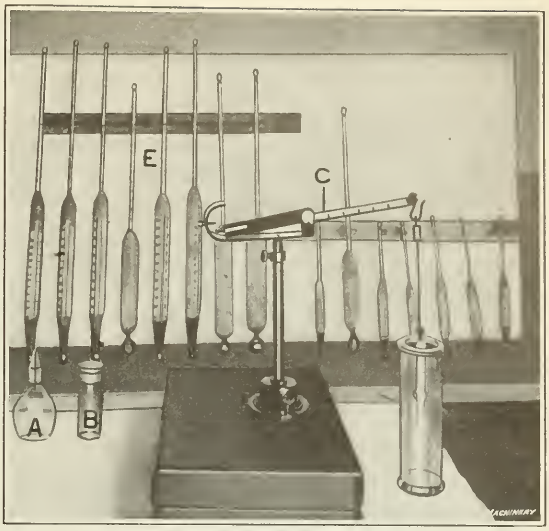

Fig. 71. Pycnometers, Westphal Balance and Baume Hydrometers for determining Specific Gravity of Oils

The pour test is simply a continuation of the cloud test, except that the temperature is noted for each drop of five degrees and the bottle is tilted each time. When the oil becomes solid and will not flow, the previous five-degree point is taken as the cold point of the oil. In making this test care must be taken to tilt the bottle slowly to avoid agitating the oil more than necessary. Where this precaution is not observed, too low a cold point will be found.

Free Fatty Acids

Free fatty acids represent the amount of free organic acid present in the oil, and this should not be confused with mineral acid, as free fatty acids are a normal constituent of the so-called "fixed" or fatty oils. Free fatty acids are determined by titrating in an alcoholic solution with a standard potash solution. The "acid number" is another method of expressing free fatty acids and is the number of milligrams of caustic potash required to neutralize one gram of the fat or oil.

Saponification

Saponification value of an oil is the number of milligrams of caustic potash required to completely saponify one gram of the fat or oil. A low saponification value generally indicates adulteration with mineral oil.

Iodine Number

Iodine value or number is the number of milligrams of iodine that one gram of a fat or oil will absorb under specific conditions, and for fixed oils the iodine value is usually fairly constant, marked variation indicating adulteration.

Purchase of Oils and Cutting Compounds Under Specification

When the quantity of oil or cutting compound used is large enough so that expenditures for this item run into considerable sums during the year, it is good practice to have definite specifications under which purchases are made. The Navy Department has drawn up specifications for the purchase of oils, soluble oils, and cutting compounds sold in the form of paste. Although these are more complete than those required by the average manufacturer, they are given in order to show the requirements for each of these materials.

NAVY DEPARTMENT SPECIFICATIONS

Oil, Lard, Mineral

Purpose—To be used for machine cutting-tool lubricant, either unadulterated or compounded with mineral oil or soda and water.

Composition—To be clean and homogeneous; free from disagreeable odors, rancidness, sediment, or ingredients injurious to persons handling the material; and to be easily soluble and retain oily consistency in kerosene or soda and cold-water mixtures. To have a specific gravity at 15 degrees C. of about 0.90, a flash point in an open tester of not less than

180 degrees C., and flow at 4 degrees C. To contain not less than 25 per cent and not more than 35 per cent fixed saponifiable oils, from 60 to 70 per cent mineral, and not more than 5 per cent free fatty acid (calculated as oleic acid).

Viscosity—Measured in a Saybolt viscosimeter (with thirty seconds water rate at 15 degrees C.) the oil to show about 185 seconds at 38 degrees C. and 115 seconds at 48 degrees C.

Gumming—A saucer with enough test oil to cover the bottom when placed in an oven at a constant temperature of 120 degrees C. for a period of eight hours, when taken out and permitted to cool gradually, shall show no signs of a gummy residue.

Corrosion—Strips of polished steel to show no appreciable corrosion in two weeks' time when partly immersed in samples of the oil, or in a mixture of the oil and kerosene, or in an emulsion of the oil, soda, and water.

Physical Test—Three gallons of the oil unadulterated will be put into a steel tank and pumped at the rate of one gallon per minute over a steel cylinder heated by an electric coil consuming 440 watts which maintains a constant temperature at 100 degrees C. in air. After a period of three hours the maximum rise of temperature of the oil shall not exceed 30 degrees C.

Soluble Cutting Oils or Cutting Compounds (Liquid Form)

Purpose—To be used in emulsion with water for machine cutting-tool lubricant.

Composition—To be a clean and homogeneous mixture of soluble alkali soap in mineral and fixed saponifiable oils. It shall be free from disagreeable odors, sediment, mineral acids, ingredients injurious to persons handling, and shall contain not more than 10 per cent water and not more than 20 per cent soluble alkali soap.

Emulsification—To be capable of readily mixing with water in all proportions without the use of sodium carbonate or other addition to form a stable emulsion.

Lubrication—The emulsified oil must lubricate turret and automatic machines sufficiently to prevent sticking, and must show no tendency to leave a gummy residue.

Corrosion—Strips of polished steel are to show no appreciable corrosion after immersion in the emulsion for two weeks.

Physical or Cooling Efficiency Test—When three pints of oil are put into emulsification with three gallons of water and permitted to flow at the rate of one gallon per minute over a steel cylinder heated by an electric coil consuming 440 watts designed to maintain a constant temperature of 100 degrees C. in air for a period of eight hours, the maximum rise of temperature of the emulsion shall not exceed 12 degrees C.

Cutting Compound (Paste Form)

Purpose—To be used for machine cutting-tool lubricant when mixed as directed.

Composition — To contain not more than 50 per cent water, not more than 25 per cent mineral oil and between 20 and 30 per cent alkali soap, and the remainder fixed saponified oils. To be free from disagreeable odors, rancidness, or ingredients injurious to handling; and to be easily soluble in water, forming a suitable stable lubricating emulsion which shows no tendency to leave a gummy residue and which will not appreciably corrode strips of polished steel in two weeks' time.

Physical Tests—When prepared in an emulsion such as recommended by the manufacturer, and which shall contain not more than 16 pounds of compound and not less than 24 gallons of cold water, it shall lubricate the tool so that in making 1-inch bolts 6 inches long turned to a finished size in one cut from 1⅝-inch hexagonal bar of nickel steel with three inches of chased thread on a turret monitor, with a travel of turret carriage, 6 inches in six seconds and flow of compound, 5 pounds per minute, the following conditions will obtain: The temperature rise of the stock shall not be greater than 35 degrees F., and the standard steel turning or parting tool not to require additional grinding until test is finished on ten bolts. The temperature during this test shall be measured by placing a chemical thermometer on the finished stock within one-half inch of the tool. The standard steel turning and cutting tool mentioned is of tungsten tool steel, class No. 2, in accordance with Navy Department specifications for "tool steel." The hexagonal nickel-steel bars will be in accordance with Navy Department specifications for "hot-rolled or forged nickel steel."

Fig. 72. Saybolt Standard Universal Viscosimeter and Auxiliary Apparatus for determining Viscosity of Oils

Use of Compressed Air as a Coolant

In milling cast iron and similar operations where the production of short chips makes lubrication of the bearing between the chip and lip of the tool a matter of minor importance, satisfactory results may often be obtained by the use of compressed air delivered to the tool and work in such a way that it absorbs the heat generated by the cut. An advantage of the use of compressed air is that there is absolutely no tendency to gum, and the work is clean and dry when it leaves the machines; also, absence of moisture does away with all danger of rusting the work or machine parts. Fig. 75 shows the method of applying compressed air in milling a typewriter part in the plant of the Royal Typewriter Co., Hartford, Conn. This bar has a slot 7/32 inch wide by 13/32 inch deep milled for its entire length, which is 8¾ inches. The compressed air is delivered through an air line arranged in such a way as to decrease the pressure at the machine to one pound per square inch. At each side of the milling cutters there are pipes *A* bent to the same radius as the cutters; a number of holes are drilled in these pipes, so that air impinges directly upon the milling-cutter teeth. The pressure of the air is not sufficient to cause the chips to be blown around, but the air absorbs heat from the cutters and work, preventing overheating and excessive wear. The slot is finished at a single cut by milling cutters 2¾ inches in diameter which run at 120 revolutions per minute. One piece is finished in one minute, twelve seconds. When finished, the work is sufficiently cool so that it can be picked up and held in the hand.

Fig. 76 shows another example of the application of compressed air for cooling cutting tools. In this case the operation is performed on a Cleveland automatic. The work is a 0.20 to 0.30 per cent carbon machine-steel piston-pin; this is of particular interest because although it is known that compressed air can be used in drilling cast iron with satisfactory results, few mechanics would expect to be able to use it in deep-hole drilling operations in machine steel. The automatic screw machine is fitted up with the regular oil-feed mechanism for the turret tools, but instead of forcing the oil through the piping, compressed air is delivered at a pressure of 75 pounds per square inch. The drill is a regular high-speed steel oil-tube type, with cutting edges ground to break up the chips so that they may be readily removed. So efficient is the compressed air that it is found unnecessary to withdraw the tool until the piece has been completely drilled to a depth of 5 inches, using a feed of 0.015 inch per revolution and a surface speed of 70 feet per minute. This speed is lower than a high-speed steel drill will stand,

but it has been found that a heavy feed with a lower speed gives the best results, as it produces chips which may be easily blown out. The chips are quite cool when they leave the hole and an excellent finish is produced. Before adopting compressed air, lard oil was used for this job, but this proved unsatisfactory due to heating and binding of the drill before the lubricant had reached the bottom of the hole. Apparently the oil made the chips adhere to one another and prevented them from being washed out freely, while with the air the chips are kept clean and cool and are blown out as rapidly as they are produced. This method is used at the plant of the Dayton Motor Car Co., Dayton, Ohio.

Discovery of Aquadag and Oildag—Compounds Containing Deflocculated Graphite

In 1906, Edward G. Acheson was experimenting with methods of treating carborundum in the electric furnace, and during the course of this work he discovered a small amount of very soft unctuous graphite, which he immediately recognized as an ideal lubricating medium. Commercial methods of making this graphite were developed and patented.

Having developed a method of producing this graphite Mr. Acheson undertook the problem of working out details for its application as a lubricant. His early efforts consisted in using the graphite dry or mixed with grease, the mixture being marketed under the copyrighted name "Gredag." In an effort to extend the field of usefulness of this graphite, experiments were conducted with the view of using the graphite in suspension in different grades of oil, but trouble was encountered by the graphite settling out. In the latter part of 1906, it was found possible to obtain a stable mixture of graphite held in suspension in water, by adding a small quantity of gallotannic acid. This treatment was defined as "deflocculation" and the graphite was called "deflocculated" graphite. The liquid is black and passes easily through the finest filter paper. This mixture of water and graphite was given the name "Aquadag." A valuable property of "Aquadag" is the fact that it does not have any tendency to rust the tools or work. In 1907, Mr. Acheson succeeded in transferring deflocculated graphite from the water medium to an oil medium in which it also remained permanently suspended, and this lubricant was given the name "Oildag." Both these lubricants are made by the International Acheson Graphite Co., Niagara Falls, N. Y.

Results Obtained with Compounds Containing Graphite

An idea of the efficiency of "Aquadag" and other compounds containing deflocculated graphite may be gathered from the experience of the Niagara Machine Co., Niagara Falls, N. Y. The records showed that the cutting-off tool of a lathe engaged in cutting off cold-rolled steel rods about one inch in diameter required sharpening about every sixty cuts when an ordinary soap cutting compound was used. When "Aquadag" was used to lubricate the tool, the life of the tool was increased to 980 cuts, and the finish was smoother.

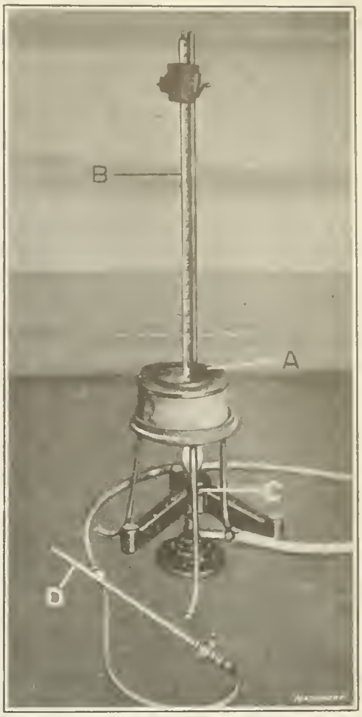

Fig. 73. Cleveland Open Cup for determining Flash Point and Fire Point of Oils

Since its discovery, "Aquadag" has been used for many other machining operations and has given very satisfactory results. For instance, in reaming holes in bronze bushings it was found that an ordinary cutting compound resulted in producing a hole about 0.0002 inch under size, due to the expansion caused by the heat generated by the cut; but when "Aquadag" is used for lubricating, friction and the generation of heat may be so far reduced that there is practically no expansion, and as a result the hole is practically the full size of the reamer. That power consumption is reduced through the use of this cutting compound is demonstrated by the fact that in one factory it was necessary to run a machine on back-gear when using an ordinary cooling compound, but when "Aquadag" was used, it was possible to operate the machine on open belt, thus securing the double advantage of a reduction of power and an increase of speed. This lubricant has been used for boring, cutting off, milling, thread cutting and other operations, and has given uniformly satisfactory results. However, the workmen are prejudiced against its use in spite of the efficient results obtained, as it makes them so dirty.

Oils Used as Tool Lubricants and Coolants

A great variety of oils are used for lubricating and cooling metal-cutting tools. The selection of a suitable lubricant will depend upon the class of machining operation and the kind of metal being machined, according to the principles explained. Some oils are used pure, notable examples being lard and petroleum oil; in other cases it is desirable to use a mixture of oils in order to obtain a lubricant of the required consistency and of lower cost than pure lard oil, etc.; still another

TABLE III. PHYSICAL AND CHEMICAL CONSTANTS OF OILS USED FOR LUBRICATION AND COOLING OF METAL CUTTING TOOLS[1]

Oil	Color	Odor	Appearance	Specific Gravity	Baume Gravity	Flash Point, Degrees F.	Fire Point, Degrees F.	Cold Test, Degrees F.	Saybolt Viscosity at 100 Degrees F.	Free Fatty Acid, Per cent	Acid No.	Saponification Value	Iodine Value	Cost per gallon in 1 Barrel Lots
Neatsfoot Oil	Strong Yellow	Animal Oil	Cloudy	0.923	21.7	390	460	35	270	18.70	37.15	197.6	56.4	1.10
No. 1 Lard Oil	Red Amber	Strong Lard Oil	Cloudy	0.912	23.6	398	453	44	182	39.71	78.84	195.0	64.4	1.00
Extra No. 1 Lard Oil	Yellow	Lard Oil	Cloudy	0.914	23.1	440	504	38	203	14.24	27.33	197.9	68.1	1.05
Sperm Oil	Pale Yellow	Faint	Clear and Bright	0.882	28.7	477	555	35	111	0.41	0.82	125.7	81.7	1.04
No. 3 Bleached Whale Oil	Dark Yellow	Characteristic	Clear and Bright	0.928	20.8	494	632	25	191	2.13	4.21	189.1	131.8	0.77
Fish Oil	Red Amber	Fish Oil	Clear and Bright	0.927	21.1	420	514	23	130	4.42	8.78	183.3	158.0	0.75
Olive Oil	Greenish Yellow	Denatured	Cloudy	0.916	22.9	505	632	10	203	3.41	6.77	187.1	82.9	1.35
Rapeseed Oil	Pale Yellow	Rape Oil	Clear and Bright	0.916	22.8	540	654	below 0	262	2.25	4.62	172.2	100.8	1.15
Peanut Oil	Pale Yellow	Peanut Oil	Clear and Bright	0.918	22.5	588	666	35	330	0.26	0.52	191.2	96.2	1.10
Cottonseed Oil	Yellow	Cottonseed Oil	Clear	0.920	22.1	476	660	21	168	0.21	0.41	193.0	106.4	1.10
Tallow Oil	Yellow	Tallow	Solid	0.913	23.4	565	646	88	54 (210° F.)	0.62	1.21	189.3	48.7	1.10
2nd Run Rosin Oil	Red Amber	Rosin	Syrup	1.056	0.8	270	354	24	63 (210° F.)	30.0	59.63	48.5	.....	0.32
Mineral Lard	Yellow	Fixed Oils	Clear and Bright	0.882	28.8	404	470	20	184	2.87	5.71	45.6	43.1	0.46
Penn. Petroleum	Red Amber	Mineral Oil	Clear and Bright	0.878	29.5	395	442	30	189	.....	.....	.....	.....	0.27

Machinery

[1] Values determined by tests conducted by Charles V. Bacon, consulting chemist of New York City. Care was taken to select samples of oils that were pure and representative of average quality obtainable in the market at the present time.

application is in the compounding of so-called soluble oil mixtures that are diluted with water to form the cutting emulsions.

There are three chief classes of oils, namely animal oils, vegetable oils, and mineral oils. As their name implies, animal oils are extracted from the fatty tissues of certain animals and fish; vegetable oils are obtained from the fruits or seeds of numerous plants. Both of these are known as "fixed" oils, because they cannot be vaporized or distilled when heated without undergoing chemical decomposition. This distinguishes such oils from the "volatile" oils, which may be readily distilled by the application of heat without being decomposed. These are known as mineral oils because they are obtained from petroleum or rock oil. Certain vegetable oils when exposed to the air absorb oxygen rapidly, forming an elastic varnish-like film, and on this account they are known as "drying" oils, of which linseed oil is the best known example. Other vegetable oils show no tendency to form such films and are known as "non-drying" oils. There is a third class, called "semi-drying" oils, which comes between the two preceding classes. Either non-drying or semi-drying oils may be used for cutting lubricants. All fixed oils contain a certain amount of fatty acids, and if allowed to stand in the air this increases and the oil becomes rancid. It is not within the province of this article to enter into a discussion of the chemistry of oils, but it will be of interest to explain briefly the methods used in obtaining the more important classes of oils used for lubricating and cooling cutting tools.

Cottonseed Oil—This oil gives good results when used pure for lubricating taps and threading tools, etc. It is also used as a constituent of some mixed oils and cutting compounds. As its name indicates cottonseed oil is obtained from the seeds of cotton plants, extraction being effected by the application of pressure. The presence of dark brown cell materials in the kernel imparts a deep red color to the oil as it runs from the press, this color depending largely upon the freshness of the seeds. The crude oil is refined by treating it with a weak solution of caustic soda, which reduces the color to a pale yellow or light brown. The best grade is known as "prime summer yellow" and should be free from water and possess a sweet flavor and odor. A second grade, known as "summer oil" will become cloudy and partly freeze at a comparatively high temperature, a fatty material separating out, which is known as stearine. By suitable treatment, cottonseed oil may be made to remain perfectly clear at 32 degrees F. for a considerable length of time; oils of this grade are known as "winter oils"—either "prime winter white" or "prime winter yellow." Cottonseed oil comes in the "semi-drying" class.

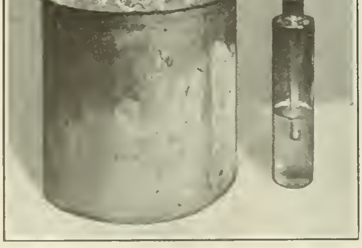

Fig. 74. Cold Test Apparatus with One Bottle in Place and One standing beside Freezing Mixture Container

Fish Oils—These oils are more extensively used in the heat-treatment of steel than in lubricating. As implied by its name, menhaden oil is obtained from menhaden, which are somewhat larger than herrings. In extracting the oil, the fish are placed in boiling pans and treated with steam which digests the flesh in such a way that after standing for some time oil rises to the top of the water and is skimmed off. The color of this oil depends upon the freshness of the fish from which it is extracted and upon the length of time that the boiling process is continued. The darker grades of oil are obtained when the boiling process is conducted for too long a time or when the fish is putrid. The crude oils vary in color from yellow to brown, but are bleached in the process of refining to almost a pure white. Unfortunately, various grades of fish oil are often substituted for menhaden oil. These are extracted from many kinds of fish by a method similar to that described. All fish oils are characterized by their distinctive odor, which is likely to be very rank in the case of dark colored oils.

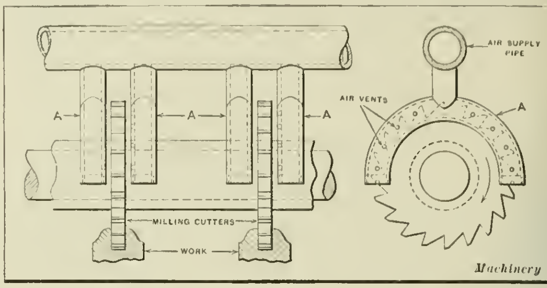

Fig. 75. Method of cooling Milling Cutters with Compressed Air

Lard Oil—This is one of the most generally used cutting lubricants, and is either used pure or as a constituent of oil mixtures or cutting compounds. The best grade of lard oil is extracted from layers of fat, known as "leaves," taken from the loins of the hog. This fat is placed in cloth bags and subjected to hydraulic pressure which squeezes out the oil. Other grades of lard oil are obtained by boiling in water the fats and tissues surrounding the abdomen. The lard is skimmed from the surface and kept warm for several hours to allow the tallow to crystallize, this process being known as "seeding." The seeded lard is then put into cloth strainers and subjected to hydraulic pressure which produces the lard oil of commerce. Lard oil may be of the following grades: "Prime winter strained," "prime," "off prime," "extra No. 1," "No. 1," and "No. 2," depending upon the class of material from which it is extracted. Judged from the standpoint of users of cutting lubricants, the chief difference between these lies in the percentage of fatty acid, which may run as high as 30 per cent in the case of a very poor grade of oil. This is a severe detriment on account of the corrosive action exerted by this acid on the work—notably in the case of brass products—and on the bearings of machine tools. To give satisfactory results lard oil should not contain over 15 per cent of fatty acid. Depending upon the temperature and pressure employed in its preparation, the "cold test" or temperature of solidification varies greatly, so that some grades of lard oil will deposit a fatty material, known as stearine, at ordinary room temperature and become stiff at 50 degrees F. High grades of lard oil will remain clear at much lower temperatures. The colors of lard oil range from practically water white to a deep brown, oils of darker color being the inferior grades.

Neatsfoot Oil—As a cutting lubricant, neatsfoot oil is recommended for use on broaches—especially when working on very hard material. Neatsfoot oil is generally understood to be obtained from the feet of cattle, but the commercial oil sold under this name is also extracted from the feet of sheep, hogs, horses, and other animals. Extraction is carried on in the following way. The feet are scalded with boiling water to loosen the hoofs, which are then pulled out and the feet are boiled for eight or ten hours. Oil rises to the surface of the water and is skimmed off from time to time, being poured through a screen to separate as much as possible of the suspended matter, after which the oil is dried with steam pipes and filtered. The purpose of removing the hoofs from the feet is to prevent darkening the color of the oil. If proper care is taken in its preparation, neatsfoot oil is low in fatty acid—generally less than ½ per cent—but commercial oil of poor grade may contain as much as 25 or 30 per cent. Neatsfoot oil is of a yellow color and it flows freely.

Olive Oil—Some people recommend olive oil as a substitute for lard oil for lubricating cutting tools. It is said to flow more freely and give less trouble through becoming thick in

cold weather. Olive oil costs more than lard oil, but it is said to be a highly efficient lubricant and the amount of oil carried away by chips is less than is the case with lard oil. This oil is extracted from olives and is sold in many different grades, the best of which—known as "edible oil"—is obtained from hand-picked olives. These are crushed in a mill without breaking the seeds, and after separating the fruit from the seeds the oil is extracted in a hydraulic press. A second grade of oil is obtained by pouring cold water over the pressed fruit and subjecting it to a second pressing operation, after which the pulp is once more mixed with hot water and again

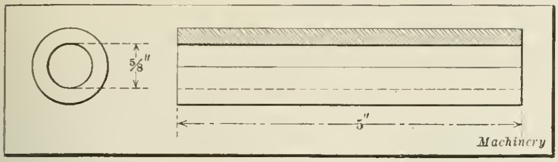

Fig. 76. Machine-steel Piston-pin drilled with Compressed Air as Coolant

pressed to yield a third grade of oil. The color of olive oil varies from pale greenish yellow to a dark olive green; as the coloring matter is extracted from the olives with the oil, the lower grades have the highest color. These grades are inferior for use as lubricants, because their high fatty acid content tends to give trouble from gumming and corrosion. Olive oil is a "non-drying" oil.

Petroleum Oil—Mixed with lard oil in various proportions, petroleum finds application as a constituent of the well-known cutting lubricant known as "mineral" lard oil. It is also employed in the soluble oil compounds; and for such machining operations as milling and drilling it may be used pure. Crude petroleum oil is obtained in many parts of the world, notably in the states of Pennsylvania and Texas, in Mexico, and in Southern Russia. Crude oil, as it comes from the wells, carries considerable suspended mineral matter which must be removed. As previously mentioned, petroleum oil is of the so-called "volatile oil" type, and is refined by distilling. The stills are heated at different temperatures in order to divide the oil into "fractions" of various composition. Important among these are naphtha, gasoline, and kerosene, which are obtained at the lower temperatures; then come the different grades of lubricating oils and greases that are secured by the successive application of higher temperatures. The color of those grades of petroleum oil used as cutting lubricants is dark yellow or light brown.

Rapeseed Oil—As a constituent of certain oil mixtures and cutting compounds, this oil finds a limited application in machine-shop work. It sometimes goes under the trade name of "Colza" oil and is extracted from rape seed. This is a "semi-drying" oil; the color is pale yellow and it has a high viscosity and flows slowly.

Rosin Oil—This oil is used as a constituent of certain cutting compounds. It is obtained by subjecting rosin to a process of destructive distillation. This consists of heating rosin in a retort to a temperature sufficiently high for it to be decomposed, allowing vapors to be driven off; among these are the vapors of rosin oil. This process is carried on in cast-iron stills which hold charges ranging from three to five tons. Crude rosin oil is a brown viscous liquid with a characteristic odor and noticeable luminescence of a bluish or violet tinge. When kept at a temperature of 300 degrees F. for several hours the crude oil loses about 4 per cent of its more volatile constituents and assumes a green luminescence which, however, can be removed by chemical treatment, giving a finished oil of a pale brown color. Rosin oil is a "drying" oil, and is not suitable for use as a lubricant except as a constituent of certain mixtures.

Sperm Oil—Toolmakers of the old school still regard sperm oil as the best possible cutting lubricant for difficult machining operations, but its scarcity and high price limit the use of this oil to relatively few shops. Sperm oil is extracted from the contents of the head cavity and several smaller receptacles throughout the body of the sperm whales. During the life of the animal the contents of these cavities are in a fluid condition, but no sooner has this "head matter" been removed than white crystalline flakes of wax, known as spermaceti, separate out, leaving a clear yellow fluid possessing a distinctive fishy odor. This sperm oil is the lightest and most fluid of all the fixed oils. An inferior grade of sperm oil is obtained from the blubber of sperm whales. Practically all sperm oil is extracted on shipboard and the crude oil is delivered to refineries, where it is placed in tanks and chilled to 32 degrees F. and allowed to stand for a couple of weeks to freeze out the spermaceti. The semi-solid mass is placed in cloth bags and subjected to hydraulic pressure which squeezes out the oil known as "winter sperm." The material left in the bags is warmed to 50 degrees F. and again pressed to obtain "spring sperm oil." A third quality of oil, known as "taut pressed sperm oil," is obtained by further pressing at higher temperature. Refined sperm oil is of a pale yellow color and has only a faint odor. Certain grades of fish oil and whale oil are often sold for sperm oil.

Tallow and Tallow Oil—These materials are sometimes used in making cutting compounds. Tallow is the general name applied to the fat of certain animals; an adjective preceding it indicates the source, as beef tallow is obtained from cattle, mutton tallow is obtained from sheep and goats, etc. The process of melting out the fat from the tissue and membrane is generally carried on in large kettles heated by live steam. At temperatures from 60 to 80 degrees F., tallow is a mixture of solid and fluid fats, and if subjected to pressure the fluid can be separated, tallow oil being the name applied to this liquid. Beef and mutton tallow are similar in general characteristics, and as regards their application for commercial purposes the term "tallow" may indicate either one. Tallow is white and the color of tallow oil is pale yellow.

Whale Oil—As a cutting lubricant, whale oil finds application in making cutting compounds and as a constituent of mixed oils. The best grade of whale oil, known as "train" oil, is extracted from the blubber of Arctic or Greenland whales, but the whale oil of commerce is obtained from many species of whales. Some whale oil is extracted on shipboard, and the crude oil is delivered to refineries on the coasts. The blubber of a large whale will sometimes yield as much as 7500 gallons of oil, while a small whale will only yield from 50 to 100 gallons. The best grades of whale oil are obtained from the first boiling, after which the blubber is subjected to a

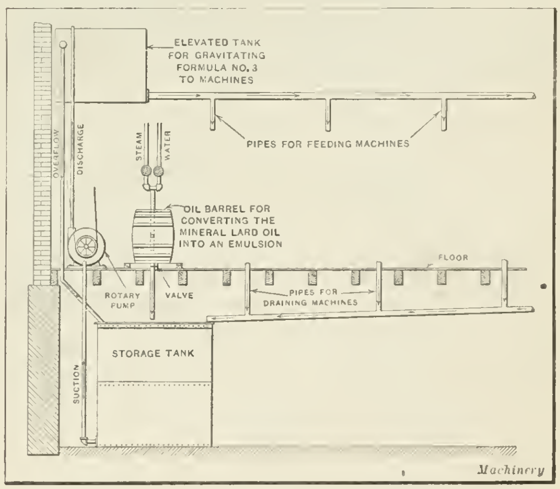

Fig. 77. Barrel for mixing Soluble Oils and Cutting Compounds with Water—Note Arrangement of Steam and Cold Water Pipes and Drain Pipe for delivering Compound to Storage Tank

second treatment, which yields a slightly inferior oil. These are known as No. 0 and No. 1, respectively. A third grade of oil is extracted from the residual blubber and flesh of the whale. Even the best grades of this oil have marked drying properties, making them unsuitable for use as a lubricant in the original condition. The color varies from white to yellow, according to grade, and is a fairly reliable indication of quality.

EXAMPLES OF EXPENSIVE TOOL DESIGNING

SOME DESIGNS IN WHICH A LITTLE FORETHOUGHT WOULD HAVE SAVED MONEY

BY F. B. JACOBS [1]

ANYONE conversant with up-to-date manufacturing methods realizes that tool designing is a comparatively expensive branch of engineering, and the mistakes of the tool designer often have a far-reaching effect. No one realizes this better than the toolmaker himself. As a practical illustration of the cost of faulty design, a few simple operations observed in several up-to-date tool-rooms are here described.

The box jig illustrated in Fig. 1 is for drilling and reaming four holes in a ring that is held on a pilot made integral with the base. This design made the machine work difficult, because the space between the pilot and the front and back sides of the jig was only 5/8 inch, which prohibited the use of an ordinary left-hand half-diamond-point tool. With a tool of this kind, the pilot could have been finished in a half hour's time after the job was set up. Owing to lack of clearance, the ends of the jig struck the bottom of the tool, so that it was necessary to use a specially made light, square-nose tool held in a boring-tool holder. It took one hour to hunt up stock and make the tool, and four hours to finish the job. Five hours' time against a half hour at a rate of fifty cents per hour shows a deficit of $2.25. To be sure, $2.25 is not going to make or break any concern, but when this amount can be saved on one simple operation by a little thought on the part of the designer, the error is inexcusable. By making the jig 1½ inch longer, which would have allowed ample clearance, $2.25 would have been saved. A still better way would have been to make the pilot of a separate piece of steel and fasten it to the jig base by screws and dowel-pins. In this case all the surfaces could have been finished on the shaper, which would eliminate setting up the piece on the lathe faceplate.

In a jig of this type it is necessary for the bushing plate to fit the jig body accurately, as the bushings and pilot are on separate pieces. There are four fitted surfaces on the bushing plate illustrated, and to machine them accurately they were done with the periphery of a small end-mill, all four surfaces being machined at one setting. Notwithstanding the fact that the superfluous stock was removed by a previous operation, the finishing operation consumed two hours. If the jig had been designed a little wider, to allow for a straight bushing plate, the fitted surfaces could have been finished on the shaper in a half hour's time. Thus the work required on this part of the jig cost seventy-five cents more than it should have, figuring on a basis of fifty cents per hour.

[1] Address: 435 Harvard Place, Indianapolis, Ind.

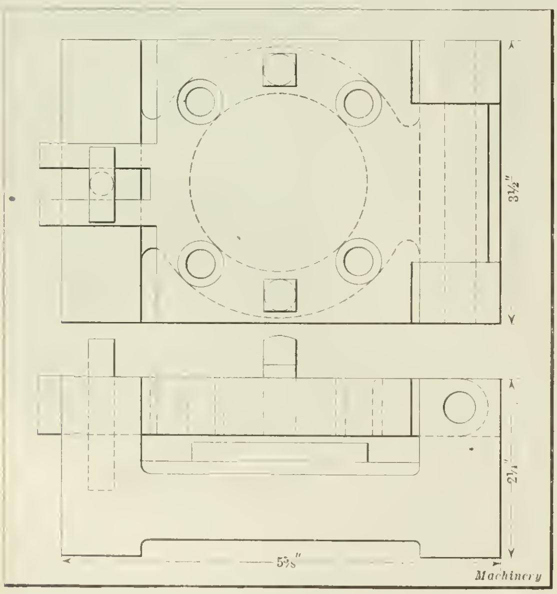

Fig. 1. Uneconomical Design of Box Jig for drilling and reaming Four Holes in a Ring

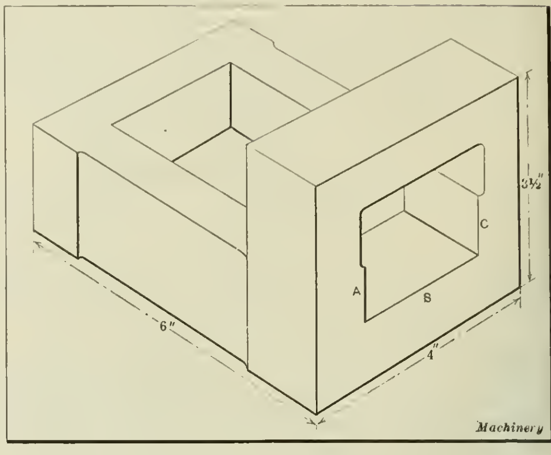

Fig. 2. Jig Casting with Solid Bridge for Set-screw

In a jig with an accurately fitting bushing plate, it is necessary to bore the hole for the hinge pin, for if the job is done otherwise, a slight error will cause a cramping action due to poor alignment. Why the average tool designer persists in specifying small hinge pins is a question that has never been satisfactorily answered. In this case the hinge pin called for was 3/8 inch. The hole was bored on the milling machine to within 0.002 inch of the desired size and then reamed with a hand reamer 0.001 inch under size to allow for a drive fit on one end of the pin, the remainder being filed to a slip fit. The toolmaker could not find a suitable small boring-bar, so he made one, which took an hour. Owing to the small size of the hole, several very light chips had to be taken with a fine feed, which brought the total time of finishing this work to two and one-half hours. Had the specifications called for a larger hinge pin, say 5/8 inch, heavier cuts could have been taken, making it possible to finish the hole in an hour. Thus it is seen that this slight error cost seventy-five cents.

The bushing plate in question was made of steel, finished very accurately. This was, of course, necessary, for if the buttons for truing up the holes before boring were set on a surface that was out of parallel, accurate results could not be guaranteed. It took three hours to plane the bushing plate, which is altogether too much. If the plate had been made of cast iron, with bosses cast for the buttons, the planing could have been done in an hour; the extra two hours spent add another dollar to the unnecessary part of the cost of the jig. Thus it is seen that $4.75 was the cost of a few slight errors. If the jig had been designed properly, the average toolmaker would have experienced no difficulty in completing the work in thirty-eight hours, which is a very fair estimate and allows him plenty of time to gossip at the tool-crib window and to make a few shop calls. Thirty-eight hours at fifty cents per hour equals $19; and as the cost of the errors is one-fourth this amount, the jig cost 25 per cent more than it should.

In an attempt to lessen the number of parts of a jig, the tool designer often makes unnecessary work for the toolmaker. An illustration of this is shown in Fig. 2, which represents a jig casting with a solid bridge over the top for the purpose of carrying a set-screw for holding the work. Owing to the solid construction, the surfaces *A*, *B* and *C* had to be planed by means of a reach tool, which is always comparatively slow cutting; and as three settings were necessary, five hours was consumed in finishing these surfaces. In this case, the bridge should have been made of a separate piece of cold-rolled or ma-

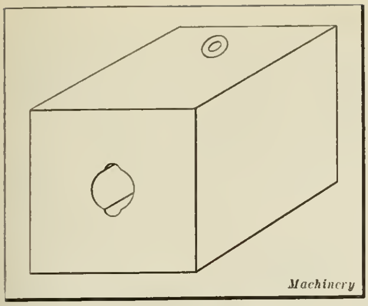

Fig. 3. Simple Jig for drilling Cotter-pin Hole

chine steel fastened in place by means of two fillister- or hexagon-head cap-screws; then all three surfaces could have been finished at one setting and in one hour. In some cases a solid form of construction is to be recommended, but the tool designer should consider carefully the amount of machine work necessary to execute his designs before putting them down in black and white.

In Fig. 4 is shown a handy form of jig for drilling a small cotter-pin hole in the piece shown to a larger scale at *A*. Jigs of this kind are excellent for some purposes, as they are comparatively cheap and quickly operated. In this instance, however, it is a case of too much jig for a very simple operation. To be sure, the jig looks simple, as it consists of two plates, with the upper one hinged, and two jaws to grip the work. As a matter of fact, it represents about fifteen hours' work for the average toolmaker. For this particular operation a more satisfactory jig is illustrated in Fig. 3; this is nothing more nor less than a block of steel with a hole drilled in it for receiving the work and a hole for guiding the drill. The larger hole is slightly relieved at the top and bottom, as otherwise the burr thrown up by the drill would make it difficult to remove the piece. The hole for the drill is countersunk at the top for starting the drill readily. This jig can be made of a piece of cold-rolled steel and protected against wear by case-hardening. As the hole for the drill does not have to be lo-

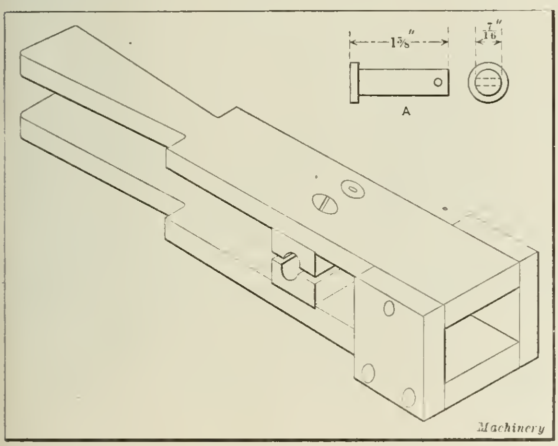

Fig. 4. More Costly Form of Jig than that shown in Fig. 3 for drilling Cotter-pin Hole

cated any nearer than within 0.005 inch of the required dimension, this jig can be made by any toolmaker in an hour, and, furthermore, it is much easier to operate than the one previously shown, as the action of holding the jig in the hand keeps the shoulder of the piece against the locating surface. This jig would drill several hundred thousand pieces before wearing out, in which event it could be replaced at slight cost.

The built-up design of jig illustrated in Fig. 5 is sometimes employed even in well regulated shops. It is a costly form of construction, as many pieces have to be fitted accurately. In the jig shown, the body is made of four pieces; the baseplate, two end pieces, and the ledge under the front of the bushing plate. As it is necessary to finish each piece all over, there is at least nine hours' work on the shaper, besides an hour's work in assembling. If the body were cast in one piece, it would be a comparatively easy matter to finish it in four hours. Built-up jigs are generally ordered when the management is in a hurry, or thinks it is, which is the same thing as far as the tool-room is concerned. To be sure, this construction saves the patternmaker a little time at the expense of the tool-room, but there is no ultimate saving, and as the design in question offers no real advantages, it seldom finds favor with up-to-date designers. At best, it is a relic of the days when toolmakers made jigs to suit themselves; and as this form of jig could be finished all over and then elaborately ornamented by scraping, it was a general favorite with the toolmakers of a quarter of a century ago. When we are in a hurry the temptation to "start something" right away is great,

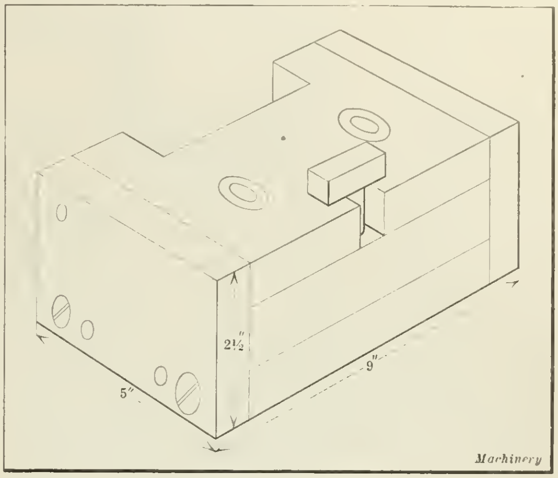

Fig. 5. Costly Built-up Jig

and often results in throwing an unnecessary burden on the tool-room. As 90 per cent of these so-called "hurry jobs" generally result in tools far below normal in efficiency and away above normal in cost, it is best to plan carefully and proceed in the regular way. It is the writer's opinion, based on many years of experience in the manufacturing world, that fully one-half the so-called "hurry orders" for tools are purely imaginary. It is common for managers to put through hurry orders for tools which, after they are completed, often lie on the toolmaker's bench for several days, and sometimes weeks, before being used.

Needless expense caused by inefficient tool designing may be found even in the case of very simple pieces. A good example of this is illustrated in Fig. 6, which shows a ring nut used on adjustable reamers, counterbores, and similar tools; this nut has four slots milled in its periphery for the accommodation of a spanner wrench. In milling these slots, the toolmaker first puts the dividing headstock and tailstock on the milling machine, if he is fortunate enough to find one vacant. Next he goes to the tool crib for an arbor and cutter, and after the job is set up he proceeds with the milling operation. It requires about one hour to mill the four slots in each of the nuts. Of course, if the toolmaker is fortunate enough to find a nut arbor long enough at the threaded end to hold the two nuts at one setting, the time will be reduced somewhat. As spanner wrenches are hard to find in any shop, these nuts are generally set up by means of a cold chisel, which soon batters them out of shape. A better form is shown in Fig. 7. In this case, four holes are drilled for the accom-

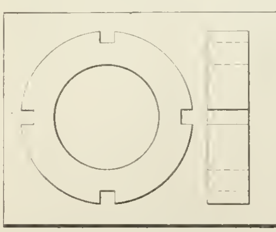

Fig. 6. Ring Nut used on Adjustable Reamers

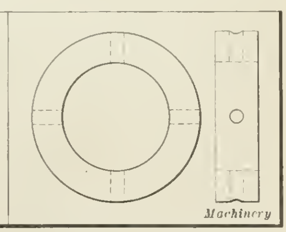

Fig. 7. Improved Form of Ring Nut

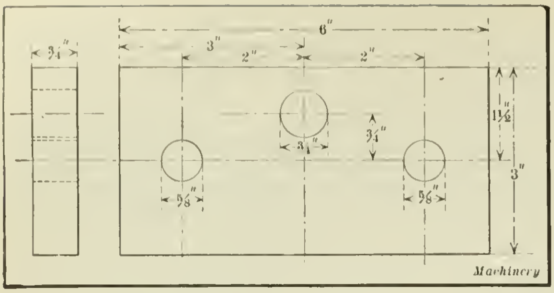

Fig. 8. Simple Piece for which Jig is to be made

modation of a tommy bar, which can be cut off from a rod of cold-rolled steel in a few seconds. As any boy can lay off and drill eight of these holes in a few minutes, it is seen that this design is the more economical in the long run.

Simple jigs can, of course, be constructed cheaper than complicated ones; but it does not follow that the simple jig is the most efficient in service, and this factor brings up a point that must not be overlooked; that is, the tool designer must be informed as to how many pieces are wanted that he may design his jig accordingly. If only six pieces like that shown in Fig. 8 are wanted, it would not be economical to design a jig for this purpose, as the six pieces may be clamped together, strapped to the platen of the milling machine, and all bored at one setting, due care being exercised to see that the spacing of the holes is correct. If fifty pieces are wanted, it would hardly be worth while to design a complicated jig, as a simple templet jig, shown in Fig. 9, will be more efficient than the method of boring on the milling machine. This is

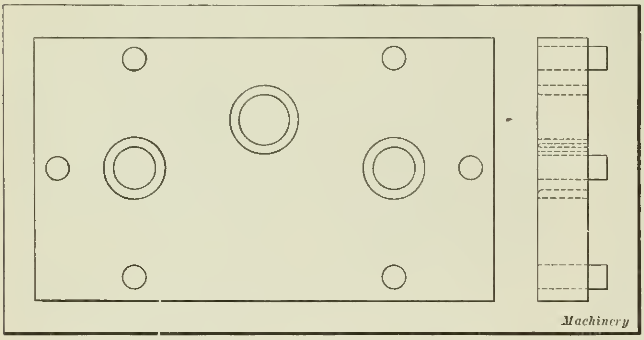

Fig. 9. Suitable Jig for making Piece shown in Fig. 8 in Small Quantities

the simplest form of jig that can be devised, as it consists merely of a plate with bushed holes to provide against wear and a few pins for locating the work. It is fastened to the piece to be drilled by means of two machinist's clamps. If several hundred pieces were wanted, the templet jig would prove too slow, as much time would be lost in clamping the templet to the work; besides, the drilling operation is unhandy, as it is necessary to support the work on parallels. A simple and convenient form of jig for this case is shown in Fig. 10. Here the templet jig is provided with four legs, to eliminate setting the work on parallels, and two quick-acting clamps. However, if a very large number of pieces are to be drilled, say 200,000, it would be economical to design a quick-acting jig, like that shown in Fig. 11. Here the work rests on a hardened pad, to prevent undue wear, and the feet of the jig are provided with hardened ends. Two adjustable screws, set to grip the work when the clamp bar is fastened, hold the work in place, and the clamp bar is fastened by means of an eccentric latch. In comparing this jig with the one illustrated in Fig. 10, it will be found that fifteen seconds is saved in getting the work in and out of the jig. To be sure, fifteen seconds does not amount to much in itself, but when drilling 200,000 pieces, fifteen seconds saved on each piece amounts to 3,000,000 seconds on the whole lot. Three million seconds equals 833 hours, in round numbers, and at thirty cents per hour, which is a fair wage for work of this kind, it means an actual saving of $249.90.

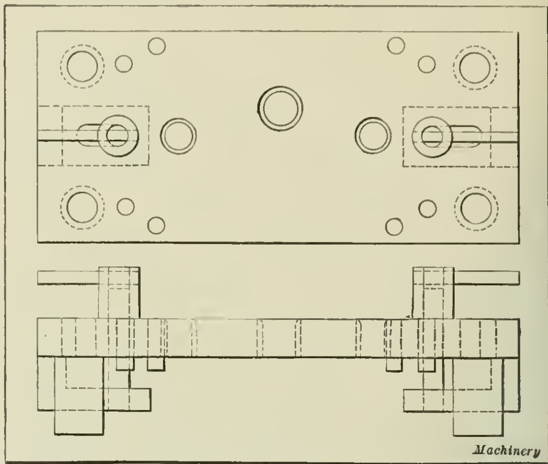

Fig. 10. Suitable Jig for making Moderate Number of Pieces like that shown in Fig. 8

Notwithstanding the fact that the illustrations of poor tool designing shown in this article are simple, they will, no doubt, bring to the mind of the practical man many instances where a saving can be shown by designing efficient jigs. It would not be fair to say that the tool designer must be a practical toolmaker in order to design efficient tools. He should, however, familiarize himself with the rudiments of actual tool-room practice to avoid simple blunders of the kind mentioned. Any toolmaker or tool-room foreman, provided he is a broad-minded man, will not hesitate to point out to the tool designer where money can be saved by designing jigs and fixtures that are readily machined. Tool designing as practiced at present, in the majority of shops at least, is far from efficient, owing to the fact that the men are prone to think that their responsibility ceases as soon as their drawings have passed inspection by the checker. Tool designers, taken as a class, can remedy this defect by spending an occasional hour or so in the tool-room noting actual operations and the time consumed in completing them. By applying the knowledge thus gained in their designs they will add materially to their efficiency.

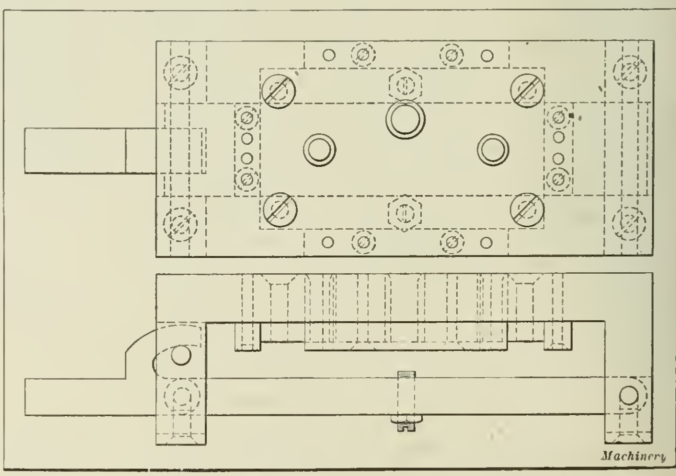

Fig. 11. Jig Suitable for making Large Number of Pieces like that shown in Fig. 8

INTERNAL BEVEL GEARING[1]

DESIGNING AND MACHINING INTERNAL AND CROWN BEVEL GEARS OF VARYING- AND PARALLEL-DEPTH TYPES

BY REGINALD TRAUTSCHOLD[2]

THE use of internal bevel gearing is limited to installations in which the included angle between the gear and the pinion shafts (the shaft angle), viewed from the rear of the gears, is appreciably greater than 90 degrees. This gearing is used, therefore, far less frequently than bevel gearing of the common externally meshing type. The pinion cone of revolution, in internal bevel gearing, rolls on the interior surface of the concave gear cone of revolution, while in the more common type of bevel gearing, the pinion cone of revolution rolls upon the exterior surface of the convex gear cone of revolution. The shaft angle, viewed from the rear of the gears, for internal bevel gearing may range from an angle quite appreciably greater than 90 degrees to one approaching 180 degrees, a range of considerably less than 90 degrees. The shaft angle of ordinary externally meshing bevel gears, on the other hand, may range from a comparatively small angle to one approaching 180 degrees, a range more than double that of internal bevel gearing.

Notwithstanding the more limited range of internal bevel gearing, the possibility of securing relatively high speed ratios within a limited space gives this type of transmission an important field—a field that would be more generally recognized and more thoroughly covered if the design of internal bevel gears were more commonly understood. Failure to recognize the adaptability of internal bevel gearing is quite probably due to an unfortunate practice, which has become almost universal, of designating the shaft angle in a different manner from that employed for the designation of the shaft angle for externally meshing bevel gears. In the common variety of bevel gears, the shaft angle is correctly designated as the sum of the center angles of the gear and pinion, as shown in Fig. 1; but in internal bevel gearing, the shaft angle is usually designated as the angle measured by the difference between the center angles of the gear and the pinion. Actually, the included shaft angle—the true shaft angle—is not measured directly by the difference between the center angles of the gear and the pinion, but by the supplement of the angle measured by such difference, as can be seen by referring to Fig. 1.

[1] For other articles on internal gearing, see "Internal Helical Gearing" in the February, 1917, number of MACHINERY and "Internal Spur Gearing" in the January number.
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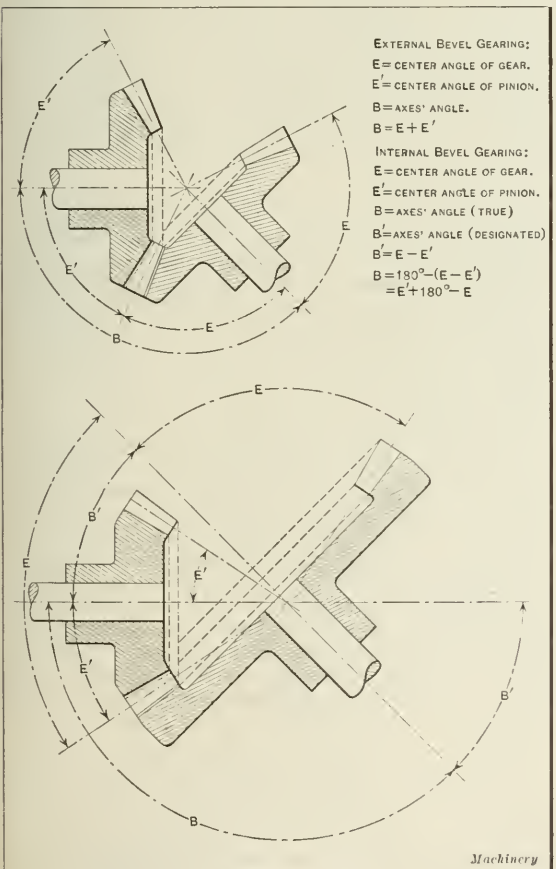

Fig. 1. Relation of Center Angles to Angle of Axes

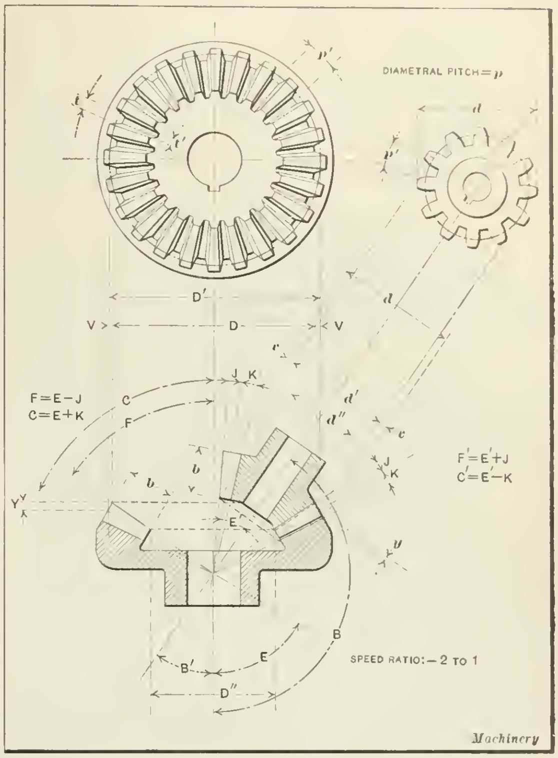

Fig. 2. Typical Internal Bevel Gears

But for the fact that the true shaft angle must necessarily be obtuse in internal bevel gearing—that is, the included angle between the gear and the pinion shafts must be greater than 90 degrees—the calculations involved in the design of internal bevel gearing are no more complicated than those required in laying out the more common variety of externally meshing gears. The tooth proportions do not differ in any way from those of ordinary bevel gears, being on the octoid system, as only such form can be practically conjugated by bevel-gear generating machines. In the formulas that will be presented for the derivation of the center angles, the supplement of the true shaft angle—the "designated shaft angle"—is employed, notwithstanding the fact that this may tend to a certain confusion, as the formulas are thereby simpler in form and more conveniently applicable.

Fig. 2 illustrates a typical lay-out of internal bevel gearing with the more important dimensions, etc., indicated according to the notation given in the following. The tooth proportions on the outer pitch circle are those employed in designating sizes of gears, as the factors entering the various formulas, etc., unless other dimensions are specifically noted.

Notation for Internal Bevel Gearing

	Gear	Pinion
Diametral pitch	p	p
Circular pitch	p'	p'
Pitch diameter, outer	D'	d'
Number of teeth	N	n
Face	b	b
Apex distance	a	a
Addendum, outer	s	s
Clearance, outer	f	f
Dedendum, outer	$s+f$	$s+f$
Depth of tooth, outer	W	W
Center angle	E	E'
Face angle	F	F'
Cutting angle	C	C'
Angle increment	J	J
Angle decrement	K	K
Diameter increment	V	v
Backing	Y	y
Outer diameter { gear, inner end of teeth; pinion, outer end of teeth }	D	d
Inner diameter { gear, inner end of teeth; pinion, outer end of teeth }	D''	d''
Thickness of tooth on outer pitch circle	t	t
Thickness of tooth on inner pitch circle	t'	t'
Speed ratio	$R = \frac{N}{n}$	
Speed ratio reciprocal	$R' = \frac{n}{N}$	
Shaft angle, true	B	
Shaft angle, designated	B'	

Formulas for Internal Bevel Gearing

$$p = \frac{N}{D'};\ \text{or } p = \frac{n}{d'} \quad (1) \qquad p' = \frac{3.1416}{p} \quad (2)$$

$$D' = \frac{N}{p};\ \text{or } D' = Np'0.3183 \quad (3) \qquad d' = \frac{n}{p};\ \text{or } d' = np'0.3183 \quad (3a)$$

$$\operatorname{Tan} E = \frac{\sin B'}{\sin B' - R'} \quad (4) \qquad E' = E - B' \quad (4a)$$

$$a = \frac{D'}{2\sin E};\ \text{or } a = \frac{d'}{2\sin E'} \quad (5) \qquad s = \frac{1}{p};\ \text{or } s = p'0.3183 \quad (6)$$

$$s + f = \frac{1.157}{p};\ \text{or } s + f = p'0.3683 \quad (7) \qquad W = 2s + f \quad (8)$$

$$\operatorname{Tan} J = \frac{s}{a};\ \text{or } \operatorname{Tan} J = \frac{2\sin E}{N};\ \text{or } \operatorname{Tan} J = \frac{2\sin E'}{n} \quad (9)$$

$$\operatorname{Tan} K = \frac{s+f}{a};\ \text{or } \operatorname{Tan} K = \frac{2.314 \sin E}{N};\ \text{or } \operatorname{Tan} K = \frac{2.314 \sin E'}{n} \quad (10)$$

$$F = E - J \quad (11) \qquad F' = E' + J \quad (11a)$$

$$C = E + K \quad (12) \qquad C' = E' - K \quad (12a)$$

$$V = s\cos E \quad (13) \qquad v = s\cos E' \quad (13a)$$

$$Y = s\sin E \quad (14) \qquad y = s\sin E' \quad (14a)$$

$$D = D' - 2s\cos E \quad (15) \qquad d = d' + 2s\cos E' \quad (15a)$$

$$D'' = D - 2(b\sin F) \quad (16) \qquad d'' = d - 2(b\sin F') \quad (16a)$$

$$t = \frac{1.5708}{p};\ \text{or } t = \frac{p'}{2} \quad (17) \qquad t' = \frac{t(a-b)}{a} \quad (18)$$

Discussion of Formulas

The formulas presented for the pinion member of an internal bevel gear combination do not differ in any way from the formulas governing the design of ordinary externally meshing bevel gears. In the case of the internal bevel gear, however, the formulas are radically different and somewhat more complicated, on account of the internal arrangement and the variable center angle of the gear. The latter condition is similar to the varying effect of externally meshing bevel gears having an obtuse shaft angle, complicated by the concave face of the gear.

The center angle of the gear member is found by first ascertaining the tangent of the angle. This is equal to the sine of the designated shaft angle of the combination—the supplement of the angle included between the respective shafts of the gears—divided by the difference between the sine of the designated shaft angle and the reciprocal of the speed ratio. The center angle of the pinion is then readily found, being the

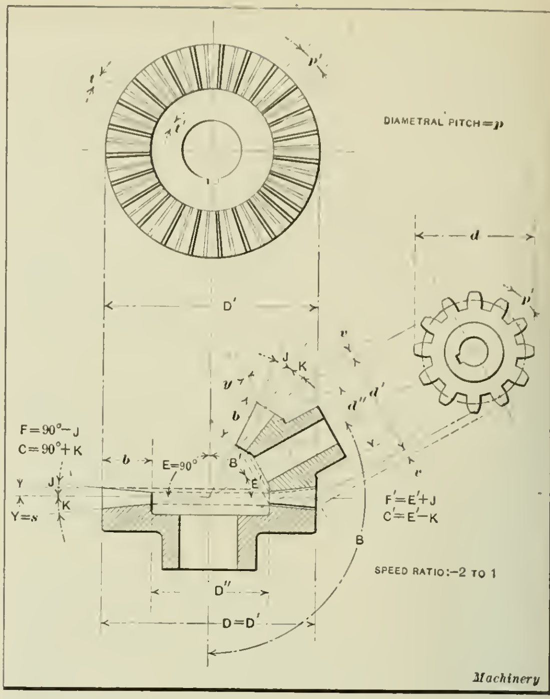

Fig. 3. Crown Bevel Gears

difference between the center angle of the gear and the designated shaft angle.

The tangents of the angle increment and decrement are, respectively, the addendum and the dedendum divided by the apex distance, the latter being the quotient of the pitch diameter (outer) divided by twice the sine of the center angle. For standard 14½-degree octoid teeth, twice the sine of the center angle divided by the number of teeth in the corresponding gear or pinion gives the tangent of the angle increment, and the product of the sine of the center angle by 2.314 divided by the number of teeth gives the tangent of the angle decrement.

The face and cutting angles of the internal bevel gear are equal, respectively, to the center angle minus the angle increment, and to the center angle plus the angle decrement, the increase and decrease of the center angle being the opposite of the pinion and ordinary externally meshing bevel gears. That is, the angle increment is subtracted from the center angle to obtain the face angle, instead of being added to that angle, and the angle decrement is added to the center angle to obtain the cutting angle, instead of being subtracted, as for ordinary bevel gears.

The diameter increment of the gear (actually a decrement) is found as usual, being the product of the addendum and the cosine of the center angle. Twice this value is subtracted from the outer pitch diameter of the gear to obtain the outer diameter of the gear—the diameter across the outer ends of the teeth. The outer diameter of the pinion member is equal to the sum of its outer pitch diameter and twice the product of the cosine of its center angle and the addendum.

The inner diameter of the gear—the axial distance between the inner ends of the teeth—is equal to the outer pitch diameter of the gear minus twice the product of the face of the gear by the sine of its face angle. The corresponding pinion diameter is equal to the difference between its outer pitch diameter and twice the product of its face by the sine of its face angle.

The thickness of the teeth of both the gear and the pinion on the outer pitch circles is, as usual, equal to half the circular pitch, or to 1.5708 divided by the diametral pitch; while on the inner pitch circles, the thickness of the teeth is reduced directly with the difference between the apex distance and the face of the gears. That is, the thickness of the teeth on the inner pitch circles is equal to their thickness on the

outer pitch circles multiplied by the ratio of the difference between the apex distance and the face of the apex distance.

Example in Design of Internal Bevel Gearing

Example:—Required, an internal bevel gear combination; 4 diametral pitch, 64 teeth in gear, 20 teeth in pinion, 2-inch face; shaft angle, 135 degrees. $p = 4$, $b = 2$ inches, $B' = 180 - 135 = 45$ degrees, $R' = 20 \div 64 = 0.3125$.

$$p' = 3.1416 \div 4 = 0.7854 \text{ inch} \qquad (2)$$

$$D' = 64 \div 4 = 16 \text{ inches} \quad (3) \qquad d' = 20 \div 4 = 5 \text{ inches} \quad (3a)$$

$$\operatorname{Tan} E = \frac{0.70711}{0.70711 - 0.3125} = 1.79192; \qquad (4)$$

$$E = 60 \text{ degrees, } 50 \text{ minutes}$$

$$E' = 60 \text{ degrees, } 50 \text{ minutes} - 45 \text{ degrees}$$
$$= 15 \text{ degrees, } 50 \text{ minutes} \qquad (4a)$$

$$a = \frac{16}{2 \times 0.87321} = 9.1616 \text{ inches} \qquad (5)$$

$$s = 1 \div 4 = 0.250 \text{ inch} \qquad (6)$$

$$s + f = 1.157 \div 4 = 0.289 \text{ inch} \qquad (7)$$

$$W = 0.250 + 0.289 = 0.539 \text{ inch} \qquad (8)$$

$$\operatorname{Tan} J = 0.250 \div 9.1616 = 0.02728;$$
$$J = 1 \text{ degree, } 34 \text{ minutes} \qquad (9)$$

$$\operatorname{Tan} K = 0.289 \div 9.1616 = 0.03154;$$
$$K = 1 \text{ degree, } 48 \text{ minutes} \qquad (10)$$

$$F = 60 \text{ degrees, } 50 \text{ minutes} - 1 \text{ degree, } 34 \text{ minutes}$$
$$= 59 \text{ degrees } 16 \text{ minutes} \qquad (11)$$

$$F' = 15 \text{ degrees, } 50 \text{ minutes} + 1 \text{ degree, } 34 \text{ minutes}$$
$$= 17 \text{ degrees, } 24 \text{ minutes} \qquad (11a)$$

$$C = 60 \text{ degrees, } 50 \text{ minutes} + 1 \text{ degree, } 48 \text{ minutes}$$
$$= 62 \text{ degrees, } 38 \text{ minutes} \qquad (12)$$

$$C' = 15 \text{ degrees, } 50 \text{ minutes} - 1 \text{ degree, } 48 \text{ minutes}$$
$$= 14 \text{ degrees, } 2 \text{ minutes} \qquad (12a)$$

$$V = 0.250 \times 0.48735 = 0.1218 \text{ inch} \qquad (13)$$

$$v = 0.250 \times 0.96206 = 0.2405 \text{ inch} \qquad (13a)$$

$$Y = 0.250 \times 0.87321 = 0.2183 \text{ inch} \qquad (14)$$

$$y = 0.250 \times 0.27284 = 0.0682 \text{ inch} \qquad (14a)$$

$$D = 16 - 2 \times 0.1218 = 15.7564 \text{ inches} \qquad (15)$$

$$d = 5 + 2 \times 0.2405 = 5.4810 \text{ inches} \qquad (15a)$$

$$D'' = 15.7564 - 2(2 \times 0.85955) = 12.3182 \text{ inches} \qquad (16)$$

$$d'' = 5.4810 - 2(2 \times 0.29904) = 4.28484 \text{ inches} \qquad (16a)$$

$$t = 1.5708 \div 4 = 0.3927 \text{ inch} \qquad (17)$$

$$t' = \frac{0.3927(9.1616 - 2)}{9.1616} = 0.3069 \text{ inch} \qquad (18)$$

Crown Bevel Gears

The transition of bevel gearing from the externally meshing type to internal bevel gearing is marked by the type known as the crown gear; that is, a bevel gear having a center angle of 90 degrees, as shown in Fig. 3. Such gearing can be classified, with equal logic, as of either the external or the internal meshing variety, but the latter is preferable, for its use is quite as limited as that of internal bevel gearing, if not more so. The surface of revolution of the crown gear is resolved into a plane surface from a cone of revolution, so that the pitch diameter of the gear is the same as its outside diameter. The backing of the crown gear—the distance from the outer point of the teeth to the pitch line—is equal to the addendum, and the apex distance is equal to one-half the pitch diameter of the gear.

The center angles of pinions meshing with crown gears are naturally quite different, for a given shaft angle, from those of the pinions in either the ordinary internally or externally meshing bevel gear combinations and are much more easily calculated; the center angle of the crown gear is always 90 degrees. The center angle of the pinion member is equal to 90 degrees minus the designated shaft angle (the designated shaft angle of the crown gear is the true shaft angle of the combination minus 90 degrees—the center angle of the crown gear—) or 180 degrees minus the shaft angle. Obviously, the shaft angle determines the center angle of the pinion and also fixes a definite speed ratio which cannot be varied without changing the shaft angle, and which is considerably less than the speed ratio obtainable with the same shaft angle by the use of internal bevel gearing. For instance, with a shaft angle of 135 degrees, shafts bearing the same relative position to each other as in the example given in the design of internal bevel gearing, the center angle of the pinion meshing with a crown gear will be 45 degrees (90 degrees — B') or (180 degrees — B) and the speed ratio will be fixed at 1.414 to 1, the ratio of the pitch diameters of the crown gear and its pinion bearing such relation. In the case of the internal bevel gear combination with a shaft angle of 135 degrees, the center angle of the pinion was but 15 degrees, 50 minutes, and the speed ratio 3.2 to 1.

Parallel-depth Internal Bevel Gearing

The variation in the depth of ordinary bevel gears, both of the internal and the common external type, seriously complicates machining operations and has led to the development of bevel gears with constant-depth teeth. For internal and crown bevel gearing, this type is shown in Fig. 4. The peculiarity of this type of design is that the center, face, and cutting angles are all equal. The radial pitch lines on either tooth profile alone converge to the common apex point, while the imaginary cones represented by the conical surfaces of the face and cutting planes are similar but normally separated from the pitch cone of revolution by the addendum and the dedendum distances of the gear teeth, respectively.

The true octoid form of tooth, the modification of the involute now universally employed for standard bevel gears on account of the necessity of such form for the successful operation of all kinds of bevel-gear generating machines, can be common to only one point along the length of the various teeth. It has become general practice to make the section of the teeth on the inner pitch circle conform to such standard. This gives to the outer section of the teeth a decidedly squatty appearance, the thickness of the teeth on the outer pitch circle being considerably greater than that of the true octoid tooth of the same depth. With the exception that the angles increment and decrement do not exist in parallel-depth internal bevel or crown bevel gears and that the tooth proportions are figured from the inside pitch diameters of the gears, the formulas presented for the solution of regular standard types of internal bevel gearing apply as well to parallel-depth internal bevel gearing.

Machining Internal Bevel Gears

Internal bevel gears and crown gears are machined in ways very similar to those employed for ordinary bevels. That is, there are three general processes of machining such gears—milling, planing, and generating. The resulting teeth are more or less exact reproductions of octoid teeth when cut by either of the first two methods, but are of the true octoid form

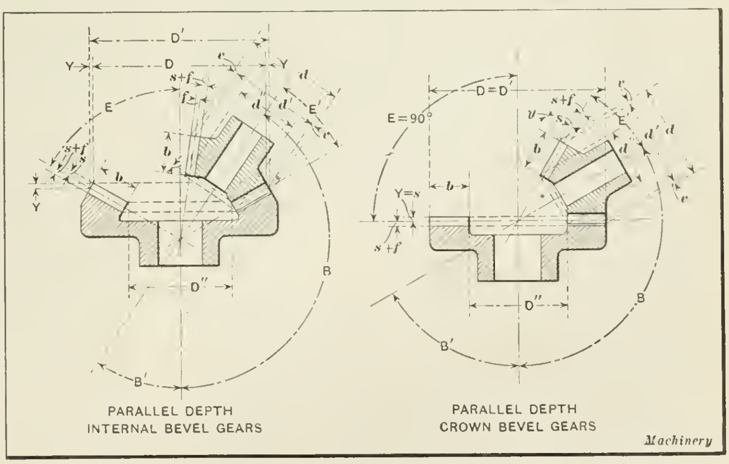

Fig 4. Bevel Gearing with Parallel Depth Teeth

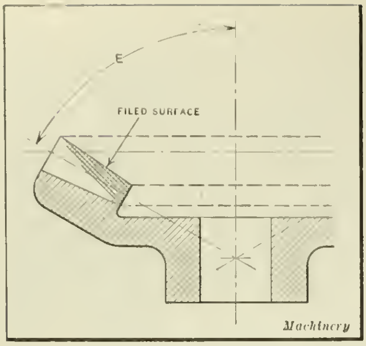

Fig. 5. Filed Surface of Milled Internal Bevel Gear Teeth

only when generated; that is, gears with tapering-depth teeth.

Milling the teeth necessitates five adjustments of the blank, or work: one position for the gashing cuts and two for the finishing cuts on either side. In milling the tapering-depth teeth, the cutter is selected for the outer pitch circle profile, but must be sufficiently narrow to pass through the tooth space at the inner end of the finished teeth. In milling the parallel-depth teeth, the cutter is selected for the inner pitch circle profile and the resulting teeth have a correct profile for the inner end throughout their length, but the depth is more and more disproportional to the true octoid as the outer ends of the teeth are approached.

The ordinary planing process is quite similar to the milling process; but special bevel-gear planing machines are also employed which cut teeth closely resembling the octoid form. These special planers employ three templets for guiding the three simple planing tools used for cutting the teeth. One of these tools, usually of the straight-faced type, is employed only for gashing, the sides of the teeth being finished with specially formed tools, one for each side. All the teeth are finished on one side before the second finishing tool is used.

Generating machines for conjugating the true octoid tooth employ one of two general methods, the planing or the milling process. The machines operating on the planing principle have a crown gear, provided with cutting tools representing its sides in successive positions, which meshes with a master bevel gear carrying on its arbor the gear blank to be cut. The crown and master gears rotate in mesh and present the work to the cutting tools, the work and the cutting tools virtually rolling together to conjugate the teeth. Generating machines employing the milling process differ in having the sides of the teeth of an imaginary crown gear represented by the plane surfaces of milling cutters. The crown gear equivalent is stationary and the master bevel rolls over it, thus presenting the work to the milling cutters in successive positions. Both types of generating machines conjugate true octoid teeth.

Filing Milled Bevel Gear Teeth

The tooth section of the tapering-depth bevel gears cut on milling machines or by the ordinary planing method is of the correct octoid form only at the outer end of the teeth. The constant cutting profile of the tool leaves an excess of material from the tip of the outer end of the tooth to the full depth of the tooth at the inner end. The excess metal increases from the outer to the inner ends of the teeth, on account of the variation in the depth of the addendum and dedendum of the teeth, which is due to the face, center, and cutting angles being dissimilar. This surplus material must be removed with a hand tool. Usually a file is employed, whether the gears are of the internal or the external type, but the surplus material is removed with much more difficulty in the case of internal bevel gears.

Fig. 5 illustrates the surface of internal gear teeth which has to be cut away in order that the pitch lines of the tooth profiles may correctly converge to the apex center and allow the proper meshing of teeth. The figure also indicates the difficulties which are encountered when filing internal bevel gear teeth due to the awkward position of the teeth for clearance in swinging the file. In filing externally meshing bevels, the machinist is placed in no such position, so that a clear swing can be taken and the task of accurately filing is not particularly difficult for the skilled workman.

Parallel-depth Bevel Gear Weakness

The parallel-depth design of bevel gearing evades the necessity of filing the teeth, but has one possible drawback in its relative weakness. As the tooth section is of the true octoid form only at the inner end, the remainder of each tooth is of less rugged proportions, notwithstanding the appearance of stubby and powerful design. The thickness of the teeth is correct for full tooth strength throughout the entire length, but the gradual relative decrease in depth, though apparently adding strength, reduces the power much as would the wearing away of the top of the teeth in actual service. This drawback is not a serious one, however, and parallel-depth bevel gears are quite generally considered the equal of gears with teeth of the true octoid form of varying depth. Certainly they are equal, if not superior, to bevel gears of varying tooth depth which are cut on milling machines or ordinary planers and have to be finished by filing or other hand tool operation.

* * *

SCREW THREAD TOLERANCES

A hearing was held in Washington in February with reference to the matter of establishing by law tolerances, clearances and allowances in specifying screw threads in manufacturing plants under the control of the War and Navy Departments. Bearing on the importance of having settled as clearly as possible all dimensions involved in the production of munitions of war, it has been said recently by an authority as to the experience in Great Britain that there is no doubt that if when the war broke out a more satisfactory system had been in use and gages had been so designed that they could have been cheaply and rapidly produced in quantity, the country would have been saved many thousands of pounds and much delay in the turning out of shells. It is appreciated that in order to bring about the best results in this country in screw thread tolerance practice it is necessary that civilian industrial authorities should be consulted thoroughly as well as officers and engineers of the government, and that moreover the standards settled upon, whether these shall be of one series or of various grades suitable for different classes of workmanship, shall be entirely commercial in regular manufacture. In the formulation of the standards, civilian makers of taps and screws, and also users, will be consulted. Dr. Stratton of the United States Bureau of Standards feels that it is entirely feasible for the industries and the military departments to follow the same practice. It is perfectly obvious that in the time of war this would have to be the case.

Accurate measurement of screw threads in commercial practice has been a slow development. Different societies including the American Society of Mechanical Engineers and the Society of Automobile Engineers, have had committees working on the subject for a number of years. It is felt now, however, that through concerted effort of representative experts in government and civil life the complex questions connected with determining just how accurately screw products can be made commercially must be brought to an early issue, and the government specifications generally acquiesced in, meeting the necessities for the high-grade workmanship which exists, of course, in various apparatus used by the government including airplanes.

* * *

SUBSTITUTE FOR BABBITT METAL

On account of the scarcity of copper in Germany, determined efforts have been made to substitute alloys containing little or no copper for those containing high percentages. It is stated in *Glasers Annalen* that German metallurgists have succeeded in producing a bearing metal alloy containing a very small percentage of copper, and a fairly small percentage of tin, which has all the properties of the highest grade of bearing metal. The alloy consists of 3.3 per cent copper, 12 per cent lead, 21.3 per cent tin, and 63.4 per cent zinc. The alloy is produced by melting red brass and adding to it first the tin and lead, and finally the required amount of zinc, which before being added to the molten alloy is preheated to about 400 degrees F. The alloy has a hardness of 42 on the Brinell scale.

LIQUID FUELS FOR HEATING FURNACES

FIXING VALUE OF FUEL OILS FOR METALLURGICAL FURNACES ON A B. T. U. BASIS

BY GEORGE P. PEARCE [1]

THE oil furnace for heating stock, whether for welding, forging or bending, is most convenient and satisfactory, and if the basic principles upon which its efficient operation depends were better known, there would be an elimination of almost all the usual oil furnace troubles, combined with greater efficiency in fuel consumption and output. Heating stock is a simple process if economy of operation is of no consequence; making a fire on the ground and putting the stock in the hottest part is one of the most primitive acts of man. Today, owing to the ever-increasing keenness of competition, it has become a matter of great complexity to heat stock at the lowest cost.

There are many things to consider in efficient furnace design. Probably the most important is the method of delivering the oil to the furnace with the least amount of air that will properly burn it. Most of the oil burners operate on the atomizing principle, that is, they mechanically break up the oil stream into innumerable particles or globules which greatly increase the exposed area and thus accelerate combustion. The efficiency of this type of burner is inversely proportional to the size of the globules, provided they are approximately uniform. Even the smallest of these globules is extremely large when compared with the oil molecule, and the act of burning takes an appreciable time; it must also be remembered that these globules are many diameters apart, and the air between them does not get much opportunity to become consumed; so an excess of air must be supplied.

There are new burners on the market which operate on the principle of vaporizing the oil, that is, reducing it to the molecular state, which allows perfect mixing so that the air supply can be cut down to the minimum amount with a corresponding increase in efficiency. The furnace itself must be adapted to the burner that will be used, and should be just large enough so that all the oil is completely burned before the gases leave the furnace. Many oil furnaces are operating with flames shooting out from two to six feet, which simply means that they are inefficient and are burning a large percentage of the oil supply outside the furnace where it is wasted. On a well designed and correctly operated furnace the escaping flames are about six inches high and without any blast action. Combustion should be almost complete before the gases reach the stock which is being heated. There are two advantages to this: first, the maximum heat is delivered to the stock; and second, since the oxygen is practically exhausted, there is no tendency to scale the stock. The furnace walls must be well insulated to prevent radiation and conduction losses, and also to actually increase the temperature in the furnace. Openings must be kept to a minimum in area for the same reason. An efficient furnace should be able to heat a 1¼-inch diameter mild steel bar from room temperature so rapidly that in three minutes the first drop of molten steel will fall from it.

Medium sized furnaces, say those heating stock weighing between five pounds and one hundred pounds, should be designed so that they will heat the stock as fast as it can be handled, and thus eliminate loss of time through the workmen waiting for the furnace to heat the stock. The error must not be made of making the furnace any larger than is consistent with proper combustion, good heat insulation and capacity for the required amount of stock. This design when properly operated will heat the stock with the least possible consumption of fuel, which is not only economical, but greatly increases the comfort of the men who have to work near it as well. With proper combustion, the presence of obnoxious and poisonous gases is practically eliminated, and if the shop is high, the use of chimneys can be avoided.

Any saving in oil that might be obtained from slow heating sinks into insignificance if the men and machinery have to wait, because the men's time and the overhead and fixed charges are much greater than the value of the oil, and, furthermore, slower output per furnace means more men, furnaces, equipment and buildings. As forging machines, in general, are very quick-acting and can easily perform their cycle of operations in less time than the piece of stock can be heated, it is obvious that the utmost economy under these conditions can only be obtained by heating the stock at its maximum rate, which is to get the interior hot enough before the exterior surface starts to melt or gets to a temperature high enough to spoil the stock for its particular work. It is doubtful if a practical furnace has ever been built which would heat stock at this rate. From the above considerations, it is apparent that, in general, the most important factor in over-all economy is the rapidity of heating, and no fear need at present be felt of reaching the limit.

The stock is heated, of course, because the temperature of the furnace is higher than that of the stock, and as soon as it reaches the temperature of the furnace it is no longer being heated. This is obvious, but to keep the furnace at the temperature to which it is desired to heat the stock is very inefficient, however desirable it may seem from the standpoint of avoiding burnt stock. Maximum economy, which also means maximum output, can only be obtained by keeping the furnace temperature as high as possible, and it must be noted that the difference in temperatures is constantly being reduced as the temperature of the stock increases, that is, the rate of heating decreases as the temperature of the stock increases.

To find the relative effects of various furnace temperatures on the rate of heating stock, a series of experiments was made with the following results:

RELATIVE HEATING TIME OF STOCK FOR VARIOUS FURNACE AND STOCK TEMPERATURES

Temperature of Furnace, Degrees F.	Stock Temperatures, Degrees F.					
	500	700	900	1100	1300	1400
1600	2.20	3.40	4.75	6.45	8.50	9.75
2000	0.75	1.20	1.60	2.20	2.90	3.45
2500	0.50	0.75	1.15	1.45	1.90	2.15
2700	0.30	0.45	0.65	0.75	1.00	1.15

Machinery

Eliminating the 1600-degree furnace, because it is not probable that such low temperatures will occur in practice, and taking the relative heating rate for unit time for the other three furnaces, the results are as follows:

Temperature of Furnace, Degrees F.	Average Relative Heating Rate
2000	1.00 (Taken as unity)
2500	1.80
2700	2.74

Thus it is seen that while the 2000-degree furnace is heating 100 pieces, the 2500-degree furnace will heat 180 pieces, and the 2700-degree furnace will heat 274 pieces. An increase of only 700 degrees F. has increased the furnace output 174 per cent. It is very apparent that the rate of heating varies much more rapidly than the difference in temperature, and a practical rule has been deduced from the tests as follows:

Temperature of Furnace, Degrees F.	Average Relative Heating Rate	Ratio of Third Power of Temperature
2000	1.00	1.00
2500	1.80	1.95
2700	2.74	2.45

As the third power ratio and the relative heating rate so nearly coincide, our practical rule is: "The relative heating rate varies as the third power of the actual temperature for furnaces used to heat stock for forging purposes." This, of course, applies only to furnaces used for heating stock to the same temperatures. A comparison between a welding and

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bending furnace by this rule would probably give erroneous figures; in fact, the bending furnace would probably be unable to give a welding temperature at all, but the effect of an increase in temperature of the welding furnace on its output could be solved by the above rule, and the same applies to the bending furnace.

As the obtaining of high temperatures is of such great value, it is well to investigate what the factors are that determine this condition, and as we already have discussed high insulation, minimum radiation and conduction, minimum air supply and efficient burners, the only thing left is the actual composition and heat value of the oil itself. The composition of oils as used for furnace work does not vary greatly, although their heating value does. As an instance of this, the petroleum of West Virginia is 83.5 per cent carbon, 13.3 per cent hydrogen, and has a heating value of 18,324 B.T.U., while the oil known as "Mineral Seal" has 83.3 per cent carbon and 13.2 per cent hydrogen, and yet gives 20,065 B.T.U.; also the oil known as "Petrolea" has 84.4 per cent carbon, 13.4 per cent hydrogen, and gives 20,410 B.T.U. The ultimate analysis of any oil does not give more than a general indication of its heating value. The reason for this is because the energy of disassociation, which is not very well known, varies for different oils; and the condition of the oxygen, whether combined with the hydrogen or not, the amount of ash, moisture, etc., are all variables. The actual B.T.U. content is the most direct indication of the oil value. The B.T.U. value and the approximate analysis of any oil being known, it is a simple matter to calculate the flame temperature T as follows:

$$T = \frac{\text{B.T.U.} - H - h}{S}$$

where H = heat converted into work by expansion of gases of combustion;

h = heat absorbed by steam produced;

S = mean specific heat of products of combustion.

Applying this formula to five oils of different B.T.U. contents, the following temperatures are derived:

B.T.U. Value of Oil	Approximate Temperatures of Combustion, Degrees F.
16,000	2952
17,000	3142
18,000	3332
19,000	3522
20,000	3712

It is apparent that the B.T.U. value has a great influence on the temperatures that can be obtained in the furnace. Moisture affects the flame temperature in two ways: first, by reducing the available B.T.U. value by the amount absorbed in the form of latent heat, which is very high, being about 1000 B.T.U. per pound of water or moisture; second, by its high specific heat when in the form of superheated steam. In the formula, the effect is apparent, by the subtraction of the latent heat from the B.T.U. and the division by the specific heat times the amount of moisture present. Oil should, therefore, be given ample time to settle as much of the contained water as possible, and full credit should also be obtained for it from the oil supply company.

From the preceding table it is seen that the B.T.U. value has a more important effect on the flame temperature than might at first be assumed. It is now necessary to find what effect this has upon the relative heating values when used in metallurgical furnaces. The rule connecting heating values with temperature has been obtained, so by applying this rule to the temperatures obtained, it is a simple calculation to get the relative heating values. First, some particular heating value must be chosen as unity, and as an oil of 17,000 B.T.U. value is in extensive use for this purpose, it will be taken to represent unity. On this basis the following table gives relative heating values:

B.T.U. Value of Oil	Relative Heating Value
16,000	0.83
17,000	1.00
18,000	1.19
19,000	1.40
20,000	1.66

Thus it is seen that while 17,000 B. T. U. oil is heating 100 pieces, 19,000 oil will heat 140 pieces. As the ultimate economy should be expressed on an actual cost basis, the equivalent value of the various oils will now be taken up. This relative value of oils will vary somewhat for each specific case, as the saving due to quicker heating is more than proportional to the extra stock heated by the same amount of oil, for there is more stock heated in the same time; thus the same amount of labor and equipment will have greater production, and the value of this will necessarily depend upon the particular work being done. It will be a conservative estimate to simply estimate the value of the oil upon its relative heating value, and taking 17,000 B.T.U. oil at $1.50 per barrel as unity, the following table gives the various values of the other oils per barrel:

B.T.U. Value of Oil	Relative Value per Barrel
16,000	$1.24
17,000	1.50
18,000	1.78
19,000	2.10
20,000	2.46

It is important to note that a high flame temperature cannot be obtained by any haphazard methods. The oil must be completely burned without smoke in approximately the theoretical amount of air and in correctly designed furnaces. If this is not thoroughly done or excess air is used, then the saving due to the increased B.T.U. value may easily be lost, as a very little excess air will quickly eliminate the increase in temperature and increased rate of heating due to the richer oil.

* * *

FARM TRACTORS

The present high cost of living, due in part to scarcity of farm products, has brought squarely before the American people agricultural conditions and the problem of producing food more cheaply. The farmer has gradually been growing poorer and poorer because the returns for his labor were inadequate for decent support. The rising costs of farm labor and the scarcity of laborers are acute difficulties. Thousands of acres of tillable soil in the East have been abandoned and the former occupants have gone to the towns and cities where they can earn a living easier. The abandonment of the farms, increased population and inefficient means of distribution, together with the demands of the millions in Europe for food, have raised prices to unprecedented heights. Farm tractors are being developed in a variety of forms and are regarded by their optimistic promoters as a partial solution of the farmer's problem. What the ultimate form of the farm tractor will be is not yet clear.

There is a great variety of styles, each of which apparently has certain advantages. One make that can be operated by one man the same as a team has the power of six horses, and may be used for doing all kinds of farm work. The turning radius is so short that the tractor can make a complete turn in a ten-foot circle. The fuel used is No. 1 engine distillate. Advantages claimed for the farm tractor are that it eats nothing when not working, and that it can be used not only as a tractor but for generating stationary power, driving grinding machinery, threshing machines and other machinery on the farm. The farm tractor is not subject to disease; it can be operated from early dawn until late at night, day after day, without fatigue. Some of the successful farm tractors are built on the caterpillar principle, being supported on endless belts or chains that give a large area of contact to support the load on soft ground and provide for traction.

* * *

Gasoline readily vaporizes when exposed to the air of any temperature down to 15 degrees F. below zero. The vapor is nearly three times as heavy as air, and when mixed with the proper quantity of air becomes violently explosive. If confined where there is poor ventilation, this mixture will sometimes remain in the explosive condition for several months. The vapor will ignite from an open flame, a spark from an emery wheel, a sufficiently heated surface, and even from a spark of static electricity from the human body.

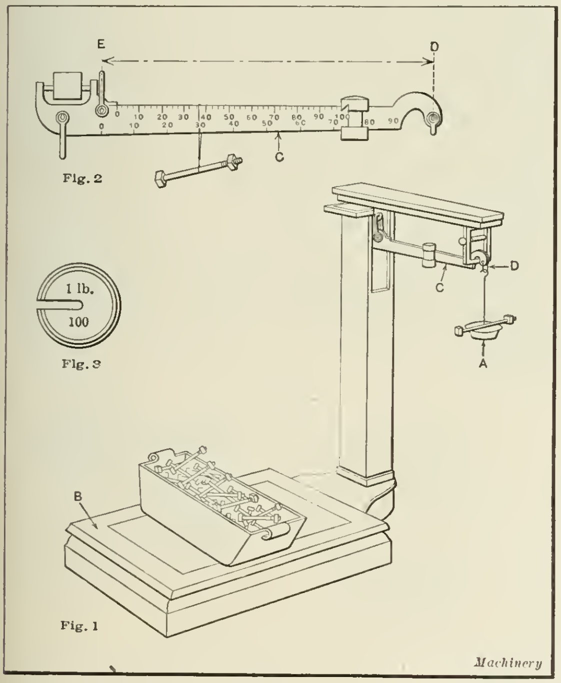
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

A COUNTING SCALE

There is always a definite ratio between the weights which hang on the tip of a scale beam and the load on the platform. On a scale of the type shown in Fig. 1, this ratio is usually 1 to 100; that is, one pound on the counterpoise *A* will balance one hundred pounds on the platform *B*. By taking advantage of this relation, it is possible to count with accuracy drop-forgings or the product of automatic machines, nuts, bolts, etc. Since they are practically of uniform weight, one piece laid on the counterpoise will balance one hundred similar pieces on the platform; ten pieces will balance one thousand, etc.

To ascertain quantities less than one hundred, it will be necessary to do a little work on the scale beam *C*, shown in Fig. 2. If one piece hung from the tip pivot *D* balances one hundred, it will balance only one-half as many when hung half way between the pivots *D* and *E*, or one-hundredth as many at one-hundredth the distance. So the distance from *D* to *E* should be divided into one hundred equal parts, and



Figs. 1 to 3. Counting Pieces on a Scale

the lines separating these parts marked with a scriber on the lower edge of the beam. It may be easier to divide the whole into ten parts and each of these into ten parts. No attention should be paid to the graduations already on the beam.

To count an unknown quantity of pieces, balance the empty box by moving the poise, which in this case has no other use. Fill the box with the pieces and put one on the counterpoise *A*; if this does not balance, add others on counterpoise *A*. When the last one put on is seen to be too much, take it off and, by means of a fine thread looped over the beam, as shown in Fig. 2, move the piece along the scale beam until a balance is obtained. Note the mark on the lower edge of the beam at this point. If there are seven pieces on the counterpoise, and the one on the scale stops at 30, there are 730 pieces in the box. It is not necessary to graduate the beam into one hundred parts. If ten equal spaces are made, the pieces can be balanced to the nearest ten and the few remaining can be counted by hand. If the pieces weigh less than 1/4 pound each, they should be counted on a smaller and more sensitive scale, since the one illustrated is not adapted for fine work. The ratio between the counterpoise and the platform is indicated on the weights, as shown in Fig. 3. It may not always be 1 to 100, but it will always be a fixed factor.

Rutland, Vt. W. H. SARGENT

REMOVING BROKEN TAPS AND SCREWS FROM BRASS PARTS

A jobbing shop, eager for work to carry it through a dull season, took a large contract at a figure that would yield a small profit if no unforeseen difficulties were encountered—and then the difficulty appeared. One of the last operations on a brass part was the tapping of a blind hole. Whenever the No. 4-40 bottoming tap broke off too short to be extracted by ordinary means, as it did with discouraging frequency, there was nothing to do but to scrap the part, on which some two dollars' worth of lathe, miller, and drill-press work had been expended. The jigs were furnished by the customer and no change in the order of operations was possible. As the size of tap-drill was specified on the blueprint and the customer refused to permit the use of a larger drill, the shop owner could only gaze sadly at the growing scrap heap which threatened to absorb all his anticipated profits.

Misfortunes, we are told, seldom come singly, and when the pile of spoiled parts had grown until its cost exceeded $200, the second bit of ill-luck arrived. The "boss" dropped his cherished watch on the floor and on opening the back of the case he saw lying loose the heads of the two steel screws which are tapped into the pillars to hold the barrel bridge in place. Trying the heads with a file, he found them hard and foresaw an expensive repair job that would further deplete his shrinking "roll."

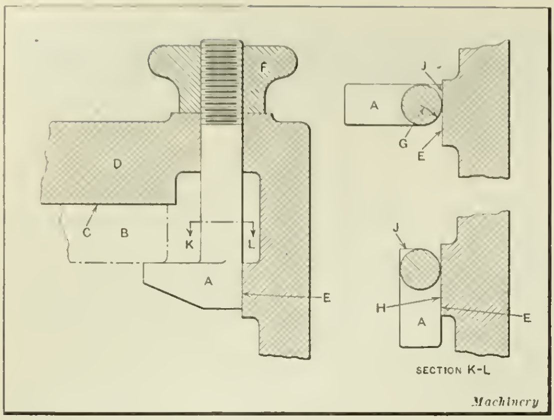
When the watch was returned and he was told that all that had been necessary was to remove the broken screws and substitute new ones, he asked the watch repairer to reveal the method of extraction. As soon as he acquired this "secret," he returned to the shop and made, in an enamel-lined kettle, a fairly strong hot solution of ordinary alum. Then placing his brass parts therein, in a few minutes he was able to loosen the fragments of taps so that they were easily removed.

It sometimes happens, especially in clock repairing, that a broken screw must be removed from a brass part which has other steel members riveted to it. In this case, as it would be difficult and expensive to take off and replace the riveted parts, another method is employed. All but the seat of operations receives a protective coat of vaseline, then very dilute cold sulphuric acid (twenty or thirty drops to a pint of water) is put upon the screw. This acts slowly, and has to be replaced by fresh acid as it becomes exhausted, but in time will do the work. Great care, of course, must be taken to remove all acid when the job is completed, the usual plan being to neutralize it with ammonia and then rinse thoroughly with hot water.

New London, N. H. GUY H. GARDNER

SELF-LOCATING HOOK BOLT

The October number of MACHINERY contained the description of an improved hook bolt, the advantage of which was a support at the back. The writer considers the design described rather expensive, and submits an alternative arrangement, as shown in the accompanying illustration. This hook



Self-locating Hook Bolt with Support at Back of Head

bolt is simple, inexpensive, can be supported at the back of the clamping point, and is self-locating.

In the illustration, *A* is a hook bolt used to clamp the work *B* against the locating pad *C* in the jig *D*. The back of the hook bolt is seated against a finished pad on the jig *E*, thus providing ample support at its weak point. *F* is a handwheel that is threaded to receive the end of the hook bolt; a nut may be used in place of the wheel, if preferred. By turning the handwheel *F*, the clamp is released, the hook bolt turning on the radius *G* until the face of the bolt rests on the face of the pad, as shown at *H*. To clamp the work *B*, all that is necessary is to turn the handwheel and the hook bolt rides again on the radius *G*, until the face *J* seats on the pad *E*. Thus the hook bolt is self-locating and it is unnecessary for the operator to look into the jig to see if the hook bolt is in the proper position for clamping and hold it while it is being tightened. This hook bolt can be used in a closed box jig and provides the necessary support back of the head, which makes it a useful and inexpensive clamping device.

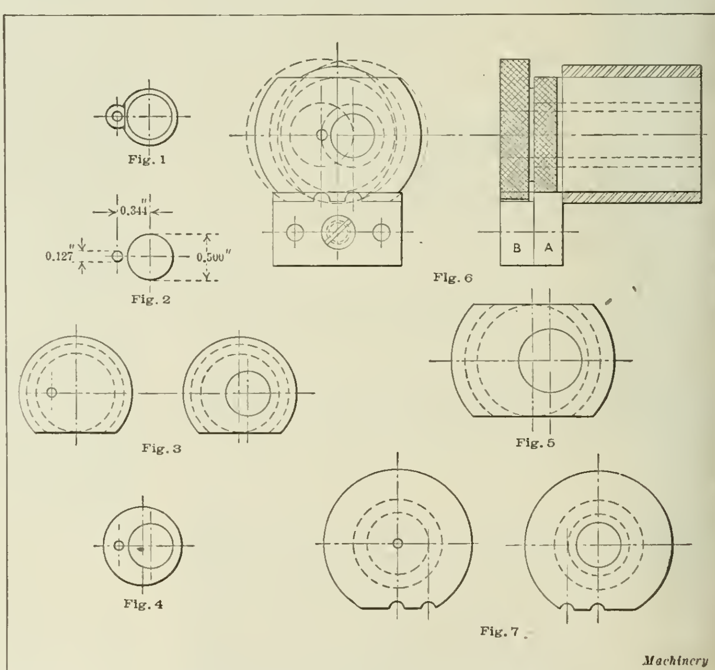
New York City THOMAS ORCHARD

ECCENTRIC BUSHINGS

In laying out drill jigs it is often necessary to provide for two holes that are very close together. On simple drilling, when fixed bushings only are used, this is easily done by the use of reducing bushings, as shown in Fig. 1; but for reamed holes which have to be so accurate that the "spot, drill, and ream" operations cannot be performed, eccentric bushings have to be used. For two reamed holes of different sizes, four eccentric bushings must be provided. The form of these bushings is shown in Fig. 3 and their proportions and disposition in Fig. 4. Every toolmaker knows how difficult and expensive the making of eccentric bushings is for the ordinary tool-room.

A case came to the writer the other day where a 0.127-inch reamed hole and a 0.5-inch hole 0.344 inch distant, as shown in Fig. 2, were to be drilled and reamed at the same setting in the jig. This was done by using only one eccentric bushing, made of soft crucible steel, of the form shown in Fig. 5. A locating block *A*, Fig. 6, was used to give the proper alignment to this bushing, and another locating block *B* was set on top of *A* to locate the bushings shown in Fig. 7 so that it would be impossible for the operator to put the eccentric bushing in the wrong position and transpose the holes. As the bushings are concentric, the locating block *B* and the bushings can be fitted freely at their contact, thus facilitating changes by the operator.

Montreal, Canada J. G. BLANCHET



Figs. 1 to 7. Bushings for drilling Two Holes Close together

BONUS SYSTEM FOR SMALL SHOP

An interesting and successful bonus plan for shop employes has recently been developed at the plant of the Guerber Engineering Co., Bethlehem, Pa., which specializes in general machine work as well as in the production of structural steel shapes and railway track material. The shops employ an average of about 160 men in the different departments of operation, exclusive of office force, engineers, or outside iron erectors.

This bonus system is the result of extensive investigation in the past few months, brought about through the continual difficulty of operating the shops at maximum capacity. It was found that for the first ten months of the past year only about one-third of the force, or an aggregate of fifty shop employes, had worked at full time during many of the months, naturally reducing the efficiency of the plant. While this might be attributed, in a way, to the prevailing shortage of experienced and efficient workmen, it was shown to the satisfaction of officials of the company that the primary cause was the fact that employes would not work regularly and consistently, owing to the increased wage scale which has been placed in effect generally in the past two years and the consequent added surplus to the earnings of the men. Thus it was deemed advisable to devise a system of bonus payments for regular attendance at work, and the results attending the introduction of the plan attest its effectiveness.

The bonus is based upon a certain percentage of the employe's wages for each month and is paid to all workmen who engage at full time on the regular working days during the respective month. This percentage is placed at a minimum of 5 per cent of the wages if fifty or less employes work full time during the month; for each additional ten, or fraction of ten, employes who so engage during the month, the rate is increased by 1 per cent, until a maximum of 16 per cent is reached in the event of the regular attendance of practically the entire force—between 151 and 160 men—in the particular month.

In addition to the men entitled to the bonus payment for regular daily attendance during the month, all employes who work full time except for one turn, or part of one turn, are given a bonus of one-half of that earned by the workmen who have a perfect record. However, the number of employes who may have missed one turn, or day, is not added to the num-

ber of men who have worked at full time, in the determination of the bonus; the rate of bonus is entirely dependent on and governed by the maximum number of full-time workers for the particular month; the greater the number of men who work regularly, the larger is the bonus for each employe.

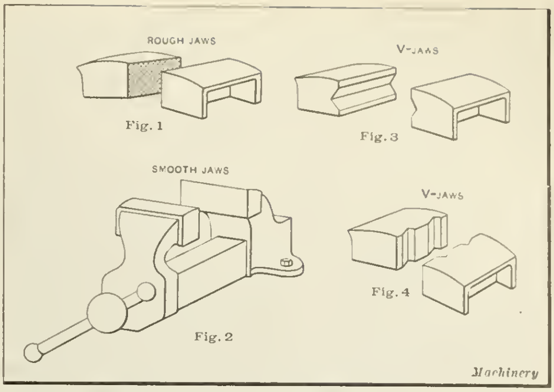
It is interesting to note that during the first two months of operation, November and December, 1916, noticeable results have been attained through the inauguration of this novel bonus plan. Approximately twice the maximum number of men were engaged at full time against the total of any previous month of the year; the record for November was slightly better than that of the following month, owing to the holiday season. In November, all departments of the plant established new records for monthly production.

Newark, N. J. L. R. W. Allison

SPECIAL VISE JAWS

An improvement that the writer thinks would add greatly to the usefulness of the ordinary vise and at the same time save labor, would be to provide for each size of vise false jaws of various designs. For heavy work, when a rough face with a good grip is necessary, the vise should have heavy coarse-cut jaws, Fig. 1, that would hold the work without any possibility of its slipping or turning. For fine or polished work, the jaws should have a perfectly smooth face, Fig. 2, that would not mark or mar the work. For round work, the vise should have V-shaped jaws. To hold work in a perpendicular position, the vees should be arranged as shown in Fig. 4, but to hold work in a horizontal position the jaws shown in Fig. 3 should be used. Anyone who has tried to hold round work in the ordinary vise will appreciate the usefulness of these V-shaped jaws. It is almost impossible to clamp round stock tight enough to keep it from turning; the writer broke three vises, at different times, trying to get the vise to hold the work. By having two or three sizes of vees in each pair of jaws to take different sizes of round work, less pressure would have to be exerted to obtain a firm grip on the work, thereby reducing the stress and lessening the chances of the vise breaking.

The false jaws could be made and kept in stock by the vise



Figs. 1 to 4. - Suggested Forms of Vise Jaws

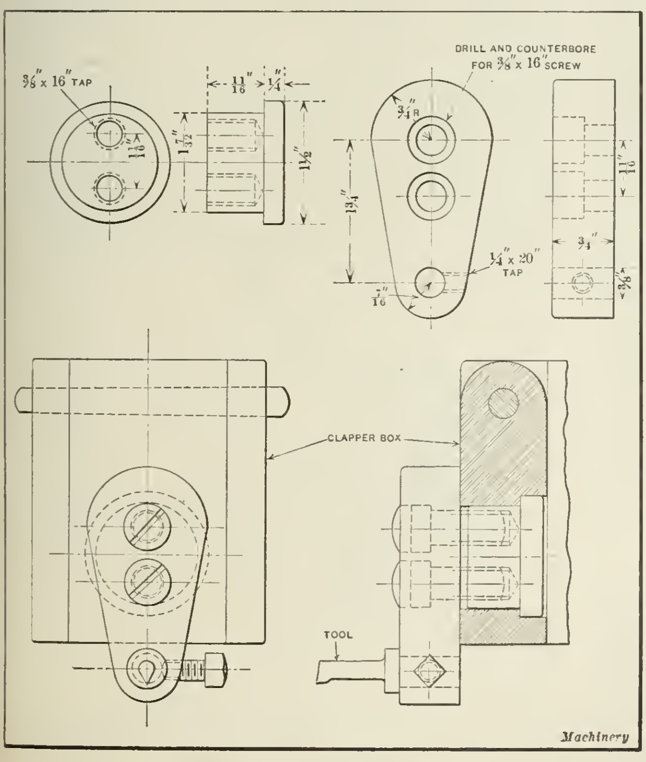
manufacturer, and could be ordered separately or in a complete set, as the occasion required. They should be of a simple design that could be easily and quickly applied without the use of set-screws or nuts. No man who has but a few pieces of work to do cares to spend time looking for a screwdriver or a special wrench to secure the jaws in position; they should fit the vise snugly and yet slip on and off like an old coat.

Plainville, Conn. Harry B. Stillman

SPLINING TOOL FOR SHAPER

The writer has designed a splining tool for a shaper that has proved very satisfactory for shaping out dies, keyways, etc.; this tool is shown in the accompanying illustration. Its advantage is that it does away with the toolpost. When the old-style tool is used the tool must be let down so far, in order to give clearance to the toolpost, that a large job cannot be done efficiently because of the tendency of the tool to chatter and to dig into the work. But with this design the tool is simply made long enough to go through the piece to be shaped, and, being rigidly held, it will not chatter. In the illustration, the dimensions are given for the stud that fits in back where the toolpost is located, but this should always be fitted to the machine on which it is to be used.

Bridgeport, Conn. Gustave Bahr



Splining Tool for Use in Shaper

PREVENTING NUTS JARRING LOOSE

Not long ago some of the nuts on a small grinding machine were continually jarring loose because of vibration. An investigation showed that both bolts and nuts were made of cold-rolled steel, and were soft; they also fitted loosely. To remedy this trouble, some bolts were turned up in the lathe, and the threads were made a tight fit in the nuts. The latter were then casehardened and screwed onto the bolts with a six-inch wrench. They have caused no trouble since. By using soft bolts and hardened nuts, and having a tight fit, the nuts are given a chance to "freeze" to the bolts, making a tight and permanent connection. This freezing cannot take place, as a rule, where both the bolt and the nut are soft; nor where both are hardened. A very tight fit is not required.

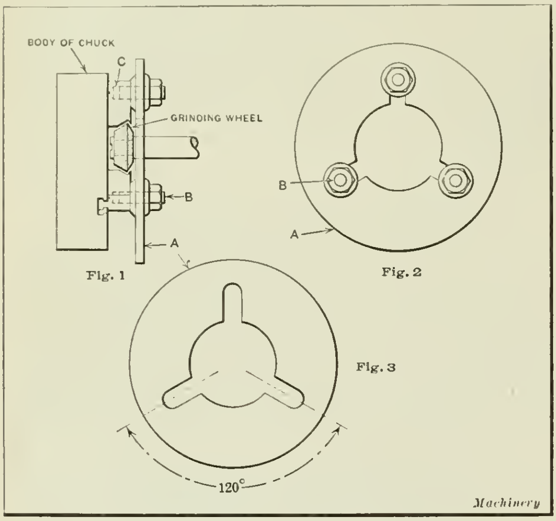
Plainfield, N. J. J. B. Murphy

TRUING SCROLL CHUCK JAWS

In connection with the devices for grinding chuck jaws true, described in the October number of Machinery, the writer would say that the device shown in the accompanying illustration has given satisfaction for some time. It is used in a shop that is turning and boring bevel gears, with cast teeth, on a Hartford automatic screw machine equipped with an automatic scroll chuck. At first, a ring with three ad-

justing screws was used to hold the jaws rigid, but this had to be set so far back in the chuck, to clear the grinding wheel, that the looseness in the chuck jaws caused the gears to run out, sometimes necessitating three or four trials before the jaws were set true. So it was decided to make a machine-steel ring *A* with elongated slots for adjustable studs *B*. A hole *C* was drilled in each jaw to take the studs.

The operation is as follows: The jaws are closed on the gear by hand and the plate is placed on the jaws with the studs in the holes. The nuts are then tightened and the relative positions of the studs and jaws are noted. The plate is then lifted off, the jaws opened, and the gear removed, after which the jaws are closed until the studs enter the holes in the same relative positions as before, and the chuck is tightened by hand. See Fig. 1. The slight play in the stud holes allows the jaws to close farther than when the gear is in position, thus allowing the grinding wheel to remove sufficient stock to true the jaws and maintain the correct radius. The pressure, being exerted on the extreme end of the jaws, places them practically in the same position as when working,



Figs. 1 to 3. Device for truing Scroll Chuck Jaws

thus securing a true grinding. Figs. 2 and 3 show the plate with and without studs. These plates are made in three sizes.

Woonsocket, R. I. HARRY BROOK

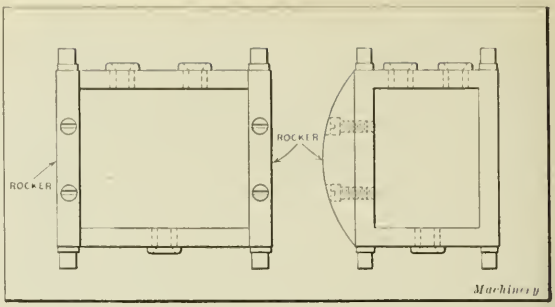
SHARP-POINT CENTER PUNCH

For accurate drilling it is generally the practice to begin with a small drill near the size of the web of the larger drill. On this principle, the writer always grinds the center punch to a more acute point than it ordinarily has—always about 30 degrees. This makes a deep impression and the small drill will follow in the center, provided the burr raised by the center punch is hammered down to compress the metal. The bottom of the center-punch mark will be visible until the drill is well started, so that it is possible to see how near the drill is to the center, without scribing a circle with the dividers. The point of the center punch will not break off if the tool is turned slightly by the fingers during the center-punching operation.

Akron, Ohio E. J. HIGGINS

A LABOR-SAVING JIG

The box drill jig shown in the accompanying illustration was used for drilling three holes in a certain piece that was to be produced in quantity. The jig is made from a forging, two stationary bushings being inserted in the top and one in the bottom. As the jig and work weighed about twelve pounds, it was hard for the workmen to be constantly lifting the jig and turning it over for the operation on the other side. So two pieces of steel were machined to a radius and attached



Drill Jig provided with Rocker to facilitate reversing its Position

to the jig between the four feet on the side opposite the leaf. With the aid of these rockers, the jig is now easily turned over from one side to the other. They do not interfere in any way with the working parts, and when changing work, the jig is supported by the rockers.

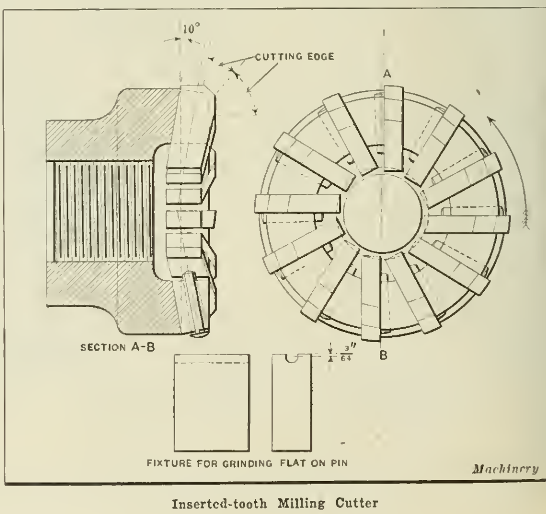
In this way, the jig is always on the drilling table, and there is no likelihood of the operator letting it fall to the ground or banging it down with a tired arm and snapping the bushing or legs, which are hardened to glass hardness. In addition, the operator does not have to work so hard and the production is considerably increased.

New Haven, Conn. ERIC LEE

INSERTED-TOOTH MILLING CUTTER

The inserted-tooth cutter shown in the accompanying illustration is one that was recently made to replace a solid high-speed butt mill. The nature of the work is such that it requires a small cutter about 3½ inches in diameter.

The holder shown contains twelve teeth of No. 2 stellite, this being the best grade for milling cast iron when the chip is light and a good deal of scale must be removed, which were the conditions in this case. The solid mills had twenty teeth, but twelve is all that is practical in this inserted-tooth holder. However, this mill cuts just as well as the other, as the stellite cutters can be run about 50 per cent faster and, with only a slight increase in feed, the same chip per tooth will be produced. The chief feature of the holder is that when the cutters become ground down until there is no room for chips, the taper pins can be driven out and the cutters reset. In the case of the solid mills, it was necessary to anneal, cut over, and harden them. The cutters of this mill, as shown, have two cutting edges, one on the 45-degree bevel and the other on the face, which need be only a little longer than the feed per revolution of the mill. The cutters are set in on an angle of 10 degrees to the face, so that when they are driven out to be reground, there is room for grinding on the face as well as the bevel. The No. 4 taper pin that holds the cutter in



Inserted-tooth Milling Cutter

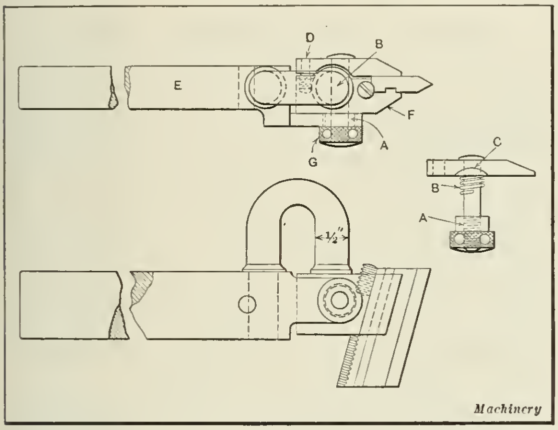
place is ground flat on one side, the same amount of stock being taken off the entire length of the pin. This is accomplished by making a fixture as shown in the illustration, which needs no explanation. The taper holes for the pins, which are, of course, drilled and reamed before the slots are cut, are drilled on the dividing head, so that they are accurately spaced and pitched at the same angle to the cutter slot as the side of the taper pin is to the cutter. This insures that the pins will bear their full length. It will be noticed that the thrust on the cutters, when in use, tends to drive them back, thus drawing in the pins and tightening their hold.

The body of the holder is made of a good grade of cast iron, as the compressive strength is much greater than that of steel and it retains its shape better. It was later found that cutters from large inserted-tooth mills of standard make could not be used after they had become less than 1¼ inch in length, as the slots for the cutters are 1¼ inch long and it is not good practice to use a cutter shorter than the slot. So these cutters were used in the smaller holders, thus saving the cost of new high-speed cutters.

New Britain, Conn. E. M. Bidwell

SPRING THREADING TOOL

The accompanying illustration shows a spring threading tool that the writer designed and has used successfully on screw gages and taps for a year and a half. The tool-holder *F* and



Spring Threading Tool

spring are one piece and made of carbon tool steel, spring tempered. The body of the tool *E* is made of carbonized cold-rolled steel and has a projection that forms a support on one side of tool-holder *F;* this keeps the tool-holder from making a staggered thread. A hole is drilled through this projection 1/64 inch larger than washer *A*, which gives tool-holder *F* a free chance to spring. Washer *A* is made of hardened tool steel, and is 0.0015 inch longer than tool body *E* is thick. Tightening nut *G* clamps on washer *A*, and tightens the blade in the holder *F*. The small coil spring *B* holds the nut against the washer *A* and keeps out chips while the blade is being removed. *D* is an adjustable screw for the blade clamp.

Kenosha, Wis. F. S. Ripley

PIERCING AND DRAWING GANG DIE

An interesting gang die was used to make the piece shown half size in Fig. 1. As shown at a greatly reduced scale in Fig. 3, the dies are made, like a half sub-press die, by using a cast-iron die-block *B* and a punch-holder *C* fitted with two hardened and ground guide pins *D*. The die *E* is made from a piece of special tool steel 1¼ by 5 by 11 inches, which was planed all over, after which the holes for the different operations were roughed out. The piece was then carefully annealed to relieve any strains that might be in the steel. It was then finished to size, hardened at 1450 degrees F., and drawn in oil to 450 degrees F., when it showed a variation of 0.003 inch. The edges of hole *F* are rounded considerably to facilitate drawing down the piece; a spring pad is used.

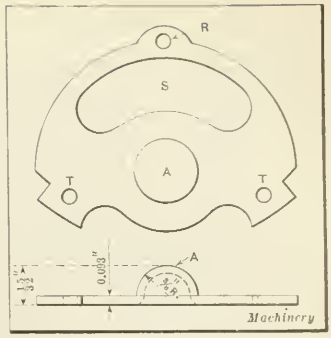


Fig. 1. Piece made in Gang Die

The part *H* is a piece of tool steel, worked out to the finished size of the boss, that has been hardened and fastened into the cast-iron die-block *B*, as shown in Fig. 2. The opening *I*, Fig. 3, in the die is fitted with a pad controlled by a heavy spring and suitable plates fastened to die-block *B*. In the ends of punches *J* and *M* are recesses in which the part that forms the boss is inserted. In this way, when the punch is to be ground down, the part forming the boss can be removed and afterward inserted. Punch *M* is 3/8 inch shorter than the cutting punch *J*, the piercing punches *L* are 3/16 inch shorter than punch *J*, and the slotting punch *K* is 1/8 inch shorter than punch *J* and has a shear of about 3/32 inch, as shown. A 5/8-inch spring stripper, held in position by shoulder screws, is used to hold the stock and strip it from the punches.

The dies were used in a No. 65 Consolidated geared press running at forty strokes a minute. As a finished piece was turned out at each stroke of the press, from 12,000 to 15,000 pieces were made in a day. The piece shown in Fig. 1 was made from hot-rolled strip steel 0.093 by 2.75 by 75.5 inches. In operation, the strips, which are long enough to make twenty blanks, are fed up against the gage marked "First Stop" in Fig. 3, and the press is tripped. A hole *R*, Fig. 1, is then punched in the strip and the boss *A* is drawn up by punch *M*. Owing to the tendency of the metal to crack across the boss *A* when the piece is made in one operation, this part is drawn up 1/16 inch larger than the finished size and with round corners, and later squeezed down to the desired size. As only the outside of the boss is used it is necessary to make the shape of this part a little full in order to get as true a radius as possible and also to make the metal fill the die.

The strip is then moved forward until the hole *R* fits over the gage pin marked "Second Stop," and the boss drops into the clearance hole *G*. When the press is again tripped, the slot *S* and holes *T*, Fig. 1, are formed by the punches *K* and *L*, respectively. The strip is then pushed forward over the blanking die *I* where pilot pins in the punch (not shown) engage the holes, centering the blank. Punch *J* then cuts out the blank and travels down and finishes the boss in die *H*, which is set solid in the cast-iron bolster. On the up stroke of the press, the blank is forced up by the pad in die *I*, which is controlled by a spring bumper fastened to the bottom of the die. This pad, working in conjunction with the spring stripper, forces the blank back into the strip of steel and it is carried out over the die when the stock is fed forward for the next blank. No stripper is necessary to remove the blank from the forming punch *J* because this punch is made slightly tapered at the large part of the ball. A plunger acting with the arm

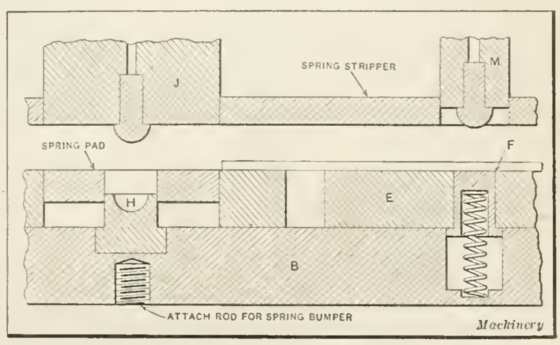


Fig. 2. Cross-section through Roughing and Finishing Dies

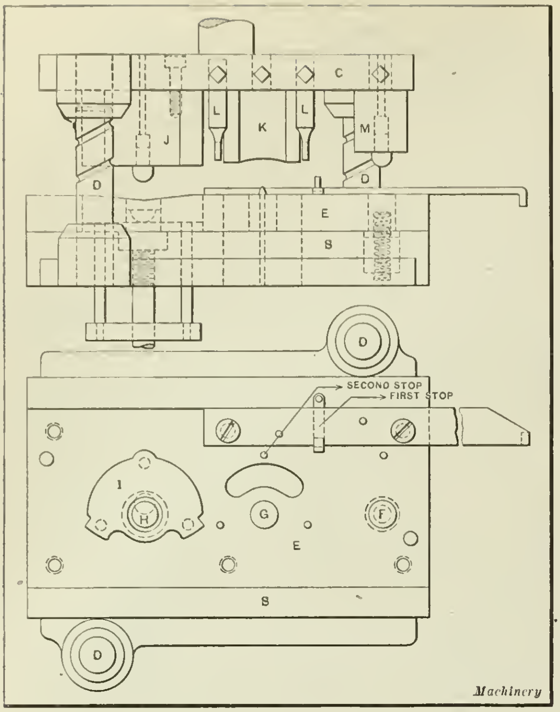


Fig. 3. Punch and Die for making Piece shown in Fig. 1

of the press knocks the blank out of the strip into a chute. All parts of this die must be accurately made or the stock will crawl, which would, of course, result in producing an unsatisfactory job.

Chicago, Ill. A. H. Wilson

BUILT-UP SNAP GAGES

In the October number of Machinery a type of built-up snap gage was described that is very well thought out but is possibly capable of improvement. The method of grinding the tolerance in the upper jaw necessitates two grinding operations when repairing after continued use. In the gage shown in Fig. 2, the tolerance is ground once only in the central piece and the jaws are ground parallel. This makes it possible to repair the gage by simply removing the jaws and grinding them true on a surface grinder; when reassembled, the gage is in condition to be used, as before. By the use of the chart shown in Fig. 1, it is possible to determine the proportions of gages that are not given in the table. This chart is self-explanatory and is simply plotted from the largest and smallest gages required and reading to the nearest fraction. This system of plotting is especially advantageous when standardizing a line of tools, as it is only necessary to plot the mean and the extreme tools in order to obtain a fairly accurate ratio for the intermediate sizes.

Leslie A. Wells

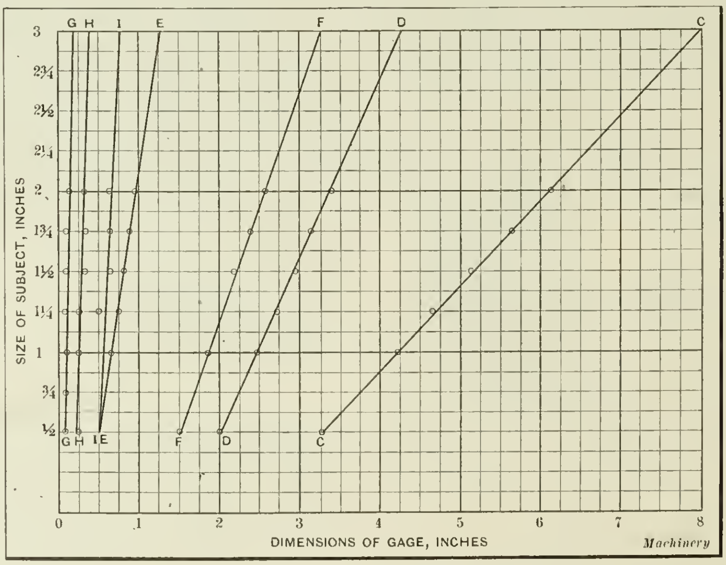
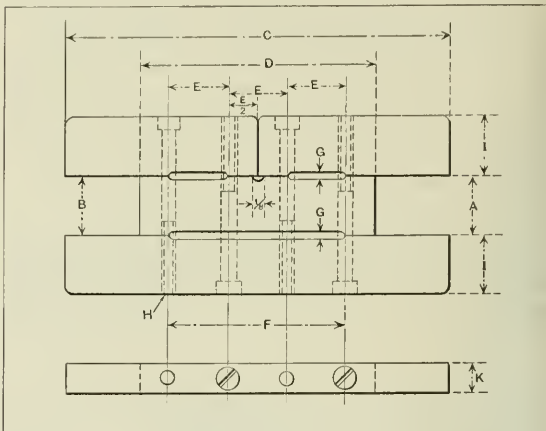


Fig. 1. Chart for determining Proportions of Gages

This type of gage was mentioned in the article referred to but was not illustrated.—Editor.

REMOVING RUSTY SCREWS

Those of us whose days are spent in manufacturing shops might open our eyes in surprise if we could see the variety of tasks laid before our brother in the trade who conducts a jobbing business in the country. As he is often the only man in the community, except the cross-roads blacksmith, with any knowledge of the metal-working arts, everything smaller than a locomotive and larger than a watch comes to him for repairs, and his ingenuity and resourcefulness become so highly developed that he is very seldom fazed by a job and obliged to send it out of town.



PROPORTIONS OF BUILT UP GAGES

A	B	C	D	E	F	G	H	I
1/2	B = A ± LIMIT	3 1/4	2	1/2	1 1/2	1/16	1/4	1/2
3/4		3 3/4	2 1/4	9/16	1 11/16	1/16	1/4	1/2
1		4 3/16	2 7/16	5/8	1 7/8	1/16	1/4	1/2
1 1/4		4 5/8	2 11/16	3/4	2	1/16	5/16	1/2
1 1/2		5 1/8	2 15/16	13/16	2 3/16	1/16	5/16	5/8
1 3/4		5 5/8	3 1/8	7/8	2 3/8	1/16	5/16	5/8
2		6 1/8	3 3/8	15/16	2 9/16	1/16	5/16	5/8

Machinery

Fig. 2. Proportions of Built-up Snap Gages

One such mechanic, however, thought that he had met his Waterloo when a sea captain brought in a sextant damaged by exposure to salt water. In order to take the instrument apart, it was necessary to remove several steel screws that were so rusted into a steel part that they defied a screwdriver. Prolonged soaking in oil having proved ineffectual, he sought the aid of a neighboring jeweler. The jeweler was also a repairer of specta-

cles, so he had abundant experience with rusted steel screws, as many men in his trade make a practice of tightening loose screws by rusting them in with potassium cyanide, regardless of the feelings of anyone who may subsequently wish to withdraw them. Carefully removing all oil, the jeweler put a bit of beeswax on each screw, heated the part until the wax melted, and easily turned them out.

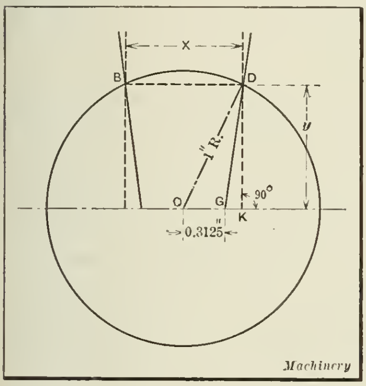
The sextant had a hardened steel worm, journaled at the ends in brass bushings fast in steel lugs. The worm was rusty and both ends were stuck to their bushings by rust. Here the machinist was on familiar ground, and needed no help. Procuring some mercury from the village drugstore, he put worm and all into it, allowing the mercury to act until the bushings were destroyed. Polishing the ends of the worm, he then made new bushings and soldered them in place. As the ordinary plumbers' solder and flux were evidently unsuited to this kind of work, he used non-corrosive fluid and 155-degree solder, both of which were furnished by the jeweler, in whose trade they are daily employed. The machinist then polished the worm thread by an old method. He turned a cylinder of soft wood, between the centers of a lathe, and mounting the worm in its own bearings on the tool-block, he fed it toward the wood until it cut grooves in the soft material. Applying fine emery and oil to this wooden "spiral gear," he soon restored to the worm its pristine finish and the sextant was ready to be assembled.

New London, N. H. GUY H. GARDNER

THE GEOMETRICAL PROBLEM

In the January number of MACHINERY, J. J. states in "A Geometrical Problem" that neither FD nor FG (or its equivalent y) can be found by trigonometry or geometry. However, the following is a simple solution by trigonometry; see diagram. From the problem, OG = 0.3125, the taper of the hole is 1 inch per foot, and the radius of the circle is 1 inch. Draw OD and the altitude DK. As angle GDK = 2 degrees, 23 minutes, 9 seconds, angle OGD = 92 degrees, 23 minutes, 9 seconds. According to the law of sines, in any triangle the sides are proportional to the sines of the opposite angles. Therefore, in triangle OGD, $\frac{OG}{\sin ODG} = \frac{OD}{\sin OGD}$, or $\sin ODG$

$$= \frac{OG \times \sin OGD}{OD} = \frac{0.3125 \times \sin 92 \text{ deg., } 23 \text{ min., } 9 \text{ sec.}}{1}$$



A Geometrical Problem

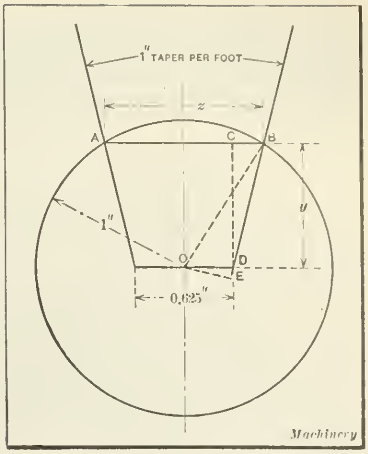
Since, sin 92 degrees, 23 minutes, 9 seconds = sin 87 degrees, 36 minutes, 51 seconds (subtracting from 180 degrees)

$$\sin ODG = \frac{0.3125 \times 0.99913}{1} = 0.31222,$$ from which it is found that angle $ODG = 18$ degrees, 11 minutes, 35 seconds. Adding angles ODG and GDK gives angle $ODK = 20$ degrees, 34 minutes, 44 seconds. Then DK, or $y = \cos ODK \times 1$ inch = 0.93619 inch and OK or $\frac{1}{2}X = \sin ODK \times 1$ inch = 0.35149 inch, making X equal to 0.70298 inch.

Detroit, Mich. LOWELL C. BLOMSTROM

Referring to J. J.'s solution of "A Geometrical Problem" by analytical geometry in the January number of MACHINERY, I would like to call attention to the fact that the problem can be solved by plain geometry or trigonometry. One of the many solutions is given in the following.

Extend BD to E, draw DC parallel to the center line, and draw OE at right angles to BE. A taper of 1 inch per foot gives an angle of 2 degrees, 23 minutes, 9 seconds, which is the size of angles BDC and EOD. Sin BDC = 0.04163, which is also sin EOD; and cos BDC = 0.99913, which is also cos EOD. As OD = 0.3125 inch, OE = 0.3125 × 0.99913 = 0.31223 inch and DE = 0.3125 × 0.04163 = 0.013 inch. $BE = \sqrt{1^2 - 0.31223^2}$ = 0.95 inch. So BD = 0.95 − 0.013 = 0.937 inch. Therefore, CD, or y = 0.937 × 0.99913 = 0.93618 inch, and AB or z = 0.625 + (1/12 × 0.93618) = 0.70301 inch.



A Geometrical Problem

Detroit, Mich. O. F. SCHWEITZER

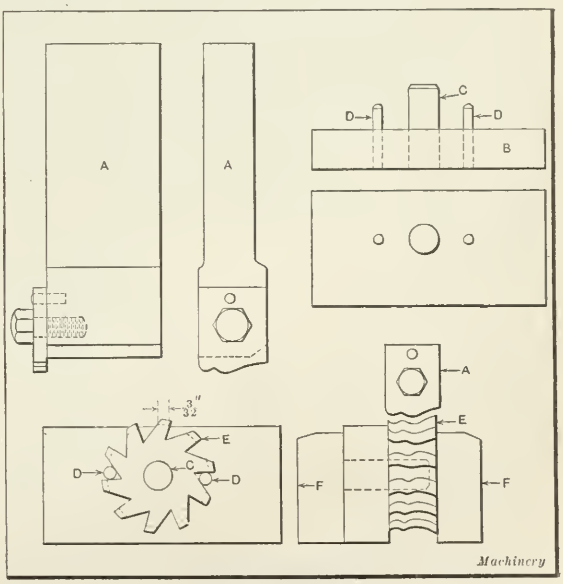
Solutions somewhat similar to these have been received from Edmund Barany of Newark, N. J., W. S. Portzinger of Lansing, Mich., and J. P. Ryan, of Hartford, Conn.—EDITOR.

TOOLS FOR BACKING OFF FORM CUTTER

Having occasion to make a form cutter and not having a backing-off machine or attachment, the following method was adopted, which proved entirely satisfactory. A male form tool was made from a model; this tool and its holder are shown at A in the accompanying illustration. Then a blank cutter was turned, with this tool located about 0.01 inch below the center of the lathe to get the proper "bite." The blank cutter was then milled for ten teeth having a land of ⅛ inch.

An indexing holder B was made to back off the teeth in the crank shaper, using the same male tool with which the blank cutter was turned. This holder consists of a piece of cold-rolled steel ½ by 1½ by 3 inches, a center stud C upon which the cutter revolves, and two dowels D. Each tooth was set forward off center 3/32 inch. The cutter and holder were held in the shaper vise and a tooth was planed at a very slow speed until the tooth was brought to the cutting edge. The micrometer stop was used on succeeding teeth.

Jersey City, N. J. WARREN H. DUNBRACK



Form Cutter and Tools for backing it off

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

CENTER OF A SQUARE

W. H. H.—Will you kindly decide the following question? A claims that a square has no center—that only a circle or sphere can have a center; B claims that a square has a center. Which is right?

A.—A square figure has no center in the geometrical sense; that is, there is no point that measures the same from all points in the periphery, as is the case with the center of a circle or sphere. But a square figure has a center of gravity; that is, the point on which a plane figure will balance. The answer to the question depends on what is meant—the geometrical center or the center of gravity. In one case A is correct, and in the other, B.

CENTRIFUGAL FORCE IN PULLEYS

H. F. C.—We have use for a small grinding wheel 1/4 inch diameter to be run at 30,000 R. P. M. by an 1800 R. P. M. motor. The first speed from the motor is secured from a 4-inch pulley which drives a 2-inch pulley; the next speed is obtained from a 14-inch pulley driving a 1 5/8-inch pulley. The countershaft on which the 2-inch and the 14-inch pulleys are mounted will run at about 3500 R. P. M. This gives the 14-inch pulley a peripheral speed of 12,800 feet per minute, which is entirely too high, of course, for cast iron. Can you tell me what peripheral speed is safe for aluminum pulleys?

A.—The specific gravity of cast iron is about 7.20 and that of aluminum 2.56; hence, cast iron is about 2.80 times as heavy as aluminum. Cast iron and aluminum are rated at about the same strength, *viz.*, 15,000 pounds per square inch cross-section. The centrifugal force developed in rotating bodies varies as the speed of the number of rotations—hence, an aluminum pulley 14 inches diameter can be run as much faster than a cast-iron pulley of the same diameter as the square root of the ratio of their specific gravities, or the square root of 2.80, which is 1.67, nearly.

FINDING HEIGHT OF CHIMNEY

C. H. G.—We have a tall chimney at our factory and wish to find its height without plumbing it; how can this be done?

A.—Referring to the illustration, set up a transit at B, measure very carefully the distance BA, sight the telescope to the top of the chimney, and measure the angle CBA. Then, in the right triangle CBA, right-angled at A, the side AB and the angle B are known, from which the height AC can readily be found. If no transit is at hand, the height can be determined quite closely in the following manner: Select a time when the sun is about midway between the horizon and the zenith, so that it will cast a comparatively long shadow. Take a pole of some convenient length, the longer the better, stand it upright so that the end of its shadow will just reach to the end of the shadow cast by the chimney, and measure the distance from the pole to the end of its shadow, which will be the same as the distance EB. Also measure the length of the shadow cast by the chimney, which corresponds to the distance AB. Then, from the similar triangles ACB and EDB, $AC\ (=x) : ED = AB : EB$. Suppose AB = 92 feet, 8 inches, EB = 11 feet, 5 inches, and the pole is 9 feet long; then $x : 9 = 92\ 8/12 : 11\ 5/12$, or $x : 9 = 1112 : 137$; from which $x = 73$ feet, very nearly, which is the height of the chimney. J. J.

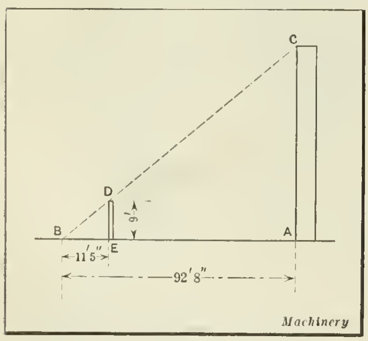
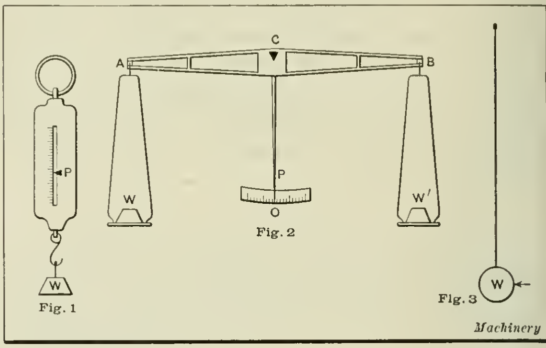


Diagram for finding Height of Chimney

ABSOLUTE MEASURE OF FORCE

H. A. E.—Please state what is meant by absolute measure of force. What does "absolute" mean in this case, and also, in the expression "absolute term?"

A.—Roughly speaking, absolute may be defined as unchanging, or unchangeable. In an equation like $7x^3 - 23x^2 + 96x - 215 = 0$, the term—215, is called the absolute term because its value is always the same, regardless of what value or values may be assigned to x. A force is measured by the effects it will produce; and one way of measuring a force is by using a spring scale, as shown in Fig. 1. The weight W pulls the indicator P to a certain mark on the scale, thus not only indicating the weight of W but also the force with which W stretches the spring. This method of measuring force is inconvenient, for the reason that we need the same mass to indicate always the same force when used as a measure of force. In the present case, the weight of the body W (and, consequently, the pull on the spring) will depend on where the body is weighed, whether at sea level or otherwise, and on the latitude of the place, the barometric pressure, the temperature of the air, etc. If, however, a beam scale, Fig. 2, is used, and the arm AC equals the arm BC, the pointer P being at 0 when no weights are in the scale pans, a weight W in one scale pan must exactly equal a weight W' in the other, in order to keep the pointer at 0. If W is known, an equal mass W' can easily be found, regardless of any of the conditions just mentioned. In so far as the earth's surface is concerned, the measurement of W' will be absolute; but at the center of the earth or at a certain point between the earth and the moon, for example, where the body has no weight, a beam scale could not be used either. Suppose that the weight W is suspended from a cord, say a mile long, as in Fig. 3, and that a force acting on it causes the weight to move a foot in a certain time, and at the end of this time, to have a velocity v. The path may be assumed to be a straight line. If the force is doubled, the velocity at the end of the same time will also be doubled; and if the force is halved, the velocity at the end of the same time will be halved. Since the mass of a body is absolute (it depends only on the amount of matter that the body contains), we have here a way of determining an absolute measure for force, and may say that the absolute unit of force is that force which acting on a mass of one gram for one second, produces a change of velocity of one centimeter per second; this force is called one dyne, and is also called the C. G. S. (centimeter-gram-second) unit of force. J. J.

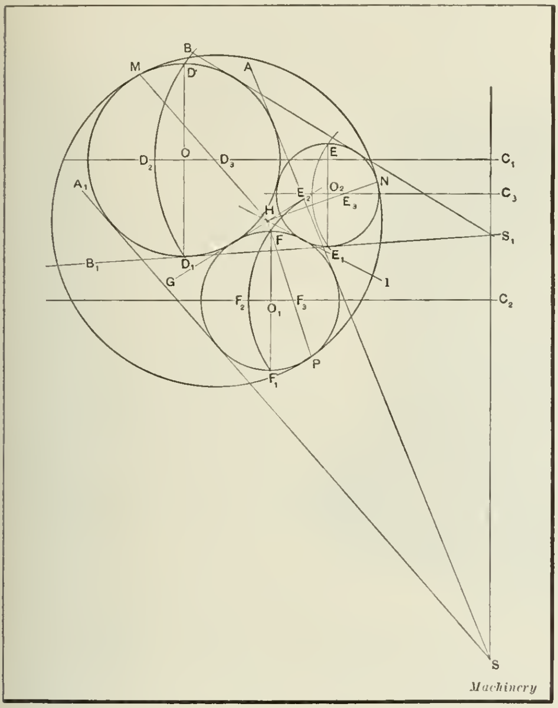


Figs. 1 to 3. Methods of measuring Force

TO DRAW A CIRCLE TANGENT TO THREE GIVEN CIRCLES

M. A. C.—Is there any exact geometrical construction for drawing a circle tangent to three circles that are tangent to each other? For example, if the diameters of three circles are 2, 1 7/16, and 1 1/16 inch, what is the smallest circle that will enclose them?

A.—There is no method known to the writer whereby this problem may be solved by applying the principles of what is called Euclidean geometry—the kind that is ordinarily studied in schools. It may be solved, however, by what is called modern or profective geometry (although the construction is not easy) in the following manner: Let O, O_1, and O_2 be the



Method of drawing a Circle Tangent to Three Given Circles

centers of the three given circles. Draw AS and A_1S tangent to the two circles O and O_1, intersecting at S; draw BS_1 and B_1S_1 tangent to the two circles O and O_2, intersecting at S_1; draw S_1S. Through the centers of the given circles, draw OC_1, O_1C_2, and O_2C_3, all perpendicular to S_1S. Draw the diameters DD_1, EE_1, and FF_1 parallel to S_1S. Through the three points D, D_1, C_1, the three points E, E_1, C_3, and the three points F, F_1, C_2, pass arcs of circles intersecting C_1O, C_3O_2, and C_2O_1 in D_2, E_2, and F_2, respectively. On OC_1 lay off $OD_3 = OD_2$; on O_2C_3 lay off $O_2E_3 = O_2E_2$; and on O_1C_2 lay off $O_1F_3 = O_1F_2$. Now draw GH tangent to the circles O and O_1, and draw IH tangent to the circles O_1 and O_2; they intersect at H. Draw HD_3, HE_3, and HF_3; they intersect the three circles in M, N, and P, the points of tangency for the circumscribing circle. Through M, N, and P, by the usual construction, pass a circle; this will be the circle sought. J. J.

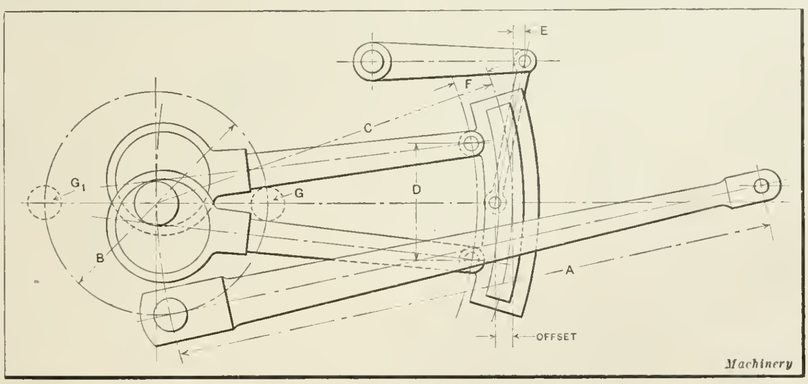


Fig. 1. Model of Stephenson Link Motion used as Base for finding Offset of Saddle-pin

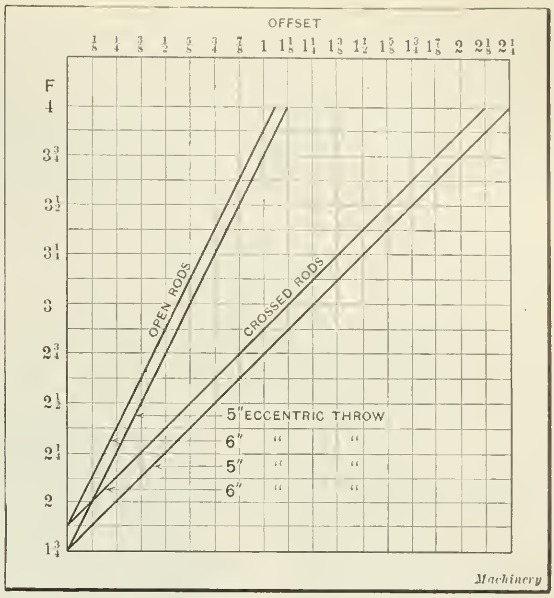


Fig. 2. Chart for determining Amount of Offset of Saddle-pin

OFFSET OF SADDLE-PIN OF STEPHENSON LINK MOTION

H. L. W.—The writer has been unable to find any formula for calculating the offset of the saddle-pin of the Stephenson link motion. The need for offset is mentioned in works on locomotive design, but no rule is given for obtaining it.

A.—The general practice of locomotive builders has been to determine the offset of the saddle-pin by trial, using a saddle with slotted holes in the pad to permit it to be adjusted until the irregularities introduced by the angularity of the connecting-rod are compensated for. No practicable formula is known by which the offset can be calculated, but C. J. Mellin, consulting engineer of the American Locomotive Co., has kindly furnished the accompanying data, which may be used in finding the offset without trial. The method was worked out on a valve model with given dimensions of gear as a base, variations being made of these dimensions and other conditions. The offset is obtained by additions and subtractions as indicated in the following: The model or base dimensions, Fig. 1, are as follows: $A = 96$ inches; $B = 24$ inches; $C = 48$ inches; $D = 12$ inches; $E = 1/2$ inch.

Example: Given a valve motion of the "open rods" type in which $A = 108$ inches; $B = 26$ inches; $C = 60$ inches; $D = 13$ inches; and $E = 0$ inch to find the offset, the eccentric throw being 5 inches, and F, 3 inches. The base figure of the offset is 5/8 inch, found in the diagram Fig. 2. The amounts added to the base or subtracted from it are taken from the following for "open rods":

Add 1/16 inch to offset for each additional 12 inches to A; subtract 1/32 inch from offset for each additional 2 inches to B; subtract 1/16 inch from offset for each additional 12 inches to C; subtract 1/4 inch from offset for each additional 1 inch to D; add 1/16 inch to offset if E is 0, from which we obtain 5/8 + 1/16 — 1/32 — 1/16 — 1/4 + 1/16 = 13/32 inch offset.

If the valve

motion is of the "crossed rods" type, then add 1/8 inch to offset for each additional 12 inches to A; subtract 1/16 inch from offset for each additional 2 inches to B; subtract 1/8 inch from offset for each additional 12 inches to C; subtract 1/2 inch from offset for each additional 1 inch to D; add 1/8 inch to offset if E is 0. If too much offset is given, the cut-off will be longer on the front end of the cylinder than on the back with open rods, and *vice versa* with crossed rods.

The connecting-rod is shown out of position in Fig. 1 for the sake of clearness. The crank-pin will be at G if the valve motion is of the "open rods" outside admission valve type and at G_1, if of the "crossed rods" type.

STRENGTH OF A RIBBED PLATE

N. F. F.—The ribbed cast-iron plate shown in Fig. 1 is uniformly loaded over a surface 29 inches in diameter at the center and firmly supported at the four corners. What load will it safely support and at what load will it fail?

Answered by John S. Myers, Philadelphia, Pa.

There is always more or less uncertainty as to the strength of ribbed cast-iron sections on account of shrinkage strains, blow-holes, and other inherent defects which may develop

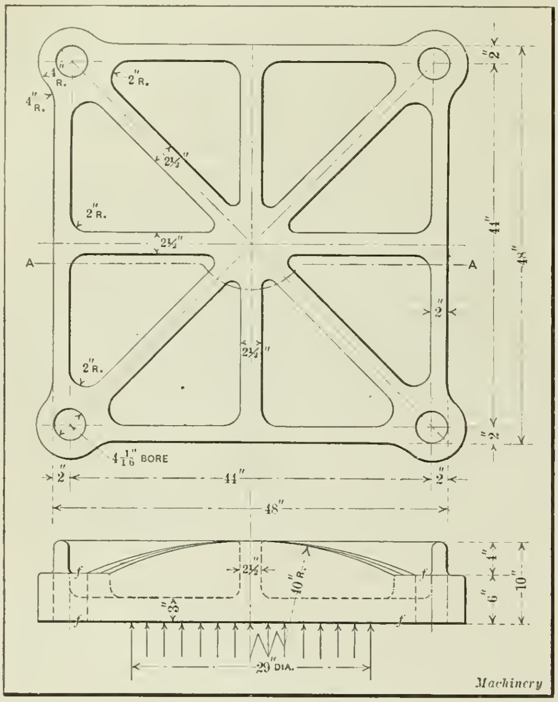


Fig. 1. Dimensions of Ribbed Plate

under load but which may not be apparent to the inspector. This is especially true of those cases where the ribs are under tension, as in the present example. In view of such considerations some designers virtually neglect the ribs when estimating the strength, treating the casting as a flat plate slightly thicker than the actual plate, thus allowing something for the stiffening effect of the ribs. While this rough and ready method has simplicity in its favor, and may be quite satisfactory when applied with discretion, it is not very satisfying from a technical viewpoint. If the ribs are of no calculable value, why not omit them from the casting as well as from the calculations? The logical method seems to be to calculate the strength based on the full value of the ribs and allow a stress sufficiently low to take into account possible imperfections in both theory and practice.

Assuming the casting to break along the line A–A, the section would be about the equivalent of that shown in Fig. 2. The area of the section is $A = 7 \times 11.5 + 3 \times 48 = 224.5$ square inches. Taking moments of the areas about the center of the three-inch plate, the distance to the center of gravity is

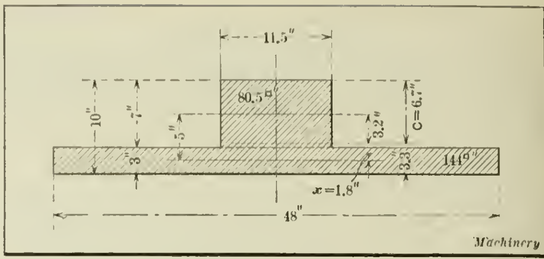


Fig. 2. Equivalent Section through Casting on Line A-A

$$x = \frac{7 \times 11.5 \times 5}{224.5} = 1.8 \text{ inch, approximately.}$$

Taking the areas times the square of their distance from the center of gravity, plus their moment of inertia about their own axis, the moment of inertia of the section is $I = 80.5 \times 3.2^2 + 144 \times 1.8^2 + \frac{11.5 \times 7^3}{12} + \frac{48 \times 3^3}{12} = 1727$. The section modulus for the tension side is then $Z = \frac{I}{C} = \frac{1727}{6.7} = 258$.

The casting may now be considered as a beam loaded as indicated in Fig. 3, when the bending moment is $M = \frac{W}{2} \times 22 - \frac{W}{2} \times 6 = 8W$. The general formula for the relations of moment M, stress S, and section modulus Z is $M = SZ$. Assuming a value of $S = 4000$ and substituting the values of M and Z gives $8W = 4000 \times 258$ or $W = 129{,}000$ pounds as the safe load based upon the comparatively high working stress in the tension side of the ribs of 4000 pounds per square inch. If the load is suddenly applied or the casting is subjected to shock, about half this value will represent the safe load.

Since the elasticity of cast iron in tension and compression is not the same, $\frac{I}{C}$ does not represent the true section modulus, being only approximately true. Also the expression $M = SZ$ is only supposed to hold good within the elastic limit, and with strict propriety cannot be applied for the breaking load. However, in view of the other uncertainties of the problem, precision is far from attainable and this relation may be assumed to be approximately true for the breaking load also. Taking a stress of 16,000 pounds per square inch, which is four times the assumed working stress, failure would occur at a load of approximately $4 \times 129{,}000 = 516{,}000$ pounds; but if the plate is subjected to shock, a load less than half this amount might cause failure.

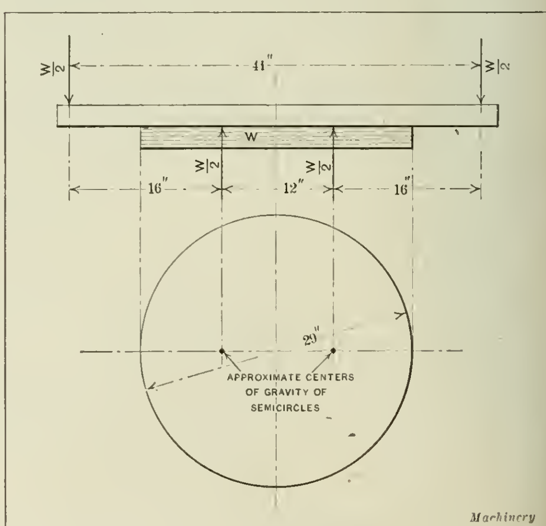


Fig. 3. Loading as a Beam

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

CONRADSON PLAIN MILLING MACHINE

This machine is arranged with a duplex helical drive to the spindle which, in connection with changes obtained from sliding gears in the speed-box, affords twelve speed changes from 12 to 275 revolutions per minute. This is the feature which represents marked departure from standard practice in the design of plain milling machines.

C. M. Conradson of Eau Claire, Wis., is now building a No. 3 plain milling machine with single-pulley drive, which is illustrated and described herewith. It will be seen that, in a general way, the design of this machine follows established practice, except for the arrangement of the speed and feed gearing. It is worthy of notice, however, that the machine is of exceptionally heavy construction. The duplex helical drive to the spindle is similar to that employed on the Conradson engine lathe. From the single driving pulley, which is 14 inches in diameter by 4 inches face width, power is transmitted through heat-treated, chrome-nickel steel change-gears, which furnish the desired range of speeds. These gears are mounted in a cylindrical case which may be oscillated in such a way that engagement is made between either a worm and a worm-wheel keyed to the milling machine spindle or between a spiral pinion and a spiral gear keyed to the milling machine spindle. Thrust is taken by heavy-duty S.K.F. ball bearings.

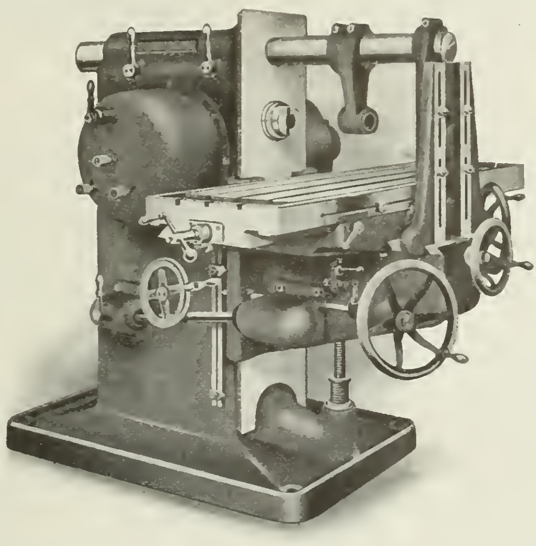


Fig. 1. Conradson No. 3 Plain Milling Machine with Duplex Helical Drive

This arrangement will be readily understood by reference to Fig. 3, which shows the mechanism in detail. It will be seen that driving pulley *A* is provided with a friction clutch *B* for engaging or disengaging the drive. This clutch is secured to shaft *C* that runs through the center of sleeve *D*. Carried at the left-hand end of shaft *C* are two sliding gears *E* and *F* which may be engaged with gears *G* and *H* to secure the first two speed changes. In either position of gears *E* and *F*, it will be seen that power is transmitted back through pinion *I*, which is keyed at the left-hand end of sleeve *D*. A third speed change is secured by sliding gears *E* and *F* to their extreme right-hand position, so that the clutch teeth on gear *F* engage direct with corresponding clutch teeth on pinion *I*. In this position, gears *G* and *H* will continue to revolve on the intermediate shaft, but they play no part in the transmission, as a direct high-speed drive is secured through sleeve *D*.

Near the center of sleeve *D* there are mounted two pinions *J* and *K* that mesh with sliding gears *L* and *M* on the lower shaft in the speed-box. Gear *M* may be engaged with pinion *J*, as shown, or the gears may be slid over to bring gear *L* into engagement with pinion *K*. Of course, it will be evident that the operation of sliding gears *E* and *F* is controlled by knob *N*, while operation of sliding gears *L* and *M* is controlled by knob *O*, spring plungers being provided to enter notches in the rods that carry these knobs when the sliding gears are engaged in various positions. From shaft *P* in the speed-box, power is transmitted to the milling machine spindle by rocking the cylindrical speed-box to engage worm and wheel *Q* or spiral gears *R*, in the manner to which refer-

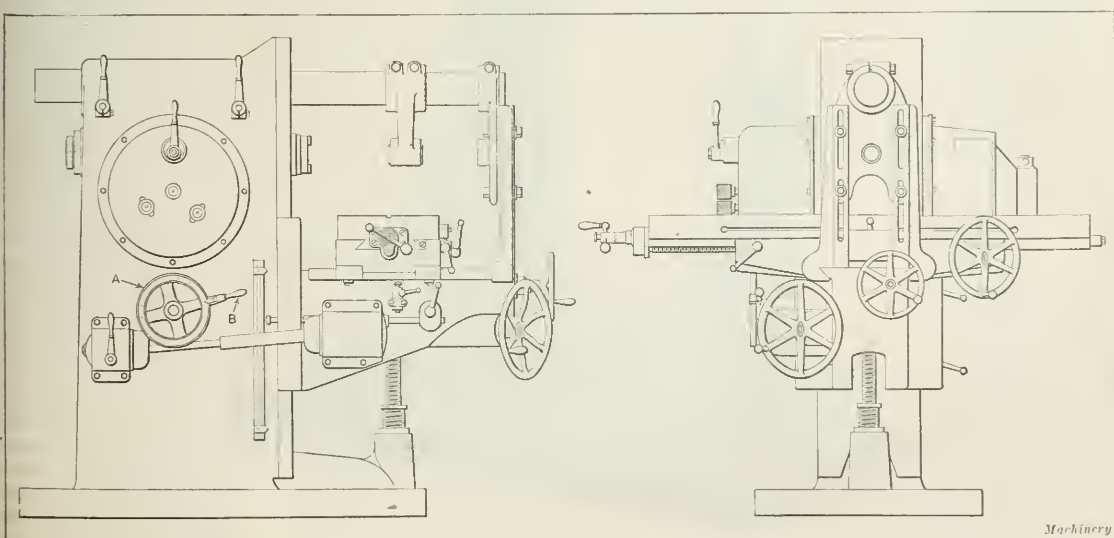


Fig. 2. Side and Front Views of Conradson No. 3 Plain Milling Machine shown in Fig. 1

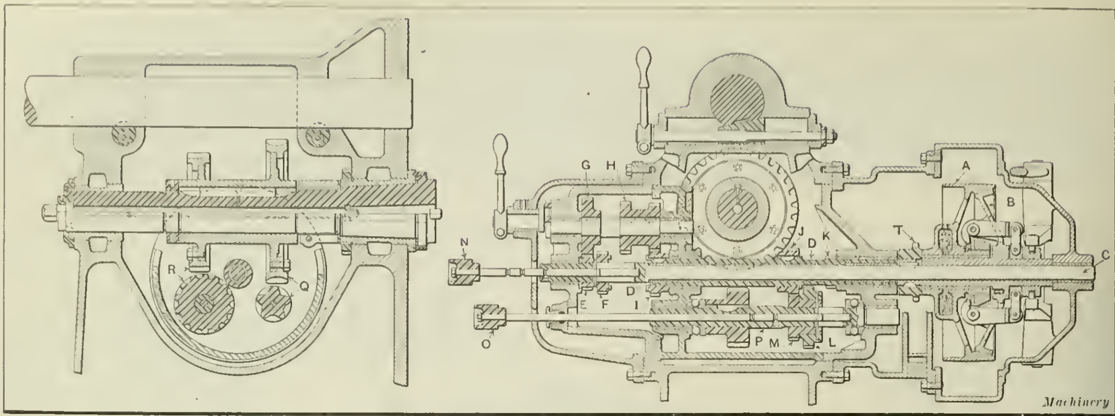


Fig. 3. Cross-sectional View through Speed-box showing Arrangement of Change-gears

ence has already been made. The worm drive and the spiral gear drive are of widely different ratio, thus providing a greater range of spindle speeds than would otherwise be obtainable. Also, these helical gear drives furnish an exceptionally smooth transmission. Rocking of the speed-box to engage either the worm-wheel or spiral gear drive is controlled by a lever. This mechanism provides twelve changes of speed, covering a range of from 12 to 275 revolutions per minute, the changes being in practically geometrical progression.

Power for operating the feed mechanism is transmitted to the gear-box by means of a chain drive from sprocket *T*, Fig. 3. This feed-box is arranged with a cone of gears, the desired rate of feed being obtained by engaging the proper gear ratio with a diving key. Movement of this key is controlled by a screw, at the end of which is located dial *A*, Fig. 2, which is graduated to facilitate obtaining the desired rate of feed. This mechanism, in connection with compounding lever *B*, provides for securing sixteen changes of feed, ranging from ½ inch to 20 inches per minute. The feed can be changed while the machine is running, and the direct-reading index on dial *A* obviates the necessity of using tables. All feeds are instantly reversible.

The over-arm is made of steel, and is 4¼ inches in diameter; this arm is clamped by wedges actuated by two levers that will be seen at the top of the machine. The maximum distance from the center of the spindle to the under side of the arm is 6⅜ inches, and the maximum distance from the end of the spindle to the arbor support is 25¼ inches. Two arbor supports are furnished, one of which supports the end of the arbor, and the other the middle. The front spindle bearing is 4¼ inches in diameter; and the spindle has a No. 11 taper hole and a 13/16-inch hole running through it. A faceplate forged integral with the spindle provides for driving face cutters.

The table is 12¾ by 63¼ inches in size, and the working surface is 12¾ by 53 inches in size. There are three ⅝-inch T-slots in the table, and the table feeds 34 inches in either direction. Each operating screw is provided with a graduated dial reading to 0.001 inch, and all handwheels are clutched. The maximum cross-feed is 10 inches, and the maximum vertical feed is 20 inches. The vise furnished with the machine has jaws 6 1/8 inches wide by 1 9/16 inch deep, and has a maximum opening of 3 5/8 inches. The floor space occupied by the machine is 96 inches in line with the spindle by 115 inches at right angles to the spindle; and the net weight of the machine is 4750 pounds.

LANDIS FLOOR-TYPE BORING, MILLING AND DRILLING MACHINE

The Landis Tool Co., Waynesboro, Pa., is now manufacturing a horizontal floor type of boring, milling and drilling machine designed to insure durability, simplicity of operation, and adaptability for a wide range of work. This machine may be used not only for boring, drilling and milling, but for tapping, splining, oil-grooving and rotary planing operations. It is driven from a motor mounted on top of the column. The drive is direct-connected to the main drive shaft, there being no belting whatever. The spindle drive is controlled by a pair of friction cone clutches, located at the back of the saddle and accessible for adjustment. This arrangement provides a reversal of the spindle for back facing and tapping.

The driving pinion for the spindle meshes with a large gear, the teeth of which are integral with the faceplate. This location of the spindle driving gear, by eliminating torsional strains, prevents one of the most frequent causes of chatter when milling. The front end of the spindle slides through an adjustable bearing carried on the spindle sleeve, but the spindle does not rotate in this bearing. The rotation

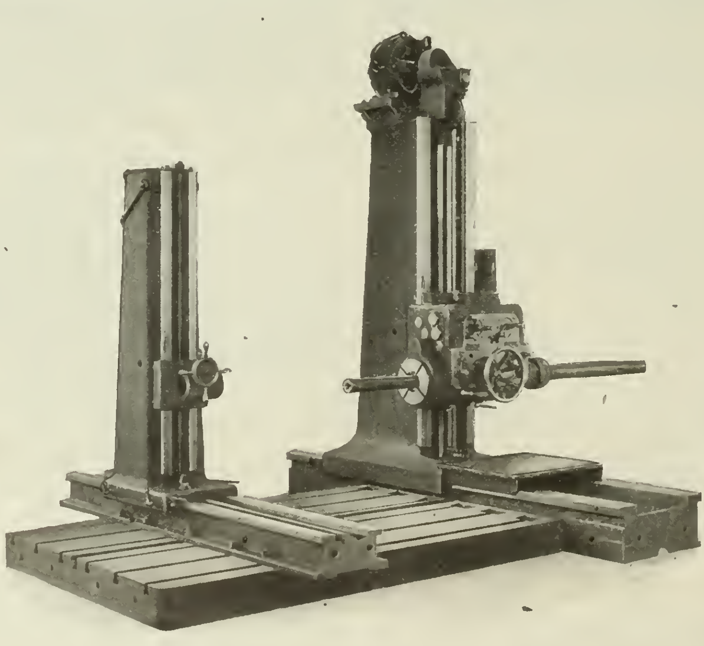


Fig. 1. Landis Floor Type of Horizontal Boring, Milling and Drilling Machine

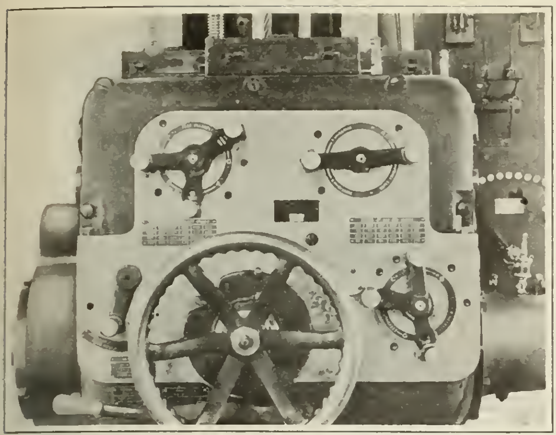


Fig. 2. Saddle of the Landis Boring, Milling and Drilling Machine

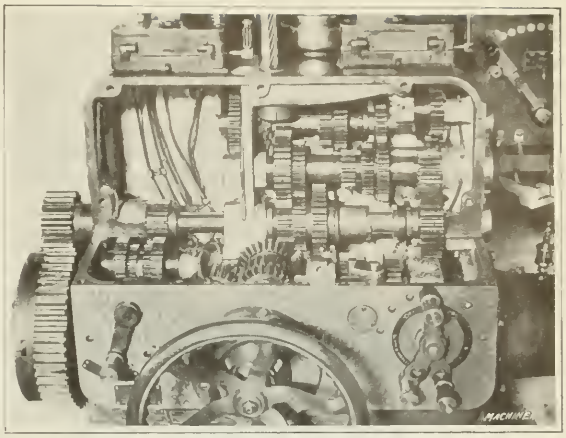


Fig. 3. Spindle Driving and Feeding Mechanism

is in another adjustable bearing, and on the external diameter of the spindle sleeve. The advantage of this design is in the provision for taking up wear on the sliding spindle bearing.

A prominent feature of this tool is the concentric screw feed of the spindle, accomplished by means of a differential train of gears. This method of feeding permits continuous traverse of the spindle without resetting. The feed is applied between the main bearings, and requires no overhanging support at the end of the saddle. The spindle is traversed by a long bronze nut, which engages a square thread on the spindle and which has a bearing only on the sides of the thread. This arrangement provides a long bearing, and the nut and spindle rotate together at the same rate of speed, except when the feed is engaged. The end thrust in the spindle, in either direction, is taken on ball bearings.

The thrust of the spindle when milling is taken directly on the main saddle casting, and is entirely independent of the end thrust of the spindle for boring. The application of feed and speed gear trains in the saddle, as one unit, gives a centralized and convenient control.

Twelve changes of feed and twelve changes of speed are available. All feeds are per revolution of the spindle and are identical whether applied to the spindle, saddle or column traverse, and no two feeds can be engaged at the same time. Any one of the twelve feeds can be used in connection with one of the twelve spindle speeds. Power rapid traverse, independent of the regular feeds, is provided for the spindle, saddle and column in every direction. With one lever, the machine can be instantly started and stopped, or reversed, independent of the main drive or motor.

The gear shifts are all of the sliding transmission type, and are tightly enclosed. This feature adds not only to the life and appearance of the machine, but also provides safety for the operator. All traversing gears are located between the ways, and close to the guiding side. The gears and shafts are made of chrome-nickel steel specially heat-treated. The spindle is made of high-carbon hammered crucible steel and is accurately ground to secure correct alignment. The oiling of the saddle parts is accomplished by the syphon system, which insures a continuous supply of clean oil to the bearings. The counterweight for the saddle operates inside the column, out of the way of the operator, thus assuring safety in accordance with state laws.

When a swivel table is used with this machine, the different sides of work may be finished without resetting. Scales and verniers reading to thousandths of an inch are provided for locating either the main or outer supporting saddles and columns in the desired positions. There is also an adjustable dial reading to thousandths of an inch for use in connection with the spindle.

The column is of very heavy construction and has a liberal bearing surface on the horizontal runway. It may be adjusted along this runway either by hand or power, and is provided with reversible feeds for milling and a rapid traverse. The spindle has a continuous feeding movement of 40 inches; the minimum distance from the center of the spindle to the floor plate is 18 inches, and the maximum distance, 72 inches. The maximum distance from the faceplate to the outer spindle support is 88 inches. This machine has been designed especially to meet the requirements of shipyards, navy yards, turbine works and similar plants, and it is capable of handling a wide range of heavy work.

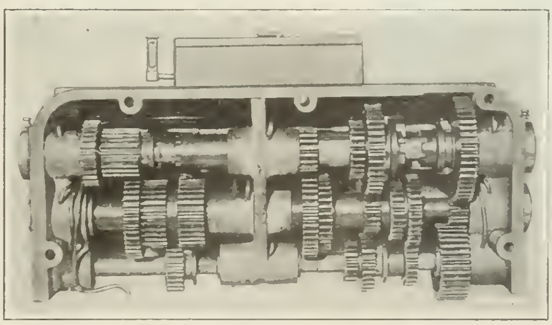


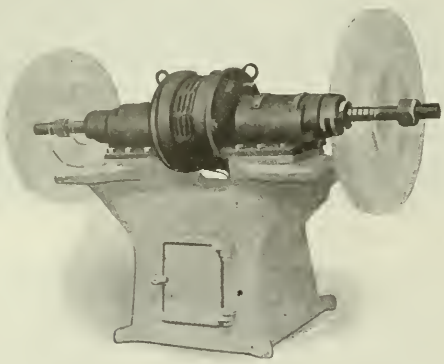
Fig. 4. Section removed from the Saddle shown in Fig. 3

WESTINGHOUSE GRINDER MOTOR

The grinder motor illustrated has been recently placed on the market by the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. It is designed for use on two- and three-phase, sixty-cycle, alternating-current circuits, and is constructed especially to meet the severe conditions to which such motors are subjected in grinding and polishing work. This grinder motor is obtainable in three sizes, having capacities of 5, 7½ and 10 horsepower, respectively. The 7½- and 10-horsepower two-phase motors are supplied with automatic starters. For the 5-horsepower two- and three-phase motors, an ordinary knife switch is employed, and a special starting switch for the 7½-horsepower two- and three-phase motors. Pedestal bases, grinding wheels, and tool-rests are furnished by the grinding machine manufacturer.

To protect all parts against wear and injury from grit and metallic dust, the bearings are made dustproof, and the motor is wholly enclosed. A large radiating surface is provided, however. The end brackets are solid and are cast integral with the feet, which are extra heavy and arranged so that they can be bolted rigidly to the pedestal. The heavy grinding wheels with which these motors are designed to be used put a great strain on the shaft and bearings. These parts are therefore made extremely strong and rugged. The shaft, which is made of axle steel, is of extra large diameter, and is extended at both ends to receive the grinding wheels. The bearings, which are the only wearing parts, have large bearing surfaces, insuring long life. Each is thoroughly lubricated by two oil-rings. The end thrust is taken up by adjustable collars.

The rotor of the motor, which is of the squirrel cage form, cannot be damaged. There are no moving contacts. The rotor bars are firmly fastened in the iron core and are short-circuited by end rings. No bolts or screws are used, and there is nothing about the rotor that can work loose even under the most severe service, or that will deteriorate under heat. The stator winding is thoroughly treated with an oil- and moisture-resisting varnish. In motors larger than five horsepower, the winding consists of coils wound on forms and completely insulated, then laid in the open stator slots and securely held in place by means of wedges.



Alternating-current Grinder Motor made by Westinghouse Electric & Mfg. Co.

BRISTOL AUTOMATIC TEMPERATURE CONTROLLER

In the field of temperature measurement as applied in industrial works and manufacturing plants the logical steps are, first, to measure and indicate the temperature with a reading instrument; second, to automatically record the temperature with a graphic recording instrument; third, to automatically control the temperature. At this time the manufacturers are endeavoring to use automatic apparatus wherever possible, thus eliminating the personal element, and there is a demand for automatic temperature controllers in many processes. The Bristol Co., Waterbury, Conn., has developed a comprehensive new line of automatic temperature controllers for gas- and oil-fired and electrically heated furnaces. The new Bristol temperature controller employs three elements: a measuring element, a contacting element and an operating element.

Fig. 1. Measuring and Controlling Elements—Thermo-electric Type

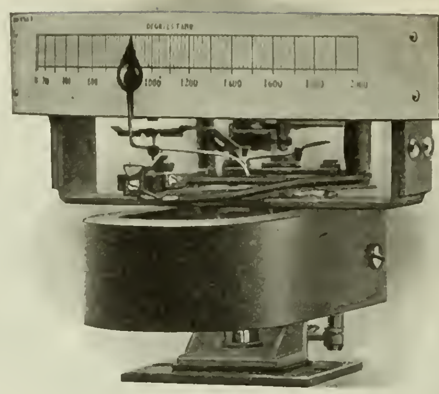


Fig. 2. Interior View of Controlling Element

The measuring element consists of a number of different types of Bristol electric pyrometers and thermometers; notably the Bristol thermo-electric pyrometer with Weston millivoltmeter movement and patent Bristol separable couples, also the Bristol vapor-filled type of thermometer which is extensively used for recording temperatures. The controlling element is combined with the measuring element and consists primarily of a patented electrical contact closing device, which operates at predetermined high and low temperatures, and by means of which electrical circuits are closed or opened, thus energizing or disconnecting the operating element. The operating element consists of the device which actually regulates the heat supply in the furnace; as, for instance, in the case of a gas-fired furnace, a pair of electrically operated gas and air valves, and in the case of an electric furnace a special relay switch opening and closing the circuits of the heating element of the furnace.

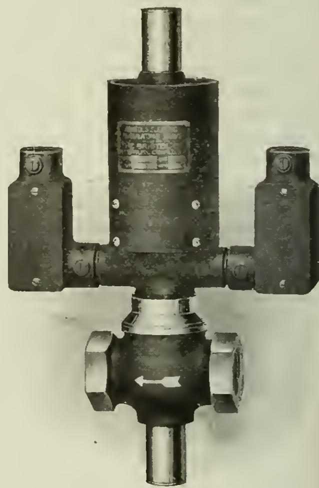


Fig. 3. Special Gas and Air Valve used in Connection with Gas Furnaces

Construction details of the new Bristol temperature controllers may be seen by reference to the accompanying illustrations. Fig. 1 shows an external view of the measuring and controlling elements of the thermo-electric type, and Fig. 2 is an interior view of the controlling element, from which it may be seen that the indicating arm is completely insulated from the operating circuits. The contacting device is absolutely frictionless. These Bristol thermo-electric temperature controllers can be furnished for all temperatures up to 3000 degrees F., and with high resistance movements for use either with base or precious metal couples. Fig. 3 shows one of the special gas and air valves, two of which are used in connection with gas furnaces if air is supplied at pressure, and both gas and air valves are operated simultaneously so as to insure having the proper mixture at all times.

Fig. 4 shows one of the vapor type Bristol thermometer-thermostats, complete with sensitive bulb and connected to the special relay switch employed for adapting these instruments to the control of temperatures in electric ovens and furnaces. Fig. 5 shows an interior view of a similar Bristol thermometer-thermostat. The special design of contact closing device has

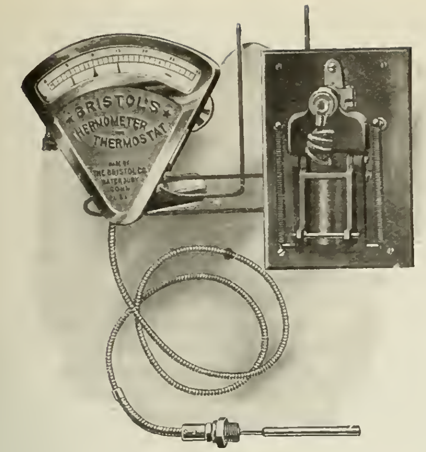


Fig. 4. Vapor Type of Bristol Thermometer-thermostat connected to Special Relay Switch

proved durable in long continued service. Both the high and low contacts are shown in this illustration, but with the Bristol automatic electrical controlling valves for both gas and air supply, only one contact is required. These temperature controllers are needed for a great variety of applications

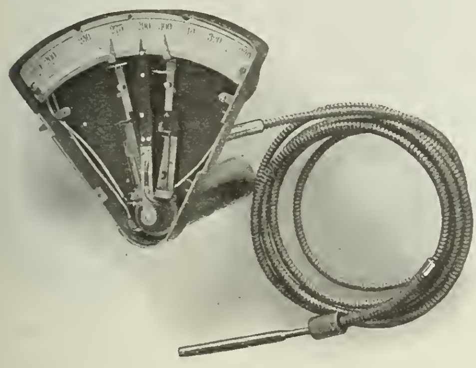


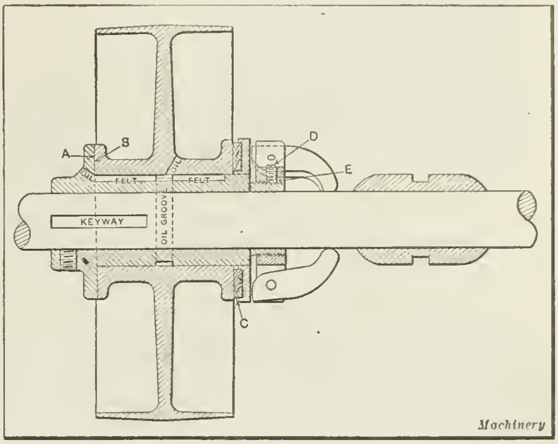
Fig. 5. Interior View of Bristol Thermometer-thermostat

and may be adapted to hundreds of processes where similar Bristol instruments are already being used successfully for measuring and recording temperature.

NATIONAL FRICTION CLUTCH

In the "Crowley" friction clutch, which has just been placed on the market by the National Clutch Co., Fulton and Lincoln Sts., Chicago, Ill., use has been made of what are known as "friction wedge plates." There are two of these plates, and they are transversely tapered and work in opposite directions; plate *A* is part of the hub keyed to the driving shaft, so that this is the driving member, and plate *B* is part of the pulley and rotates freely upon the hub that carries plate *A*. When the three fingers are pressed against compression plate *C*, it forces the pulley along the hub so that the tapered faces of plates *A* and *B* are brought into contact. As previously mentioned, these plates are transversely tapered and they work in opposite directions. Plate *B* is driven by the belt on the pulley, and plate *A* is keyed to the shaft to provide for carrying the load; when the clutch is first engaged, frictional contact between plates *A* and *B* starts the machine, and then as the load is picked up, the two friction plates, working in opposite directions, bring the two wide parts of the plates together, thus increasing the pulling power of the clutch.

There are three longitudinal grooves in the hub, one of which is shown in the illustration, which run the full width of the pulley; also there is a circular groove running around the hub at right angles to the axis of the shaft. The longitudinal grooves are filled with felt, which becomes saturated with oil and provides the clutch with a lubricating system that has sufficient capacity for one month's service. Adjustment of the clutch is taken care of by loosening setscrew *D* in spider *E* and turning this spider on the threaded part of the hub, to the right to tighten, and to the left to loosen. These clutches are heavily constructed to adapt them

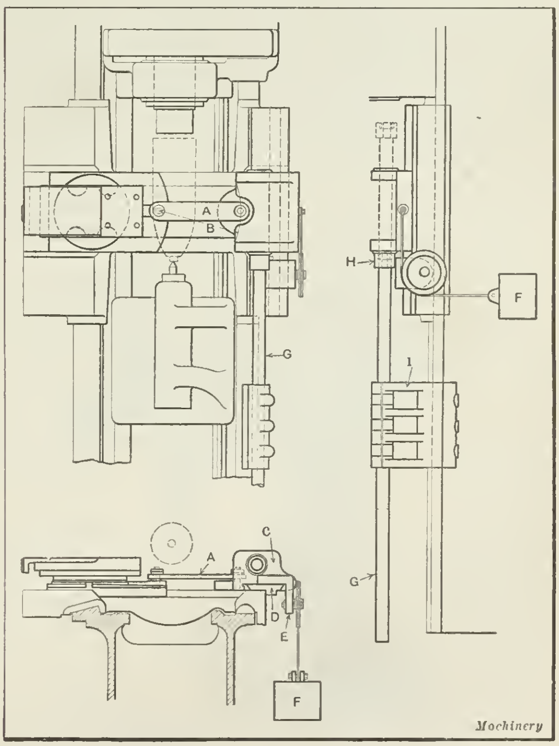


"Crowley" Friction Clutch made by National Clutch Co.

for severe service; at the same time, they are of compact construction, operate easily, and release instantly. "Crowley" friction clutches are built in sizes from 2 to 20 inches in diameter.

AUTOMATIC PROFILING ATTACHMENT

Houston, Stanwood & Gamble Co., Cincinnati, Ohio, is now manufacturing an automatic profiling attachment which forms the subject of the following description. This device consists of a radius rod *A* with a distance between its centers equal to radius *B* of the nose of the shell. One end of this radius rod



Shell Profiling Attachment for Lathes

turns on a pin fastened to the cross-slide that carries the tool, while the pin at the other end of the radius rod is attached to a slide *C* that moves along a longitudinal guide *D* attached to the rear of the carriage. There is a stop *E* on this longitudinal guide against which the slide is held by means of a weight *F*, which is attached to the slide by a wire cable and pulley. In addition to the parts referred to, there is a bar *G* with a cap *H* and powerful clamp *I*, by means of which the stop-bar is located and held in the desired position.

In this diagram it is assumed that the shell will be machined in the usual position with its nose toward the tailstock of the lathe. As the longitudinal guide and the slide which it carries move with the carriage, the cylindrical portion of the shell is turned in the same way as it would be on a lathe without a profiling attachment. When the carriage reaches the position shown in the diagram, at the beginning of the curvature of the shell nose, slide *C* engages cap *H*, which prevents further movement of the slide relative to the bed of the lathe and to the shell; but the carriage and tool continue their longitudinal movement, which causes rod *A* to move through the sector of a circle. In this way, the cross-slide is moved in to form the nose of the shell.

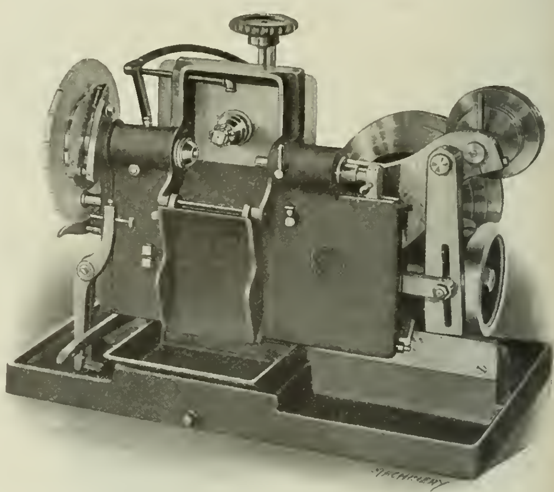
This action is automatic up to the point at which the tool reaches the end of its cut at the point of the shell. Then the operator must stop the longitudinal feed of the carriage, withdraw the tool from the cut, and return the carriage to the starting point by means of the wheel that governs hand traverse of the carriage. As the operator moves the carriage toward the headstock, slide *C* is held against stop *H* by means of weight *F* until stop *E* is reached, after which slide *C* moves with the carriage to the starting point, thus completing the cycle of the turning operation. It will be apparent that the operation of this profiling attachment is automatic, and that the only attention required from the operator is that incident to any lathe turning operation, *i. e.*, adjustment of the tool to the cut, starting and stopping the carriage feed, and returning the carriage to the starting point.

WALTHAM GEAR-CUTTING MACHINE

Waltham Machine Works, Newton St., Waltham, Mass., have recently added to their line the 4-inch gear-cutting machine illustrated and described herewith. Sufficient power is provided for cutting 16-pitch gears. The operations of feeding the slide and indexing the work are automatic, and are continued until the machine stops upon completion of the last cut. An index is used which is 10 inches in diameter; and the indexing mechanism is so arranged that it can be easily adjusted for any even number of divisions into which the index is cut, making it possible to use one index for several different divisions, eight being the smallest number of divisions that can be obtained. These indexes are interchangeable with those used on Waltham 3-inch gear-cutting machines, and additional indexes can be furnished at any time. The use of a cutter not over 1⅜ inch in diameter is recommended, as a small cutter of this kind tends to give a smooth cut, and the machine was designed for the use of a tool of this kind working at its full capacity. The cutter-slide is lifted during the return of the work-slide, so that the indexing is done without loss of time. Alignment of the cutter to the center of the work is obtained by rotating the front bearing of the cutter-spindle, which is threaded for this purpose. The bearing should be clamped after the position of the cutter has been obtained and a gage is furnished to assist in centering the cutter.

Adequate protection is afforded to prevent chips from finding their way into the bearings, and the cutting oil or compound is carefully controlled while the chips are fed into a receptacle directly below the work-slide, from which oil is drained to a reservoir located at the back of the machine. An individual oil-pump is provided. Complete protection of the indexing mechanism, cams, and slides against damage from chips, is obtained by a plate attached to the cutter-slide and held in contact with the back side of the hood on the work-slide. A removable cover completely encloses the work and cutter when the machine is in operation; this arrangement makes the machine especially well adapted for cutting brass, as it does away with trouble due to tendency to become clogged with chips. The work-slide is driven through a worm and gear keyed to the cam-shaft, and a positive movement is given by the cam both for the cut and return, the latter being made in one-seventh revolution. With the standard cam provided, the available adjustment of the stroke is from 2 to 3 inches, but shorter cams can be furnished for cutting pinions and other short stroke work. Location of the work-slide in relation to the cutter can be adjusted laterally by turning a pinion shaft on the front of the work-slide, and the depth of cut is controlled by a graduated handwheel at the top of the cutter-slide.

A countershaft suitable for use on a wall is furnished with the machine. It is placed directly over the machine, and in order to allow for the lift of the slide, the cutter-spindle is driven by a horizontal belt from an intermediate shaft attached to the machine. This shaft has an adjustment for tightening the belt, and reversible idler pulleys are used. In connection with two-step pulleys on the countershaft and cutter-spindle, this makes possible a number of different speeds



Four-inch Gear-cutting Machine built by Waltham Machine Works

for the cutter without changing the speed of the countershaft. For general classes of work, this speed should be about 700 revolutions per minute. Four steps are provided on the worm spindle cone pulley, giving a variety of feeds. The work-spindle takes a spring chuck so that the work can be held either by this means or by special arbors suited to the needs of the particular class of work to be handled. Complete equipment of the machine includes an individual oil-pump, a countershaft, one index, one work-slide cam, and one cutter-arbor. Work-holding arbors are furnished as an extra equipment, and a cabinet base can be provided for those who do not wish to use the machine on a bench. The space occupied by this gear-cutting machine is 28 by 18 inches, and it weighs approximately 500 pounds.

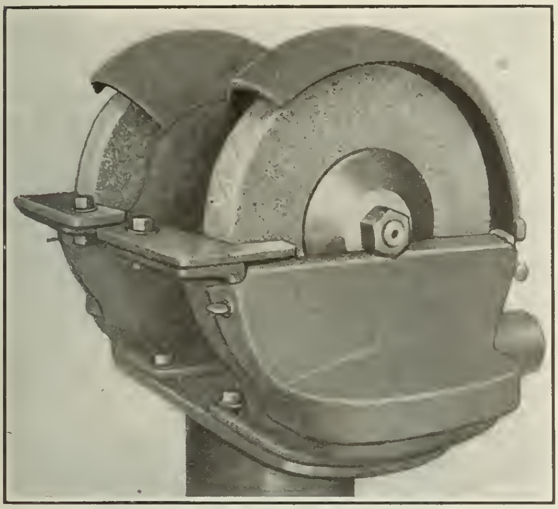
ELLIS-SMITH POWER HACKSAW

Ellis-Smith Mfg. Co., Inc., 216 Niagara St., Buffalo, N. Y., is now manufacturing a small high-speed power hacksaw especially adapted for use in garages and repair shops. This machine is 24 inches long, 6 inches wide, stands on 10-inch legs, and has a capacity for sawing work up to 4 by 4 inches in size. The slide is furnished with large adjustable V-bearings; the saw arm takes a 9-inch blade and is driven by a crank working between the V-bearings. This design provides a compact form of construction. The saw frame is equipped with a sliding weight to provide for obtaining the desired pressure between the saw and the work. This machine is furnished with an automatic stop, and for use in plants not equipped with power a crank can be furnished for driving the machine by hand.

FORBES & MYERS GRINDER

In the June, 1914, number of MACHINERY, a description was published of a motor-driven grinder which had just been placed on the market by Forbes & Myers, 178 Union St., Worcester, Mass. Recently this firm has modified the design of the grinder to provide connections to an exhaust system. In general design, the machine is similar to the former model; it is equipped with wheels 12 inches in diameter by 2 inches face width, and driven by a two-horsepower fully enclosed motor. The tool-rests are adjustable in two directions; the spindle is 1 inch in diameter through the wheels and is carried in ball bearings of ample size, and heavy malleable iron guards are provided over the wheels.

As previously mentioned, the new feature consists of the provision for collecting dust. Heavy particles collect in a basin under the wheels, which can be reached by removing the cover from the lower half of the wheels; finer dust is carried out through a pipe at the rear of each wheel. Even when not connected to an exhaust fan, the design of this grinder is such that most of the fine dust is carried out through the pipe, due to the natural circulation of air caused by the wheels. This grinder is built in only one size, with a motor adapted for connection to circuits of two or three phase, twenty-five or sixty cycle, and of any voltage. The speed of the wheels is 1800 R.P.M when operated on sixty-cycle current, and 1500 R.P.M. when operated on twenty-five-cycle current. The grinder finds application for general work in machine shops and forge shops, and for snagging small castings in foundries. Numerous other uses can be found for this machine in grinding light work.

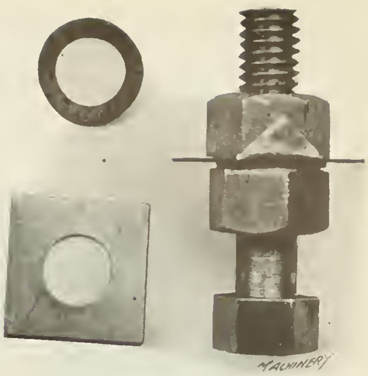


Forbes & Myers Grinder for connection to Exhaust System

"LOXON" NUT LOCK

F. R. Blair & Co., Inc., 50 Church St., New York City, are now manufacturing what are known as the "Loxon" nut locks. It is claimed that these provide as positive a lock as that furnished by a castellated nut and cotter-pin. The "Loxon" nut lock can be easily applied and locked; and it is also an easy matter to release a nut held with this device. Another advantage claimed for this nut lock is that it can be used repeatedly and is suitable for use on soft steel, cast iron, brass, bronze, aluminum, etc. The "Loxon" nut locks should not be used on hardened steel. These nut locks are made in six sizes for use on bolts 5/16, 3/8, 7/16, 1/2, 9/16, and 5/8 inch in diameter. In place of the regular square washers, special shapes can be furnished for use in counterbored holes, against shoulders, etc.

The accompanying illustration shows the method of applying "Loxon" nut locks. It will be seen that there is a square washer and a "seating ring," which come between the under side of the nut and the work. The seating ring is made of hardened steel and roughened so that the points imbed themselves in the metal, and one corner of the washer is bent up against one face of the nut to lock it in place. In the accompanying illustration the lower nut represents a casting or piece of work of any sort, while the upper one may be supposed to have been applied to a stud or machine bolt. "Loxon" nut locks are equally serviceable for locking cap-screws in place.

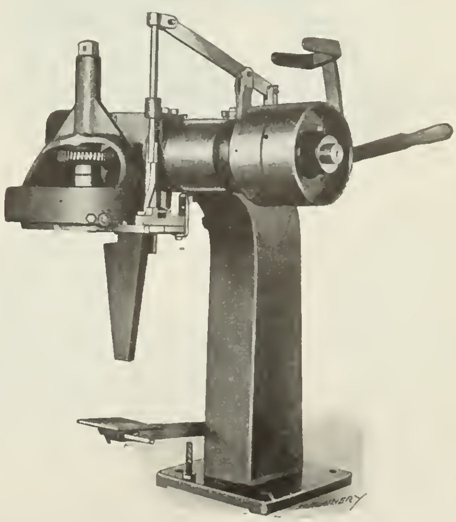


"Loxon" Nut Lock made by F. R. Blair & Co., Inc.

REYNOLDS SCREW COUNTER

Reynolds Pattern & Machine Co., 101-103 Third Ave., Moline, Ill., has recently added to its line a machine adapted for counting and delivering a fixed number of screws into a package. The machine shown in the accompanying illustration delivers eight screws. Those who are familiar with the screw-driving machines of this company's manufacture, will see that the present equipment is of similar design in so far as the hopper and delivery chute are concerned. It has been especially developed to meet the requirements of hardware manufacturers, etc., who have occasion to pack a certain number of screws with each unit of their output, these screws being used by the purchaser in assembling the goods contained in the package.

In operation, a quantity of screws is put into the magazine or hopper, and when the operator has placed the other articles in the package into which the screws are to be delivered, the package is set in place beneath the delivery chute and the operating lever of the machine is depressed. Through suitable connections, this operates an escapement which, in turn, delivers the screws into the chute down which they pass and drop into the package placed to receive them. The machine may be set for delivering any number of screws, according to the requirements of the work, and provides a rapid method of handling work with automatic control that eliminates errors due to the carelessness of employes.



Screw Counter built by Reynolds Pattern & Machine Co.

GRAND RAPIDS UNIVERSAL GRINDER

The machine shown in Fig. 1 is known as the Grand Rapids No. 2 universal cutter, drill and tool grinder, and has just been placed on the market by the Grand Rapids Grinding Machine Co., Grand Rapids, Mich. In working out the design of this machine, equal attention has been paid to the provision

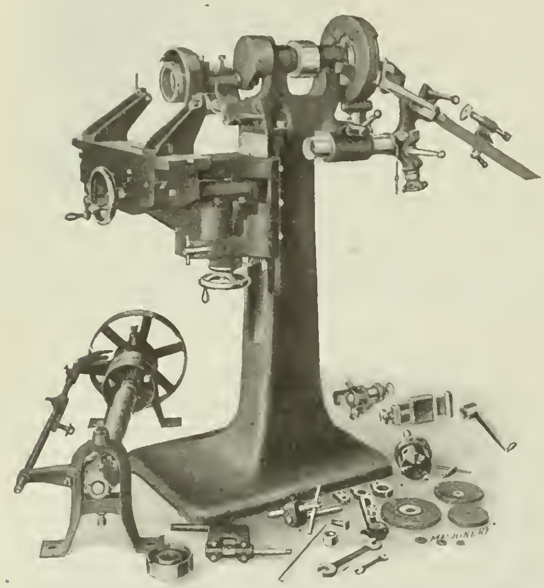


Fig. 1. Grand Rapids No. 2 Universal Drill, Cutter and Tool Grinder

of means for grinding drills, cutters and reamers, so that all of this work is done by the machine proper and not by attachments. The spindle speed for the small cutter grinding wheel is necessarily much higher than that required for the large drill grinding wheel, so that a double spindle construction is necessary. This is taken care of by using a "Fabroil" cloth pinion on the cutter grinding spindle, which is not only noiseless at high speed, but eliminates other troubles incident to the use of metal gears, and the "Fabroil" gear is as strong as the cast-iron gear with which it operates. Both spindles are carried in large bronze bearings, which are ring-oiled and

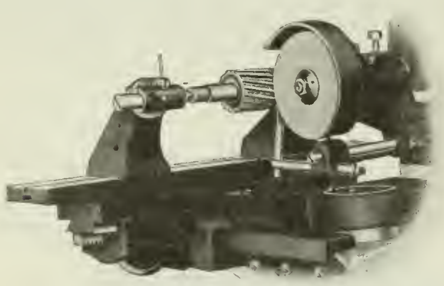


Fig. 2. Grinding a Milling Cutter held on Centers

easily adjusted for either radial wear or end play. The spindles are made of crucible steel accurately ground to size.

For drill grinding, the holder has a capacity for drills from ⅛ inch to 2½ inches in diameter, and what is more important, one standard holder provides for obtaining any desired angle of point and any desired clearance; two-, three-, or four-lip drills of any size or type of shank may be ground, even though the shank is larger than the diameter of the drill. A wheel truing device is provided for truing the grinding face of the wheel, so that it may be kept accurate. The cutter grinding part of the machine will handle any cutter, reamer, or tool that any universal grinder will handle, provided it comes within the capacity of the machine, which is as follows: diameter of work held between centers, 9½ inches; length of

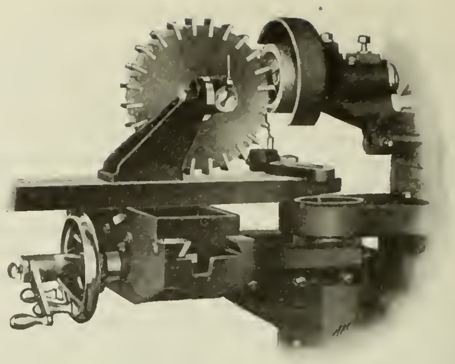


Fig. 3. Sharpening Faces of Inserted-tooth Milling Cutter

work held between centers, 20 inches; longitudinal movement, 15 inches; transverse movement, 7 inches; vertical movement, 6¾ inches; capacity for face mills, up to 12 inches in diameter; and capacity for internal work, from ⅝ inch in diameter and up to 3¼ inches in depth.

Points of particular interest in the construction of this machine are as follows: The table will swing through a full 360 degrees, and the same two screws—one at the front and one at the back of the sub-table—that lock it in the position to which it has been swiveled also lock the table securely down upon the sub-table. A scale reading to 1/16 inch taper

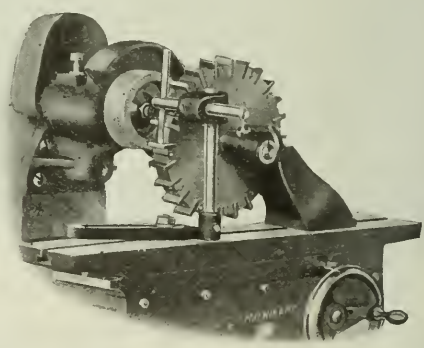


Fig. 4. Sharpening Sides of Teeth of Cutter shown in Fig. 3

per foot is provided for making settings of the machine for taper grinding operations. An auxiliary lever is furnished that can be instantly mounted on the longitudinal movement handwheel by simply slipping it over the wheel, and tightening it up by means of a thumb-screw, thus providing a lever action that is convenient for many classes of grinding. The headstock is provided with tongue slots in both directions, so that it can be mounted either in line with or across the table; and the vise is also carried on the headstock, so that it can be mounted in either position. This vise has a swivel action of its own, so that it presents the work to the wheel in either

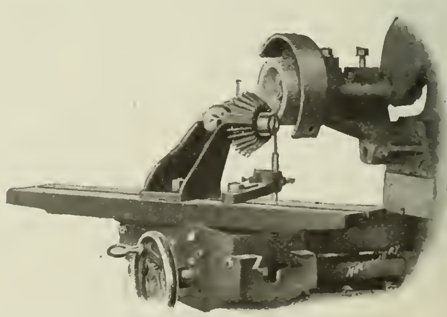


Fig. 5. Table set over for grinding Tapered Cutter

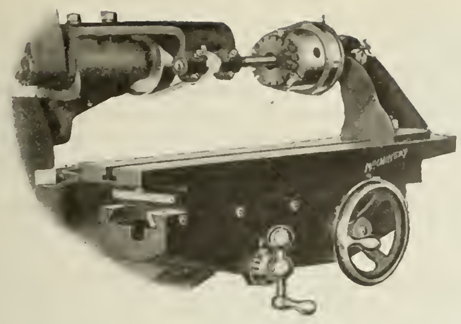


Fig. 6. Performance of Internal Grinding Operation

horizontal, vertical or angular position. Both vertical and cross-feed screws operate in bronze nuts that provide generous bearings for the screws, which have dials reading to 0.001 inch.

BICKETT MILLING AND PROFILING MACHINE

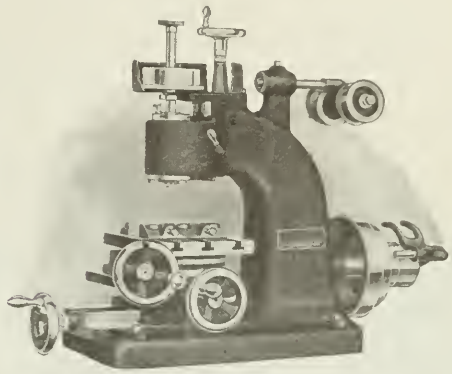
In working out the design of a No. 0 vertical milling and profiling machine which has recently been placed on the market by the Bickett Machine & Mfg. Co., 1118 Richmond St., Cincinnati, Ohio, a departure has been made from the practice of using an adjustable knee, all adjustment being provided in the spindle head of the machine. It is claimed that this provides a more rigid table support, thus reducing vibration to a minimum and maintaining alignment at all times. This machine is especially designed for operation at high speed, and may be driven at 2500 revolutions per minute. It is adapted for such work as die-sinking, letter cutting, cam milling, splining, etc., and finds application in factories engaged in the manufacture of sewing machines, typewriters, electrical and scientific instruments, firearms, adding machines, etc.

The use of radial-thrust bearings adapts this machine for operation at the high speeds referred to, and also enables advantage to be taken of a high transmission efficiency by reducing friction losses to a minimum. These ball bearings are self-oiling and will run for a long time without requiring attention; their use has been the means of practically eliminating trouble from hot bearings. If desired, the machine can be furnished with a lever feed attachment in place of the handwheel and elevating screw. This attachment is convenient when rapid vertical adjustment is required, as in certain classes of profiling. In working out the design, attention has been paid to providing means for convenient operation.

The spindle is made of crucible steel, accurately ground to size. It is fitted with a No. 3 Hardinge collet, which is held by a draw-in attachment operated from the top of the spindle. The spindle head is gibbed to the column of the machine, and the vertical adjustment is two inches, obtained by means of an elevating screw at the rear of the spindle. Two changes of speed are provided, and as mentioned, the machine may be safely driven at 2500 revolutions per minute under continuous operation. The spindle pulley is 1¼ inch wide by 4 inches in diameter; it is flanged at the bottom and provided with a belt guard. The intermediate pulleys are 2½ inches in diameter and are flanged on both sides. The two-step cone pulley has steps 8 and 6 inches in diameter; and the tight and loose pulleys are 3½ inches in diameter by 1¾ inch face width.

A handy belt shifter is provided for starting and stopping the machine. The table is 7 by 10 inches in size and has three ½-inch T-slots machined in it. This table may be rotated by means of an Acme-thread screw, which is carefully fitted to a large worm-wheel. The worm feed can be easily engaged or disengaged and is provided with means of compensation for wear. The longitudinal, transverse and vertical feed-screws are provided with adjustable dials graduated to read to 0.001 inch, and all screws have Acme threads.

The equipment furnished with this machine includes the following: one toolmaker's vise with jaws 6 inches wide by 1 inch high, with a maximum opening of 6 inches; one No. 3 Hardinge collet; one draw-in attachment; and the necessary wrenches for making all adjustments. A pedestal 26½ inches high may be furnished as a special equipment. The principal dimensions of the machine are as follows: total height of

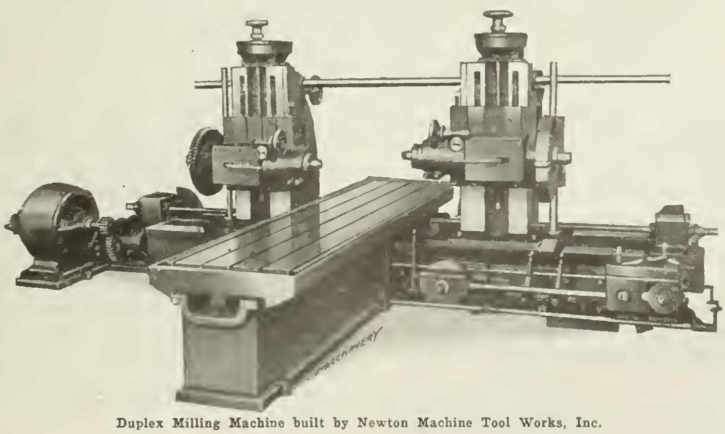


Bickett No. 0 Vertical Milling and Profiling Machine

machine without pedestal, 26½ inches; width of base, 11 inches; length of base, 20 inches; distance from top of rotary table to spindle nose, 4¼ inches; maximum longitudinal feed, 6 inches; maximum transverse feed, 5 inches; maximum vertical feed, 2 inches; and weight of machine, 200 pounds.

NEWTON DUPLEX MILLING MACHINE

One of the latest additions to the line of machinery built by the Newton Machine Tool Works, Inc., Philadelphia, Pa., is the duplex milling machine illustrated and described herewith. A feature of its design is the exceptional provision made for power control; it will be noted that the spindle saddles move vertically on the uprights, while these uprights move horizontally on the bed. Both saddles and uprights have reversing feed and reversing fast power traverse; provision is also made for independent or simultaneous adjustment of the spindle saddles, and of the uprights. For the spindle saddles, the vertical feed per revolution of the spindle is from 0.012 to 0.134 inch, and the same feed in inches per minute covers a range of from 0.068 to 7.40. Reversing fast traverse for the spindle saddles covers a range of from 6.10 to 63.4 inches per minute. The feeds of the uprights cover a range of from 0.011 to 0.113 inch per revolution of the spindle, or from 0.059 inch to 6.360 inches per minute. Reversing fast traverse for the uprights covers a



Duplex Milling Machine built by Newton Machine Tool Works, Inc.

range of from 5.25 to 54.50 inches per minute. The available range of spindle speeds is from 5.4 to 55.2 revolutions per minute.

This machine is driven by a Fort Wayne Electric Co.'s 230-volt, twenty-horsepower electric motor running at from 300 to 900 revolutions per minute. It is provided with a work-table which has square lock bearings on the base with overlapping gibs. Drive is provided through an angular rack and worm pinion, with hand adjustment, and there are nine changes of sliding gear feed provided by a gear-box, in which the gears run in oil. Available feeds for the work-table are from 0.041 to 0.427 inch per revolution of the spindle, or from 0.222 inch to 23.93 inches per minute. Reversing fast traverse for the table covers a range of from 19.7 inches to 17 feet per minute. The dimensions of the table are as follows: width over finished surface, 42 inches; length over all, 14 feet; and available length for milling operations, 12 feet, 6 inches. The work-table can be arranged to mill to greater lengths when the requirements of the work to be handled on the machine make such a provision a matter of necessity.

Attention has already been called to the fact that the spindle saddles are adjustable vertically on the uprights, and that these uprights are provided with means for making horizontal adjustment on the bed. Each spindle is driven through a worm and worm-wheel encased to provide for flooded lubrication, and the drive for each spindle is independently clutched at the inside of the driving worm-wheel sleeve. The spindle saddles are counterweighted, and provision is made for simultaneous or independent vertical hand adjustment; a similar provision is made for the reversing vertical feed and reversing fast power traverse. The saddles have narrow-guide alignment control bearings on the uprights, and provision for rigidly bolting in any desired position. The uprights have independent and simultaneous horizontal hand adjustment, and reversing fast power traverse, with provision for rigidly bolting in any desired position. Both the saddles and uprights are fitted with taper shoes, and the saddle elevating and upright adjusting screws have bearings at each end to insure their operation under tension. The spindles can rotate independently or in unison. Each spindle sleeve is furnished with independent hand adjustment up to 6 inches, and measurement of the spindle sleeve and vertical saddle adjustment is provided through conveniently arranged scales.

The principal dimensions of the spindle and allied members are as follows: distance from face of uprights to center of spindles, 6¾ inches; distance from center of spindles to table, 2 inches to 35 inches; distance between ends of spindles, 12 inches to 90 inches; diameter of spindle in driving worm sleeve, 4 inches; diameter of spindle at large end of taper, 6 9/16 inches; diameter of spindle in sleeve, 4 3/8 inches; diameter (outside) spindle flange, 9 inches; and approximate outside diameter of spindle driving worm-wheel, 27 inches. The spindles are bored in the nose to accommodate a straight plug 3 inches in diameter, and are arranged to drive cutters by means of face keys 1¼ inch wide. If desired, the spindles can be bored taper up to No. 6 Morse and drilled through to accommodate a cutter retaining bolt. The machine is adapted for using cutters up to 16 inches in diameter when working on cast iron.

FOSTER UNIVERSAL TURRET LATHE

It will be seen that this universal turret lathe is adapted for performing both chucking operations and operations on bar stock. Single-pulley drive and a geared head make it an easy matter to employ either belt drive or motor drive. Two tool-carrying units are provided, one of which is a slide carrying a hollow hexagon turret, and the other a cross-slide with a square turret at the front and provision for securing special tool-holders at the back. Details of the mechanism are fully explained in the following article.

The Type I-B universal turret lathe shown in the accompanying illustrations is just being put on the market by the Foster Machine Co., Beardsley Ave. and Ward St., Elkhart, Ind. The first machine has been in successful operation in this company's shop since the early part of December, and a complete set of jigs and fixtures for efficient and economical manufacturing of this machine is now in the course of construction. The machine, which is of the universal turret lathe type and capable of handling both bar and chucking work with equal facility, has been designed by Oskar Kylin, now chief engineer of the Foster Machine Co. The machine, as shown by Figs. 1, 2 and 3, is of the geared head type with two tool-carrying units, one of which is equipped with a hollow hexagon type of turret and the other with a cross-slide. The latter extends across the ways of the bed and carries on the front end a square turret adapted for holding forged cutters. The rear end forms a table and has several tapped holes to provide for mounting a variety of tool-holders. The illustrations show a machine equipped with draw-back automatic chuck for bar work, but this can be replaced by a three-jaw geared scroll chuck for chucking work.

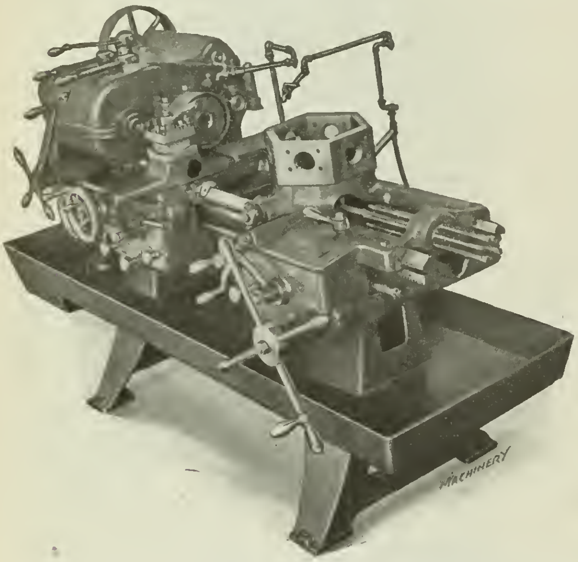


Fig. 1. Foster Type I-B Universal Turret Lathe with Two Tool-carrying Units

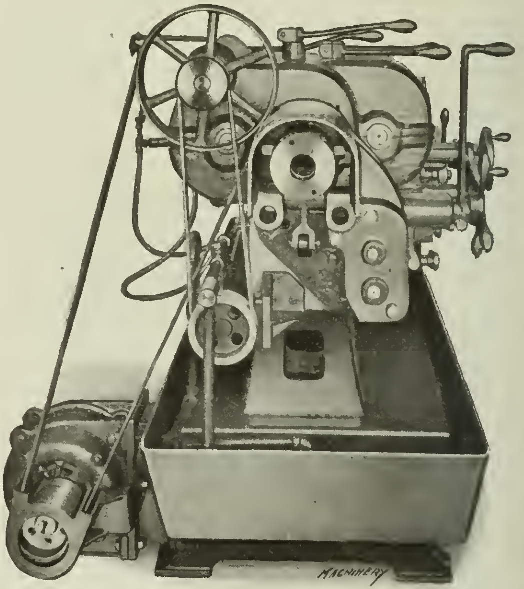


Fig. 2. End View of Foster Universal Turret Lathe, showing Motor Drive

All-geared Head

Fig. 2 shows a machine arranged for motor drive, but it can also be driven by means of a plain tight and loose pulley

countershaft mounted in the ceiling. Fig. 4 shows a view of the geared train in the head, the upper guard being removed to show the mechanism. As seen in this illustration, the pulley shaft is mounted in phosphor-bronze boxes and carries a wide faced pinion, which on one side engages the large gear underneath it for the forward driving of the spindle, and on the other side a reversing idler for the reverse motion of the spindle. The friction driving member, which is mounted inside and between these two gears, is of powerful construction and operated by means of the long lever seen in Fig. 4. Twelve speed changes for the spindle in either direction are obtainable by three clusters of sliding gears, operated by levers mounted on the top of the head casting, as shown plainly in Fig. 1. All sliding gears and gears engaged by them are heat-treated and hardened. The teeth are of the Fellows standard stub tooth form, with a 20-degree pressure angle which insures greater strength, less wear and quieter running. This gear tooth system is used for all the gears throughout the machine.

SPINDLE SPEEDS												
R.P.M.	20	2[illegible]	36	48	64	86	111	149	200	267	355	480
LEV. A	RIGHT	RIGHT	RIGHT	RIGHT	RIGHT	RIGHT	LEFT	LEFT	LEFT	LEFT	LEFT	LEFT
LEV. B	LEFT	LEFT	LEFT	RIGHT	RIGHT	RIGHT	LEFT	LEFT	LEFT	RIGHT	RIGHT	RIGHT
LEV. C	LEFT	RIGHT	CENTR'L	LEFT	RIGHT	CENTR'L	LEFT	RIGHT	CENTR'L	LEFT	[illegible]	CENTR'L
	SPEED OF PULLEY - 510 R. P. M.											

Fig. 5. Range of Spindle Speeds and Directions for making Changes

An important feature of the design is the oiling system used for the automatic lubrication of all gears and bearings throughout the entire head. The gears run in a bath of oil, and the splash is caught by a system of overhead ribs and conducted back into the main cavity of the head. The belt, whether driven by means of an overhead countershaft or by an individual motor as shown in Fig. 3, is capable of delivering to the pulley about six horsepower. This is somewhat in excess of the heaviest requirements of the machine, even when several cuts are taken simultaneously, which is a frequent occurrence on a machine of this type and represents a time-saving feature. However, the friction clutch in the gears in the head is proportioned to stand a load in excess of the greatest amount of power that will be delivered by the belt.

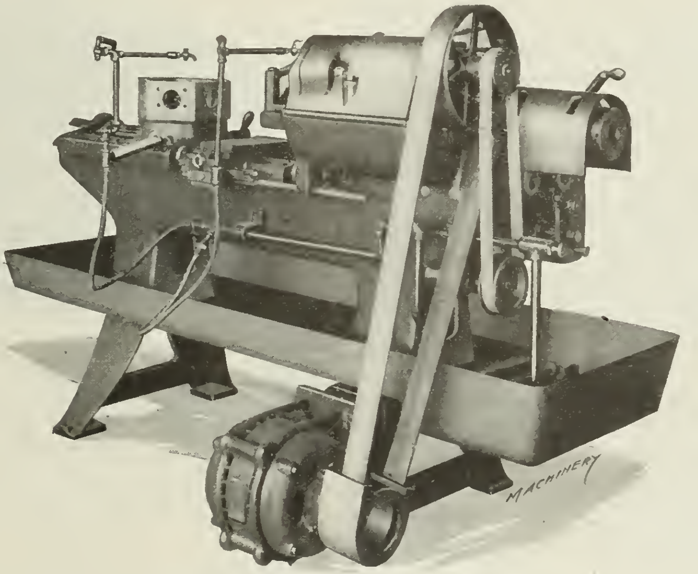


Fig. 3. Rear View of Foster Universal Turret Lathe

The spindle is made of a forging of high-carbon machine steel and is journaled in bronze boxes of exceptional length, in spite of the fact that the wear is reduced to a minimum by means of the automatic flooded lubrication. The twelve spindle speeds range, as seen in Fig. 5, from 20 to 480 revolutions per minute, and these are arranged in as perfect geometrical progression as is obtainable with geared trains. This range is wide enough to provide the correct cutting speed for work ranging from hard cast iron of the largest diameter that can be carried in the three-jaw scroll chuck down to and including the smallest diameter bar which it is practicable to turn in a machine of this size.

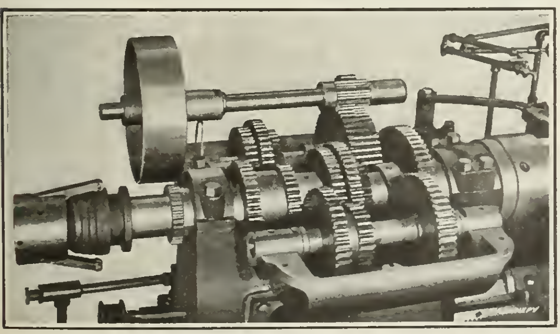


Fig. 4. Arrangement of Gears in Head—Cover removed to show Mechanism

Gear-boxes

The gear-box, which is mounted on the end of the bed and shown in Fig. 6, is designed to carry and enclose the gears for driving the feed-rod which actuates the various feed movements for the tool-carrying units. In this connection, it is timely to call attention to the location of the feed changing mechanism for the twelve changes of feed. The gears and mechanisms for this purpose are located in the aprons of the tool carriages with the exception of one gear-shift located in the gear-box, the gears in this shift being heat-treated and hardened sliding gears. This sliding gear cluster is operated by means of a plunger shown in Fig. 1, which carries a knob for convenience of operation. In addition to the gears, the gear-box carries a forked lever for operating the automatic chuck and also supports the bars that are employed for the bar feed.

Cross-slide and Carriage with Carriage Apron

The feed chart, which is illustrated separately in Fig. 7, shows the unusually wide feed range which covers changes from 0.0016 to 0.100 inch per revolution of the spindle, and also shows the method of obtaining these changes. The feed changes obtainable are sufficient to provide the proper feed for any work from soft cast iron to wide forming in steel and also for the varying depths of cuts which necessitate varying feeds for maximum production. As already mentioned, the feed mechanism is located in the apron and changes are obtainable by means of sliding gears operated by plungers. The sliding gear clusters are made of chrome-nickel steel and heat-treated. Thus the maximum strength and wearing quality is obtained in connection with compactness and lightness of the apron unit. The driving pinion which engages the rack mounted on the front side of the bed is also made of chrome-nickel steel which is heat-treated. The gear train is driven from the feed-rod by means of the worm and gear as shown plainly in Fig. 8, which shows the apron dismounted from the machine.

Attention is called to the automatic drop-out friction which engages and disengages the longitudinal feed movements. This is operated by means of the six screw stops mounted in a revolvable spool as seen in Fig. 8. When one of these stop-screws, as the carriage is moving longitudinally forward on the bed, abuts against the adjustable stop-rod, it causes a longi-

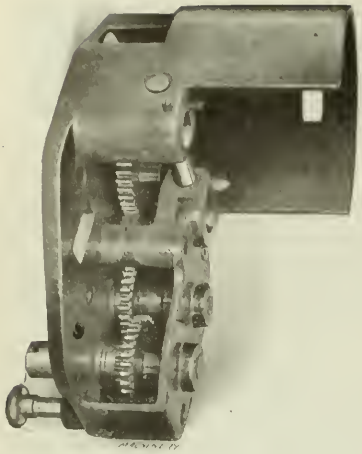


Fig. 6. Gear-box for Gears employed to drive Feed-rod

tudinal movement of the stop-spool, which releases a catch and causes the horizontal lever to drop and thus release the feed friction. The advantages of this design are quick operation and assurance that the drop-out action will always occur at one and the same point. The design of the friction release for the cross movements of the slide is similar to that of the longitudinal friction release. However, this is not automatic, but hand-operated by means of the short vertical lever. The reverse for the longitudinal and cross motions is also located in the apron and is obtainable by means of sliding gears.

For the purpose of duplicating diameters, there is mounted on the front end of the cross-feed screw, a dial of large diameter, on which are mounted a number of clips which are brought to register with a zero mark on the cross-slide. Very close duplication of work can thus be obtained. On the cross-slide is mounted a square turret for carrying four forged cutters. This turret is so designed that the vertical lock-bolt is located underneath that corner where the cutting action almost invariably takes place, and is operated by a handle mounted on the top of the turret. Forward movement of this lever, when the lock-bolt is engaged, binds the turret rigidly to its seat. The rear of the cross-slide forms a table and has several tapped holes in it for the purpose of mounting a variety of standard and special tool-blocks or tool-holders. This feature is especially valuable when manufacturing parts in large lots, as it provides means for mounting specially designed tools and also for holding forming tools too wide to be mounted in the square turret.

A clamp handle is provided on the top of the carriage for clamping the carriage to the bed. Another feature worthy of special mention, which is valuable in connection with thread cutting, is the mechanism at the front end of the cross-slide that enables the tool to be withdrawn the necessary amount and at the proper time reset and feed the proper amount for taking the next cut. This mechanism consists of a disk mounted loosely on the cross-feed screw, to be turned in the reverse direction and then again brought back to a starting point, at which point the bar strikes the end of the semi-annular groove and thus registers the former position of the cross-slide. The disk, which is held at the cross-slide by means of a brass shoe and set-screw, can then be slipped past this point each time the proper amount for the feeding of the next cut of the thread cutting tool.

Hexagon Turret and Saddle with Saddle Apron

The turret is of the hollow hexagon type and has an unusually large bearing on the saddle. The vertical lock-bolt, mounted as close as possible to the cutting tool, is withdrawn by means of the lever, and this lever also operates the binding mechanism for the turret. The first part of the upward movement of the lever toward the left unbinds the turret from its seat and further movement withdraws the lock-bolt and leaves the turret free to be indexed by hand. This is an economical and quick way of indexing a turret on this type and size of machine. The seven stop-screws, one of which is for the corner stock stop, which are held in a revolvable spool carried by the saddle, are geared to the turret and thus indexed with it. Forward movement of the saddle causes a stop to butt against a stop-block mounted between the ways of the bed. A slight forward movement of the saddle causes a longitudinal movement in the stop and stop-spool, which is transmitted to a catch that is thus released and causes the feed lever to drop. The feed friction is thereby released and forward movement of the saddle arrested. The design is similar to that of the saddle apron which has already been described. The feed changes obtainable in this unit are the same as those for the cross-slide unit, and the feed changes are the same as shown in Fig. 7.

FEEDS PER REVOLUTION												
	.0016	.0027	.0047	.0063	.0083	.011	.014	.019	.025	.033	.056	.100
KNOB D	IN	IN	IN	OUT	IN	OUT	IN	OUT	IN	OUT	OUT	OUT
KNOB E	OUT	IN	IN	IN	OUT	IN	OUT	IN	OUT	OUT	OUT	OUT
KNOB F	CENTER	OUT	IN	CENTER	CENTER	OUT	OUT	IN	IN	CENTER	OUT	IN

MACHINERY

Fig. 7. Range of Feeds per Revolution and Directions for making Changes

Design of the Bed

As plainly seen in Figs. 1, 2 and 3, the head is cast integral with the bed. The comparatively short span between the front and rear legs made it possible to design a bed of extraordinary rigidity without the use of an undue amount of metal. The front and rear walls of the bed are connected by a number of heavy ribs, thereby preventing distortion of any individual section of the bed by distributing the strain throughout the entire bed section. The carriage ways are of the V-type and of very liberal dimensions. This makes the unit pressure on the ways caused by the tool carriages very low and reduces wear.

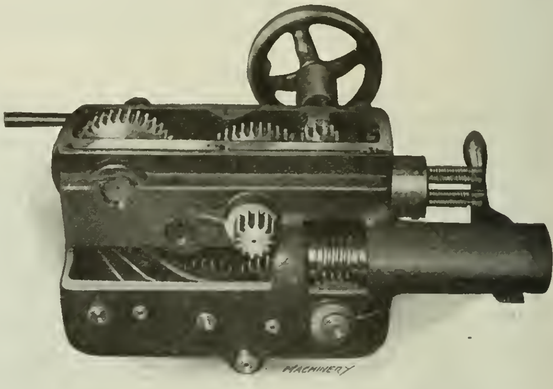


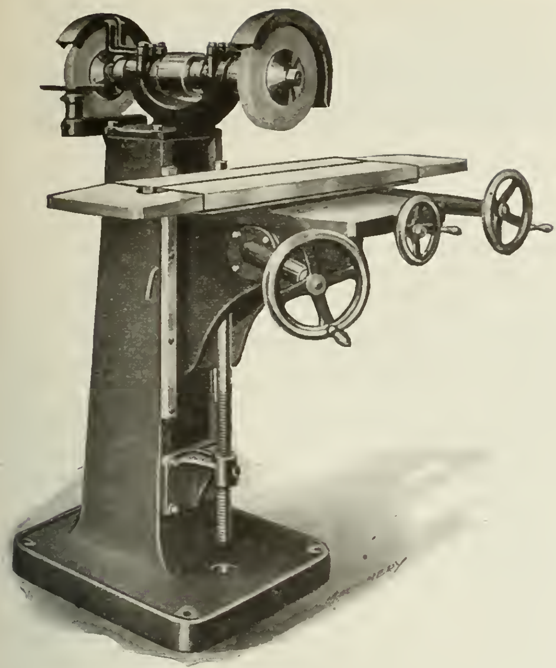
Fig. 8. Rear View of Apron, showing Mechanism for making Feed Changes

Oil Pump and Piping

Figs. 2 and 3 show the method and system used for supplying the cutting tools with coolant. The oil-pump is driven by belt from the main pulley shaft and is mounted on the rear side of the gear-box. The coolant is drawn from the well in the steel pan and delivered by means of the pump through piping and flexible tubes. Each tool-carrying unit has its separate pipe fitted with swinging joints and stop-cocks for adjusting the position and flow of the stream of coolant. In addition, coolant can also be supplied through the hollow hexagon turret, for oil-tube drills and similar cutting tools requiring this device. Special attention is called to the arrangement of the piping enclosed by the oil-pump, making priming of the pump unnecessary.

Motor Drive

Figs. 2 and 3 show the machine arranged for individual motor drive with the General Electric five-horsepower motor mounted on the rear of the front leg. This makes a neat and compact arrangement; but this arrangement is special inasmuch as the machine is regularly equipped with the overhead tight and loose pulley countershafts driven from the lineshaft.



Tool and Surface Grinder built by Peter J. Metz Machine Works

METZ TOOL AND SURFACE GRINDER

Peter J. Metz Machine Works, 560-562 W. Washington St., Chicago, Ill., are now manufacturing a tool and surface grinder shown in the illustration accompanying this description. It is intended for general shop and tool-room service, and has been designed for grinding flat surfaces such as blanking, stamping and piercing dies, punches, lathe and planer tools, and similar work. The spindle is made of high-carbon steel and runs in split conical boxes made of anti-friction phosphor-bronze and provided with adjusting nuts. This construction permits of easy compensation for wear. A graduated dial is provided on the vertical feed-screw, the graduations reading to 0.001 inch, but finer adjustment can be readily obtained when such degree of accuracy is required. Traverse movement is obtained by a screw feed operated by a handwheel.

Longitudinal movement of the table is obtained by a rack and pinion, with a handwheel located at the front of the machine, which is found convenient when grinding dies, gages, and tools. Under one wheel there is an adjustable tool-rest, and under the other wheel there is a short surface table having a 5/8-inch milled T-slot at the center. All bearing surfaces are protected from dust and dirt, and the ways are hand-scraped to a perfect bearing. Provision has been made for oiling all bearings that are subject to wear, and the table is provided with a dovetail slide with gibs for taking up wear. Attention is called to the fact that all operating handles are located at the front of the machine where they are convenient for the operator to reach at all times. This machine is furnished complete with two grinding wheels, a countershaft, wheel guards, and tool-rests.

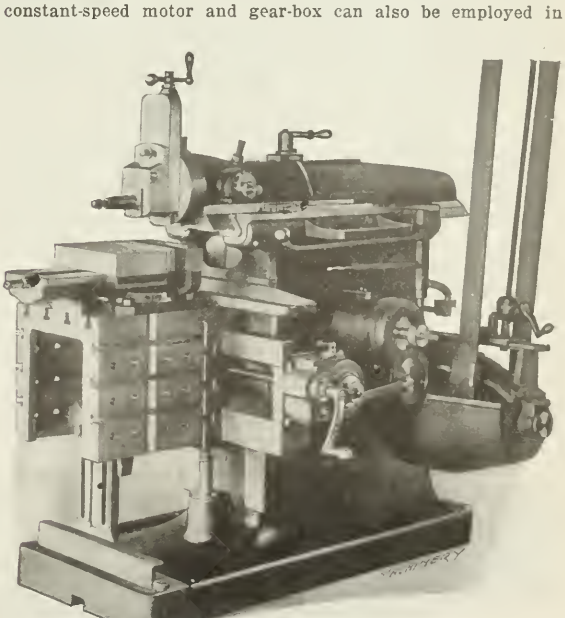
The principal dimensions are as follows: size of grinding wheels, 8 inches in diameter by 1 inch face width; diameter of spindle between flanges, 3/4 inch; distance from center to center of wheels, 19 1/2 inches; size of working surface of table, 9 by 24 inches; longitudinal movement, 24 inches; traverse adjustment, 9 inches; speed of countershaft, 500 revolutions per minute; size of pulley, 4 inches in diameter by 2 3/4 inches face width; size of driving pulley countershaft, 12 by 3 1/4 inches; size of tight and loose pulleys on countershaft, 6 inches in diameter by 4 inches face width; height from floor to center of spindle, 40 1/2 inches; length of spindle bearing, 4 3/8 inches; floor space occupied, 18 by 22 1/2 inches; and weight of machine, 550 pounds.

HENDEY CRANK SHAPER

The 20-inch crank shaper which forms the subject of the following description, is a recent addition to the product of the Hendey Machine Co., Torrington, Conn. It will be seen that the frame and base are cast integral, and an oil pan is provided in the base to catch all drip from the bearings and keep the floor clean. The bull gear hub is cast solid and is liberally proportioned to take all strain in the drive when the machine is at work. The crankpin is hardened and ground, and the crankpin block is also hardened, ground and bushed with a cast-iron sleeve for the crankpin bearing. The ways for the ram have an included angle of fifty degrees, and the gib for the ram is combined with the cap in a single casting, making a very rigid construction and at the same time allowing for ample adjustment in a horizontal direction. The ram has a bearing in the frame 11 1/4 by 34 inches, and the ram casting is braced to provide the necessary rigidity for taking heavy cuts. It is possible to set the ram in any position while the machine is either working or at rest, the length of the stroke obtained for any position being shown by an index.

The cross-feed mechanism is operated entirely at the end of the cross-rail in all its adjustments, and a dial and indicator control the amount of feed, which can be varied while the machine is in motion. It is possible to start, stop or reverse the feed while the machine is running by means of a ball lever at the top of the case. The feed is operated only on the reverse stroke. A quick and positive method of binding the tool-head swivel to the head of the ram is furnished by a single screw. Power down feed is optional, and the down-feed screw has a micrometer dial reading to 0.001 inch. The driving cone has four steps, and the shaft has an outboard bearing in the end of the casting that forms a guard for the belt. An expanding friction cone clutch drive of large diameter engages with a cone operated by a long horizontal lever at the side of the frame. This shaper is back-geared and this, together with the four-step cone pulley, provides eight changes of speed. A belt-shifting mechanism is furnished as part of the regular equipment, on which cams are arranged to move the shifters alternately and the belt can be changed much quicker than by hand.

When so desired, the machine may be arranged for individual motor drive, in which case an adjustable speed motor is employed with connection to the power shaft by means of a slight chain drive. The motor should develop about five horsepower and run at from 400 to 1200 revolutions per minute, although a slightly higher speed range can be employed. A constant-speed motor and gear-box can also be employed in



Crank Shaper built by Hendey Machine Co.

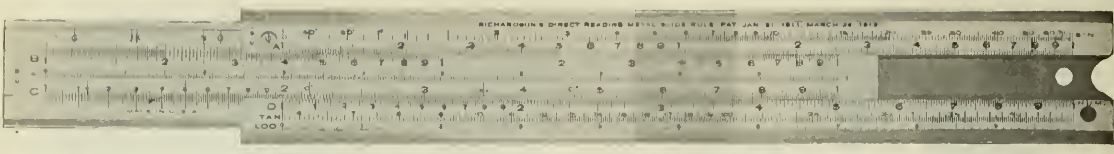


Fig. 1 Richardson "Direct-reading" Slide-rule with All Scales exposed so they can be seen

place of the equipment referred to. The cross-rail is clamped to the column with a square lock and the elevating screw is telescopic. An adjustable bottom support is provided for the table which slides on a channel-shaped track serving to protect it from chips and dirt that would throw the table out of alignment. The vise has a graduated base that is held down by four bolts, and this base also acts as a clamp to hold the vise firmly down upon the table. A boss is cast on the under side of the vise, which supports the vise ways, and at the same time ties these ways together to provide additional stiffness. The thrust of the screw which actuates the sliding vise jaw is taken at the head end of the vise casting.

The principal dimensions of this machine are as follows: actual stroke, 20¾ inches; horizontal travel of table, 24½ inches; vertical travel of table, 15 inches; minimum distance from ram to table, 4 inches; size of top of table, 16 by 20 inches; size of side of table, 16¼ by 15 inches; range of power cross-feed, 0.008 to 0.200 inch; size of ram bearing in frame, 11¼ by 34 inches; travel of head slide, 7½ inches; power feed of head slide, 0.005 to 0.060 inch; opening of vise, 13 inches; size of vise jaws, 12 by 2⅞ inches; keyseating capacity, 3½ inches; toolpost opening for tools, ⅞ by 1¾ inch; range of strokes per minute, from 8 to 115; floor space occupied, 54 by 92 inches; and net weight of machine, 4100 pounds.

RICHARDSON SLIDE-RULES

The two rules described in this article are known as a "direct-reading" slide-rule and a "merchant's" slide-rule, respectively. The former has the usual A, B, C and D scales, and scales for handling problems involving the use of trigonometric functions, logarithms of numbers, log functions of angles, and commonly used engineering constants. The merchant's slide-rule is a simplified rule with scales for performing the usual operations of multiplication and division, and special scales for the solution of problems in percentage and interest.

George W. Richardson, 4212 W. 24th Place, Chicago, Ill., is now manufacturing two slide-rules which form the subject of the following description. One of these is known as a "direct-reading" slide-rule, and the other is termed a "merchant's" slide-rule. Both are made entirely of metal with the scales and numerals marked in black and red on a white background. An advantage of the metal construction is that there is no tendency for the slide to bind during damp weather.

Richardson Direct-reading Slide-rule

Reference to Fig. 1, which shows the Richardson direct-reading slide-rule, will make it apparent to those familiar with the Mannheim slide-rule scales that the Richardson rule is provided with the standard A, B, C and D scales. With these scales are performed problems in multiplication, division, the extraction of square roots and cube roots, etc., with which all users of slide-rules are familiar.

So far as we know, Mr. Richardson is the first to graduate a special logarithmic slide-rule scale for problems in addition and subtraction. On the slide between the B and C scales, it will be seen that there is graduated a logarithmic scale reading 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, and below the D scale (and also below the scale marked "Tan") there is graduated a similar logarithmic scale. Suppose it is required to add together 12, 16 and 14. The method of procedure is as follows: Place the cross-line on the runner over 12 on the lower logarithmic scale and bring the left-hand index of the upper logarithmic scale under the cross-line. Next move the runner to the right until the cross-line comes over 16 on the upper logarithmic scale, and read the sum of these two numbers, 28, under the cross-line on the lower logarithmic scale. Next move the slide to the right until the left-hand index again comes under the cross-line on the runner; then move the runner over until 14 on the upper logarithmic scale comes under the cross-line, and read the sum of 28 and 14, 42, on the lower logarithmic scale. Problems in subtraction are performed by reversing this practice.

Problems involving the use of logarithms may be handled direct upon this slide-rule. If a number is known and it is desired to find the logarithm of that number, the method of procedure is to move the runner along so that the number whose logarithm is desired lies under the cross-line on the runner. Then directly below this cross-line on the logarithmic scale will be found the mantissa of the desired logarithm. The characteristic of the logarithm is determined by inspection, according to the usual method. Conversely, knowing the logarithm and desiring to obtain the number corresponding to that logarithm, the runner is moved out to the logarithm, and the number read on the D scale. In this way, all problems involving the use of logarithms can be handled without the use of tables.

Trigonometric problems can also be handled on the Richardson direct-reading slide-rule. At the top of the rule, over the A scale, will be seen a scale graduated 40 minutes, 50 minutes, 1 degree, 70 degrees, and to the right of this scale appears the word "Sin." When an angle is known and it is desired to obtain the sine of that angle, the runner is moved along so that the cross-line lies over the angle; the desired sine of that angle is then read on the A scale. For instance, the sine of 30 degrees is seen to be 0.5. Knowing the value of the sine, the corresponding angle may be obtained by reversing this process.

Below the D scale there is a similar degree scale with the word "Tan" marked at the left. In the present case, however, it will be seen that the scale starts with 6 degrees and runs up to 45 degrees. The reason for this is that up to 6 degrees the tangent of an angle is the same as the sine of that angle, so that for obtaining the tangents of angles less than 6 degrees the sine scale may be employed. For angles from 6 to 45 degrees, tangents are obtained in the same way that has already been explained for the sine scale, in the case of tangents use being made of the "Tan" scale and the D scale. Reversing this process enables one to obtain the value of the angle from the known value of the tangent. From the relation between the sine and cosine and the tangent and cotangent of an angle, cosines and cotangents may be obtained from the sine scale and tangent scale, respectively. These scales also provide for operating with logarithms of trigonometric functions.

To facilitate the handling of many problems in engineering,

Fig. 2. Richardson's "Merchant's" Slide-rule with Special Provision for solving Commercial Problems

the graduations of the B and C scales on the slide have been extended as partially shown by the portion of the slide extending to the left, so that provision is made for graduating constants on the space at each side of these scales. For instance, take the case of problems involving the use of data expressed in meters where it is desired to obtain results expressed in inches. At the upper left-hand corner of the rule opposite the end of the A scale (and at the lower right-hand corner opposite the D scale) there are holes which are known as "key holes." Taking the case of a problem involving the use of meters, the slide is run along until the letter Q appears in the key hole. We are then ready to proceed with our problem. Suppose, for the case of simplicity, that it is desired to determine the number of inches in 4.5 meters. The runner is moved along the A scale until the cross-line lies over 4.5, and the desired result is then obtained by reading the number that appears under the cross-line on the B scale. For instance, it will be seen that 4.5 meters equals 177 inches. There are twenty-two of these constants graduated on the slide, which greatly facilitate the performance of many engineering problems. A list on the back of the rule gives the key letter and significance of each constant.

Richardson's Merchant's Slide-rule

For the use of merchants and other business men, many of whom have not made a detailed study of mathematics and have not been instructed in the use of the slide-rule, Mr. Richardson has developed a simple rule illustrated in Fig. 2. At the top of this rule there are two scales marked D^1 and D^2, which are graduated similarly to the C and D scales of the ordinary slide-rule. These can be used for problems in multiplication and division. At the center of the slide there is a scale corresponding to the two upper scales on the rule, but reading in the opposite direction. This scale is marked CI, and is used to obtain reciprocals of the numbers graduated on the scale at the top of the slide. For instance, setting the runner at 2 on the scale marked D^2, the corresponding reciprocal 0.5 will be found on the scale marked CI.

One of the most valuable uses of this slide-rule is in the calculation of problems in percentage and interest, for which purpose it is the means of saving a great deal of time. At the bottom of the rule will be seen a scale marked D^3 at the left, while the word "Prin" appears at the right of this scale. At the bottom of the slide there is a scale at the left of which appears "%," while at the right of this scale is the word "Rate." Similarly, at the top of the slide there is a scale with "Days" marked at the right-hand end, while at the extreme top of the rule is a scale at the right-hand end of which appears the word "Int."

In order to explain the use of this rule for the rapid solution of problems of this kind, suppose it is desired to calculate the interest due on a loan of $4800 for seventeen days, interest being at the rate of 5¼ per cent. On the "Prin" scale, set the cross-line on the runner over 4800. Move the slide so that 5¼ on the "Rate" scale comes under the cross-line. Then without moving the slide, move the runner along until the cross-line is over 17 on the "Days" scale. The interest due will then be read under this cross-line on the top scale marked "Int." The amount due is found to be $11.91. This result can be obtained in a few seconds, where it would involve several minutes time for an average accountant to obtain the result.

* * *

EXPOSITION AT SPRINGFIELD, MASS.

An industrial exposition and conference will be held in Springfield, Mass., May 26-June 2. This will be the first event of the kind ever held in the country, and is the result of the feeling in the great manufacturing centers of the eastern states and New England that something tangible should be done to fortify the industrial interests to meet conditions likely to follow the close of the European war. The exposition grounds are well situated; the buildings erected in the summer of 1916, are on a railroad siding and afford ample accommodations for expositions and conferences. Further information can be obtained from John C. Simpson, general manager, Springfield, Mass.

NEW MACHINERY AND TOOLS NOTES

Welded Stellite Tools: Haynes Stellite Co., Kokomo, Ind. These tools consist of a drop-forged, heat-treated, carbon-steel shank to which a stellite cutting edge is electrically welded. They are made in all standard toolpost sizes and with straight, right-hand and left-hand shanks.

Small Swaging Machine: Etna Machine Co., Toledo, Ohio. While this machine will handle the usual run of small swaging work, it will swage any tapers that can be handled with a comparatively short die. Its greatest capacity is 1 inch in diameter and the dies are 3 inches long. The flywheel should run at 400 revolutions per minute.

Universal Tool Grinding Machine: Acme Grinder Co., Cincinnati, Ohio. This machine is intended for tool sharpening and small grinding of a similar nature. The headstock and the vise swivel in all directions. The vertical screw for elevating and lowering the knee is provided with a ball thrust bearing to reduce the friction.

Universal Turret Table: Milliken Machine Works, West Newton, Mass. This tool consists of a base, designed to be bolted to the machine table, and a revolving top. A tongue in the base fits in the slots of the machine table, while the revolving plate has T-slots and a hole for locating work centrally. This tool may be used on milling machines, shapers, surface grinders, drilling machines, etc.

Shaping Machine for Locomotive Boxes: Newton Machine Tool Works, Inc., Philadelphia, Pa. The principal features of this machine are a vertical feed and an angle-plate for mounting horizontally the part to be machined. The boxes are placed in a horizontal position so that the marks on the boxes are visible. The feed of this machine is accomplished by a pawl, and this arrangement insures a definite amount of feed at each stroke.

Trumbull Tapping Machine for Thin Work: F. S. Trumbull, Bridgeport, Conn. The essential part of this machine is a small electric motor, upon the shaft of which is mounted a Gronkvist automatic collapsible chuck. This machine will tap holes up to ¼ inch in diameter. Two coil springs force the work into the tap after it is placed in position and a pedal is used to back off the spindle. A switch automatically stops the machine when the pedal is released.

Portable Band Wheel Grinding Machine: W. C. Barnhart, Seattle, Wash. With this machine band wheels, pulleys, and similar work may be ground without being removed from their bearings. The grinding wheel is revolved simply by frictional contact with the surface being finished, so its use is limited to parts that can be driven at a peripheral speed of from 5000 to 9000 feet per minute. Varying the angle of the abrasive wheel with reference to the axis of the pulley changes the speed of the wheel.

Hand Milling Machine: Superior Machine & Engineering Co., Detroit, Mich. This machine is designed to handle fine work. Its range of mills is from ⅛ inch to 5 inches in diameter. If desired, a slotting attachment or vertical milling head may be applied in place of the regular head. Both the head and the knee slide are on the same column. In the back of the column is a two-speed gear-box, and in a box outside the column are two transposing gears; provision is made for obtaining a wide range of speeds.

Plain Grinding Machine: Fitchburg Grinding Machine Co., 76 Winter St., Fitchburg, Mass. In the June, 1914, number of MACHINERY, descriptions were published of the styles A and B, 6 by 15 plain cylindrical grinding machines which had just been placed on the market at that time by the Fitchburg Grinding Machine Co. As originally designed, the machines were equipped for belt drive, but in order to meet the demand for the use of electric power, machines of this type are now being constructed with an individual motor.

Releasing Tap- and Die-holder: Ideal Brass Co., Indianapolis, Ind. This tap, which is driven by two pins, is brought up to the work and continues to cut after the turret stops until its movement causes the pins to release. By adjusting the amount of tool travel after the turret stops, it is possible to work up close to a shoulder. When the holder starts to reverse, a roller runs up a taper groove until it grips the shank and backs up the tool. Left-handed threads may be cut by placing this roller in a second taper groove provided for the purpose. By placing rollers in both grooves, a non-releasing holder is obtained.

* * *

PUTNAM CAR WHEEL GRINDER—CORRECTION

The net weight of the heavy-duty car wheel grinder built by the Putnam Machine Co. of Fitchburg, Mass. and described in the February number is 50,000 pounds with the motors, and 45,000 pounds without the motors. Owing to a typographical error the weight was stated in the description to be 5000 pounds.

THE AMERICAN INSTITUTE OF WEIGHTS AND MEASURES

The revival of the agitation for the adoption of the metric system has aroused the opponents of the system, and an organization called the American Institute of Weights and Measures was formed in 1916 to support the present English system of weights and measures. At a meeting of the council of the institute, held at the Engineers' Club, New York City, February 19, the following officers were elected: president, W. R. Ingalls; vice-presidents, Henry D. Sharpe and D. H. Kelly; treasurer, Walter M. McFarland; commissioner and secretary, F. A. Halsey.

The objects of the new institute are declared to be: the maintenance and improvement of our present (English) system of weights and measures, for the good of our commerce and industry and the well-being of our country; the education of the people with respect to the importance of our weights and measures, through the dissemination of correct information with respect to them and to the danger inherent in changes of our basic standards of measurement; the improvement of old and the development of additional standards as they may be needed by reason of new conditions in commerce, industry, science and engineering; the promotion of wise legislation for the conservation of our basic English units of weights and measures, and opposition to hasty legislation, involving changes from our fundamental English standards.

The annual dues of association members are $100 for associations which are national in scope and $25 for all others. The annual dues of corporation members employing less than 500 employes are $25, and of those employing more than 500 and less than 1000, $50; and $25 for each additional thousand employes, or fraction thereof, up to a maximum of $500. The annual dues of individual members are $5.

The institute will open offices in New York City. Applications for membership should be sent to F. A. Halsey, commissioner, Hill Bldg., Tenth Ave. and 36th St., New York City.

* * *

SHEET METAL TESTING MACHINE

Tensile strength tests are unsatisfactory for determining the quality of thin sheet metal that is to be worked in power presses, etc., because of two reasons: in the first place, such tests do not yield reliable data for very thin sheets; second, the quality of metal which is to be worked by drawing, stamping, folding, etc., is dependent upon ductility and similar properties rather than upon tensile strength. The following article describes a machine for determining what is known as the Erichsen value, i. e., the depth in millimeters before the metal is torn, of an impression made by forcing the sheet metal through a die. A chart gives Erichsen values for various metals, based upon data obtained by several thousand tests.

In determining the quality of metal sheets, the only method used in the past has been the "tensile strength" test. The tensile strength testing machine does not give reliable results

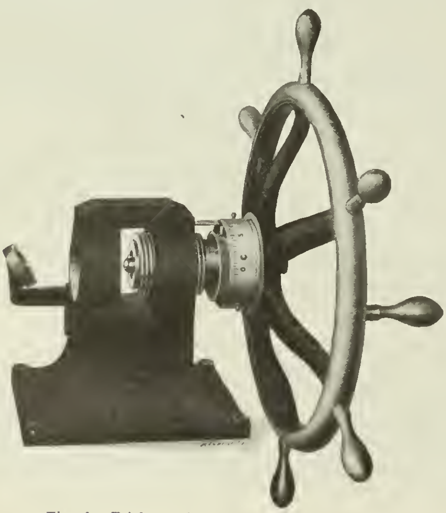


Fig. 1. Erichsen Sheet Metal Testing Machine

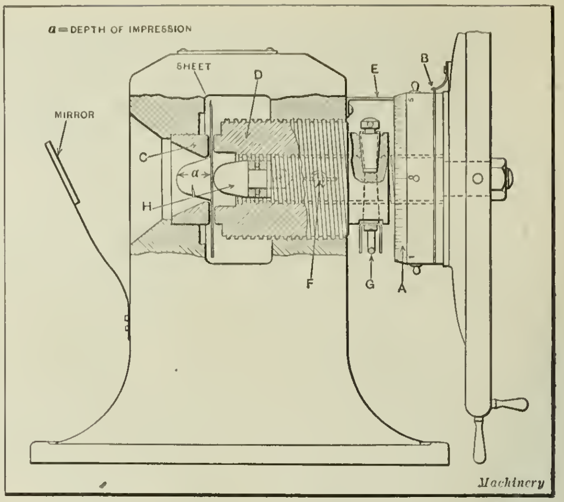


Fig. 2. Partial Cross-sectional View of Machine, showing Arrangement of Die, Tool and Holder in which Specimen is secured

with thin sheets, and in the practical application of metal sheets it is not so much the tensile strength, but the drawing, stamping, compressive and folding qualities which determine whether the material is well suited for manufacturing purposes. A. M. Erichsen, a Norwegian metallurgical engineer, has devised a method for testing metal sheets on which patents have been granted in the U. S. A. and in all foreign

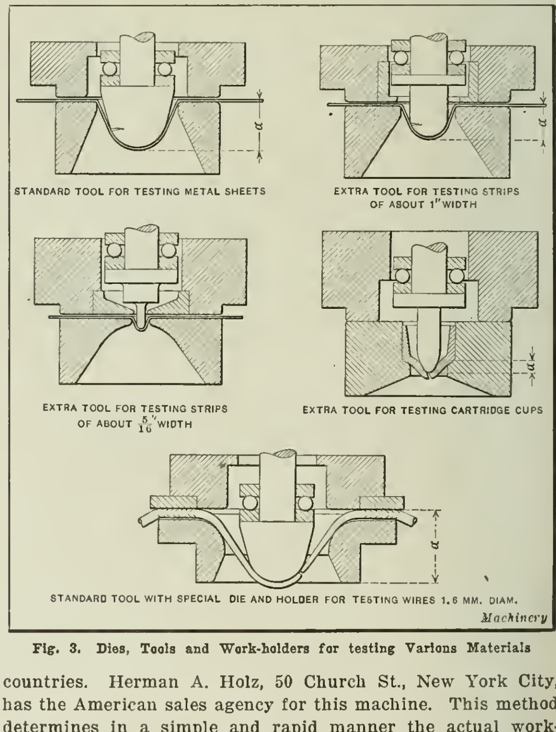


Fig. 3. Dies, Tools and Work-holders for testing Various Materials

countries. Herman A. Holz, 50 Church St., New York City, has the American sales agency for this machine. This method determines in a simple and rapid manner the actual workability of metal sheets to the point of fracture. A specimen of the sheet or strip is clamped between two dies and held in such a way that the metal has "play" and can flow, while a tool having a rounded end (a perfect semi-ball) is moved gradually forward under the influence of a ram, actuated by a micrometer screw, until fracture occurs. The test piece is under the permanent observation of the operator, so that the point of fracture can be determined with great accuracy (to 0.01 millimeter). The depth of the impression required to produce fracture can be read off directly from a micrometer scale and represents the "Erichsen value" of the sheet, which is a basis of the workability of all metal sheets for manufac-

turing purposes. Great tenacity combined with high tensile strength will give the best drawing and compressive values, which, however, are neither proportional to the effective modulus of elongation nor to the ultimate tensile strength.

Advantages of the Erichsen Method

The advantage of the Erichsen method lies, first of all, in the possibility of obtaining actual test figures in a few moments, and without any previous preparation of the test piece. It is therefore possible to test in a short time a large number of different qualities of metal sheets or strips, thus providing an effective means of control both for the manufacturer and the purchaser of the material. Another advantage is that all Erichsen machines are made from the same precision gages and are adjusted in exactly the same manner; hence the results obtained in testing homogeneous material are strictly comparable. It is therefore easy to lay down standard specifications regarding the quality of metal sheets by simply agreeing on certain minimum Erichsen values. Another important point of advantage is that the "dome" produced by the indentation permits ready observation of the macro-structure of the drawn metal, often giving valuable information about the treatment which the material has undergone. The operation of the machine is so simple that any intelligent workman can readily use it. While its high accuracy makes it suitable for use in testing laboratories, the machine can just as well be used in the shops, as it is of very solid and rugged construction.

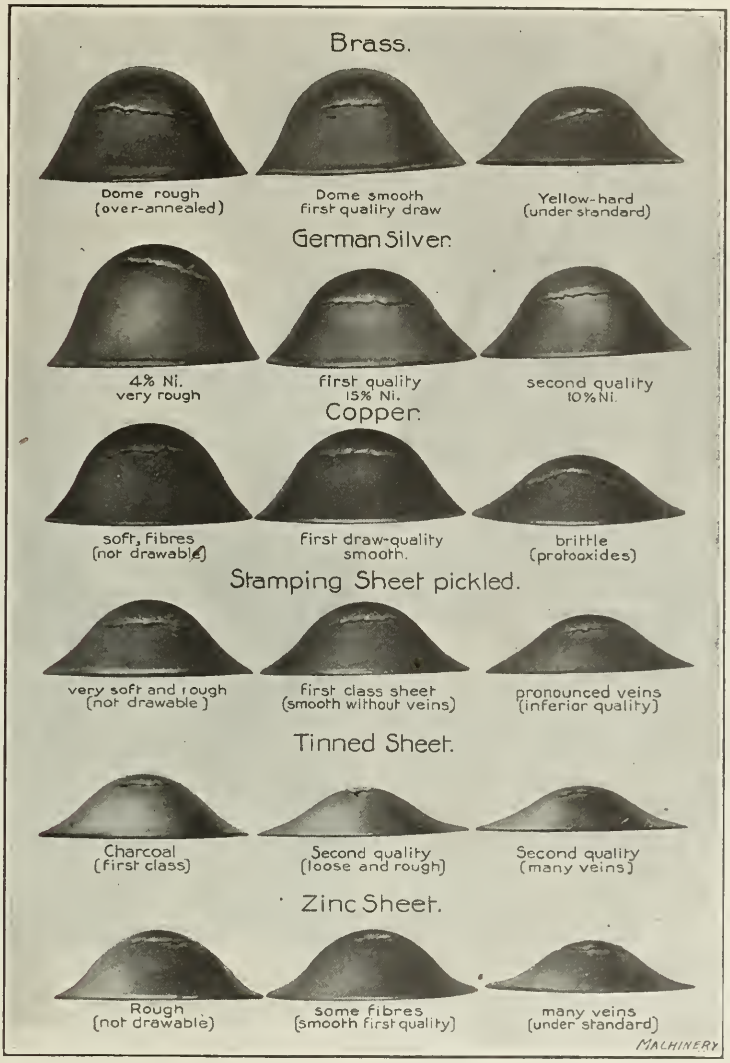


Fig. 4. Fractured Test Specimens of Different Materials showing Variations in Erichsen Value and Nature of Tear

Observation of Tested Specimen

While the Erichsen machine permits the accurate measurement of the thickness of the test specimen, which should be noted when starting the test (see instructions for operating the machine), there are two other points that should be observed: (1) Formation of the fracture. Investigate whether the fracture runs around the dome or whether a previous fracture in a certain direction is noticeable. In the latter case the metal is fibrous and not very well suited for drawing and folding purposes; it will then also have a low drawing value. Pronounced fibrous formation is often noticeable in first quality sheet iron and tinned iron sheets, while in the case of iron and steel strip the fibrous formation disappears more and more when being repeatedly annealed and cold-rolled. On the other hand, non-ferrous sheets are usually not fibrous, with the exception of zinc sheet, the workability of which is thereby considerably reduced. The second point to be observed is: (2) Macro-structure. Investigate whether the dome retains a surface similar to that of the sheet in its original state or whether it becomes rough or close-grained. If it becomes rough, it is not suitable for drawing or pressing operations. This loose structure appears in ferrous and non-ferrous sheets, and is caused by excessive annealing. The Erichsen method thus provides also a means of controlling the proper annealing process. The dome frequently appears close-grained on the surface, mostly in copper and brass sheets. In copper sheets this results from the influence of reducing gases on copper protoxide, which occurs chiefly when copper is annealed in open reverberatory furnaces. This fine grain can often be seen in copper sheets with the naked eye. In brass sheets, this evil may be traced to various causes; very often it is produced by too sharp pickling. A high-quality drawing and pressing sheet should, therefore, have: (1) A good Erichsen value. (2) As little as possible fibrous formation. (3) A smooth surface of the testing dome, which must not show a rough or close-grained appearance. Furthermore, the sheet must be free from scale and flaws (noticeable with the naked eye), and any blisters and hollow spots that may be present in the sheet will show up immediately upon commencing the test.

Standard Specifications for Trade Qualities

The curves in Fig. 5 show the relation between the thickness and the Erichsen value of good metal sheets. Their meaning to the trade will be readily understood; a brass stamping sheet of, say, one millimeter thickness, should not crack in the Erichsen machine below 14.25 millimeters depth of indentation. If it has less than 14.25 millimeters Erichsen value, its quality is below standard. These standards were laid down by Mr. Erichsen by averaging several thousands of tests in his many years' experience. They permit excellent comparisons to be made between the manufacturer and purchaser of the sheets, although most of the large users of metal sheets will work out special standards for their various requirements. In case the drawing values determined exceed those given in Mr. Erichsen's standard curves, the sheet may be said to be of good trade quality or even better.

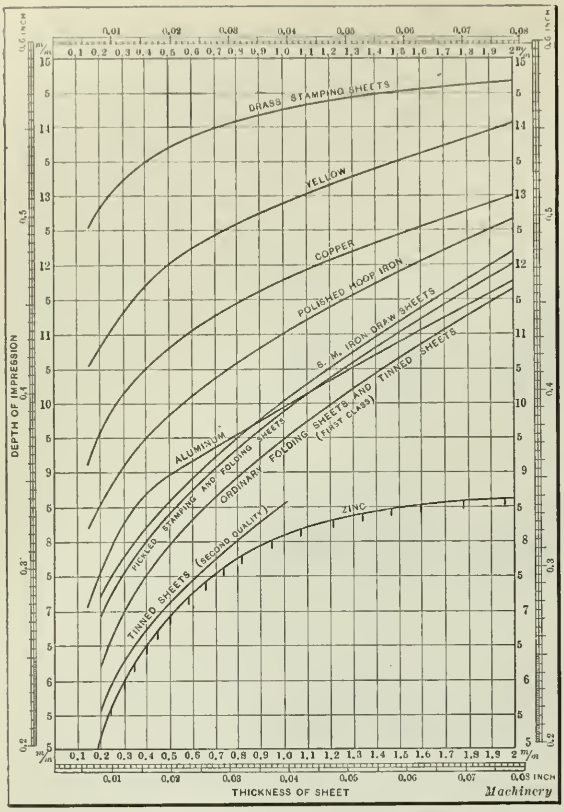


Fig. 5. Chart showing Normal Erichsen Values for Various Thicknesses of Different Kinds of Sheet Metal

Directions for Use of Machine

The first operation is to measure the thickness of the sheet to be tested. Set scale *A*, Fig. 2, to zero by shifting the movable collar on which it is engraved until the spring *B* snaps into a small hole. Insert the sheet specimen (about 3½ by 3½ inches) in die *C*, turn the wheel until the sheet is firmly clamped between die *C* and holder *D*, as shown in the diagram, and read off the thickness of the sheet on scale *A*, which is divided into 0.01 millimeter. The total range of this scale is 5 millimeters, and readings can be continued on scale *E*. After the thickness of the sheet has been measured, turn the handwheel back five small divisions on scale *A*

TABLE I. NORMAL ERICHSEN VALUES OF 1/64-INCH ANNEALED FERROUS SHEETS

Material	Depth, m. m.	Depth, inch.
S. M. hoop iron, polished	9.5	0.374
S. M. sheet, first class	8.2	0.323
S. M. stamping sheet, pickled	8.0	0.315
Common folding sheet	7.5	0.295
Charcoal tinned sheet	7.5	0.295
Second quality tinned sheet	6.7	0.264
Brass or copper plated sheets	8.5	0.335

Machinery

(0.05 millimeter), in order to give the test piece a certain amount of play, which is the same for all gages of sheet (*i. e.*, 0.05 millimeter). To secure the holder *D* in this position, tighten wing screw *F* at the right side of the machine. Now shift scale collar *A* until the zero point of the micrometer scale meets the zero point on scale *E*. Then shift the gear by pressing against milled ring *G* and turn the handwheel to the right (in clockwise direction). Tool *H* now moves forward into the sheet, and the bulging will be immediately noticed in the mirror.

Watch the image carefully in the mirror until the moment of fracture is reached, when the depth of impression is read off on scale *E* (in millimeters) and on *A* (in hundredths of a millimeter). In approaching the point of fracture, the wheel should be turned slowly, so that readings may be accurate to 0.01 millimeter. After the depth of impression has been read and noted, loosen the screw *F*, turn the wheel quickly to the left, until the gear shifter snaps automatically back to the outer gear, and the machine is ready for another test. It is obvious that the machine should be mounted firmly and in such a position that as much light as possible falls on the dome of the indentation, so that it can be closely watched in the mirror. Not only the threads, but also the die and tool should be kept lubricated. It will be noticed in testing thick sheets (2 to 5 millimeters) that the power required to produce fracture is considerably reduced, if grease is kept on the die and tool; this question of lubrication, however, does not influence in any way the measurement of the Erichsen value. The size of the test pieces for use in the standard machine should be 3½ by 3½ inches, and strips up to 2⅜ inches in width can be tested with the standard tools. For narrower strips up to 1 inch and 5/16 inch, respectively, additional interchangeable tools are required.

TABLE II. NORMAL ERICHSEN VALUES OF 1/64-INCH ANNEALED NON-FERROUS SHEETS

Material	Depth, m.m.	Depth, inch
Brass stamping sheet	13.5	0.532
Yellow metal	11.7	0.461
Pure nickel	11.5	0.453
German silver stamping sheet	11.5	0.453
A-1 German silver sheet	11.0	0.433
Copper sheet	10.5	0.413
Aluminum sheet	8.7	0.343
Zinc sheet	6.5	0.256
Silver sheet, 0.875	7.5	0.295

Machinery

Tube Testing

Pieces of metal tube are cut open and carefully straightened out with a mallet. The Erichsen test is then conducted in the same manner as with sheet metal. The appearance of the surface of the dome will then often give valuable information. Drawing grooves (caused by tools in the tubemaking machinery) and long drawn flaws will be shown as sharp transverse fibers and result in premature fracture, while excessive annealing will be recognized in the known manner (see under "Observation of the Tested Specimen").

Testing Spring Quality of Sheets and Strips

Sheets and strips are often purchased on the specification of "spring hardness." These grades are to be based upon the deflection, and the values given in Table III refer to brass sheet of 0.5 millimeter (0.02 inch) thickness.

Hardness Tests

As the depth of the Erichsen impression varies, on material of identical composition, in a certain relation to the Brinell hardness of the sheets, the Erichsen machine may also be looked upon as a valuable apparatus for determining the degree of hardness of iron and steel sheets and strips. The Erichsen machine thus offers means for the manufacturing plants to establish their own standards also for the hardness of metal sheets and strips, which cannot be determined accurately by the well-known methods of hardness determination.

TABLE III. SPRING HARDNESS AND ERICHSEN VALUES FOR BRASS SHEETS[1]

Grade of Spring Hardness	Soft	⅛ Hard	¼ Hard	½ Hard	¾ Hard	1/1 Hard	Spring Hard	Double Spring Hard
Deflection, per cent	0	3	5	10	15	25	35	50
Erichsen value	13.7	12.3	11.3	10.5	9.8	8.5	7.4	7.2

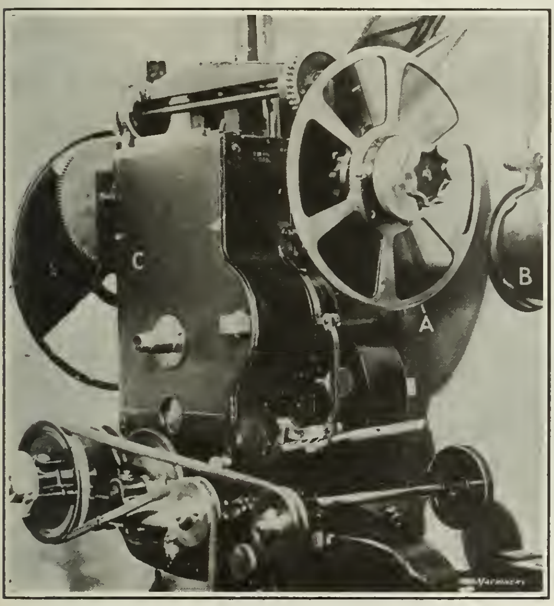
Machinery

[1] The depth of the Erichsen impression of sheets of other thickness is proportionate to the standard Erichsen curve.

COLORED MOVING PICTURES

While colored moving pictures are not new, recent improvements have been made in the color process which may result not only in increasing the popularity of the movie show (if that be possible) but in making moving pictures much more effective in commercial work, either as a means of advertising or selling goods. The Prizma pictures, which represent the latest development in the color process, are not only superior to the plain black-and-white pictures because of the natural color effects obtained, but have a "depth" which is more realistic.

The Prizma films are, to the casual observer, similar to films for black-and-white pictures, although they possess latent values obtained by the use of a gelatin color screen or filter on the camera. This screen, which is between the film and the lens, is in the form of a thin circular disk and has four equally spaced sections with two pairs of complementary colors. The first pair is composed of red and green-blue, and the second of yellow and blue. When the camera is in use, one exposure is made for each of the four colors, so that four negatives are obtained for each revolution of the color screen. These exposures occur at the rate of twenty-four a second and the screen is geared to revolve six revolutions per second, in unison with the movement of the film, so that



Projector equipped with Color Wheel Attachment

it makes one complete turn during the time that four exposures are made.

The camera controls a single strip of film of standard width, which is perforated on the edges as usual and is pulled down, step by step, back of a single lens. When an exposure is made through the red screen or color filter, the light rays, excepting from any shades of red that may be before the camera, are excluded; similarly, all but the green rays are excluded by the green filter, and so on. Between the film and the lens there is a shutter to cover the film at the time it is being drawn down after each successive exposure. Simultaneously with every fourth exposure and at the time that the red screen is opposite the lens, a little light is admitted to the edge of the film through a special aperture, thus marking every fourth or red-screen negative so that it can be distinguished readily from the others. This mark enables the different film sections to be joined together properly, or so that the film, from one end to the other, has four successive exposures for each revolution of the color screen. When the film has been joined in this way, it will keep in step with the color wheel attachment of the projector after it has once been synchronized.

The positives used in reproducing the picture are printed as usual and may be exhibited on any standard projector after equipping it with a color wheel attachment, as shown in the accompanying illustration. The color wheel *A* is driven through gearing of such ratio that it makes one revolution for a film movement equivalent to four pictures or exposures, the same as the color filter of the camera. This projector color wheel is held in a given position by a spring detent, which engages any one of six slots (the number of slots corresponding to the number of color screens), so that the wheel can be synchronized with the film when starting a reel, by simply turning it one or more screen sections backward or forward, as may be required. The light from *B* passes through the different screens and then through the film, the movement of which is controlled by the mechanism in projector *C*.

While the spectator has the impression that each picture contains all of the colors and tints that appear to the eye, this is an illusion; what actually is shown is a red picture, a blue-green picture, an orange-yellow picture and a blue picture. These four shades photographically cover the entire range of visible colors and follow each other in such rapid succession that, owing to the persistence of vision, the impression remains that all of the colors and tints appear simultaneously. For instance, the red, white and blue of the American flag apparently appear simultaneously, although, in reality, these colors follow each other in rapid succession, but the impression remains that all three colors were seen in every picture. Black-and-white pictures may be shown by simply swinging the color wheel *A* away, so that the light does not pass through it, the geared drive being so arranged that one gear revolves about the other, planetary fashion, when changing the position of the wheel.

* * *

CORROSION OF METALS

BY W. H. DOOLEY [1]

When we consider the rapidity with which iron, steel and other metals corrode under ordinary conditions, with the resultant expenditure of many millions of dollars annually for depreciation and expense of renewals, we see that the problem of metal corrosion is one of great importance to the metal trades. This question also interests a large proportion of civilized people, because the security of life depends, to a large degree, on the durability and safety of structures and machines.

What is corrosion? Everyone has noticed the reddish-brown deposit that gathers on the surface of iron and steel that has been exposed to the air—particularly damp air. This reddish substance is called "rust" by the ordinary person, and is composed principally of oxide of iron, which is formed of two parts of iron and three parts of oxygen. It is represented in most technical magazines and books by the symbol Fe_2O_3. The first two letters represent the Latin term ferrus, meaning iron, and the letter O represents oxygen. The iron and the oxygen from the air unite in such a way that they cannot be separated without resorting to a process equivalent to smelting. Oxide of iron has great attraction for water, so it absorbs moisture from the air. The corrosion of iron or steel is the iron oxide combining with water. The result is similar in composition to iron ore, which is smelted and reduced to iron in a blast furnace. Corrosion of metal is often spoken of by workmen as the "eating of metals"; by scientific men it is called "oxidation."

Corrosion takes place first on the surface of iron and steel and follows the path of least resistance. It does not take place evenly over the surface of the metal. Sometimes it will penetrate a plate before attacking the adjacent surfaces. This is due to the fact that corrosion varies as the material in the metal and the treatment the metal receives in the iron mill. For example, the more porous the metal the more rapidly it will corrode. Blow-holes furnish a splendid foundation for corrosion, as do also such impurities as slag, scale or segregated parts of the metal. This is the reason why it is impossible to tell just why one piece of metal will corrode more quickly than another piece of the same kind.

Corrosion takes place faster in the presence of acids than under ordinary conditions. This is why corrosion proceeds

[1] Address: 277 Putnam Ave., Brooklyn, N. Y.

more rapidly after a thunder shower, when the lightning has changed part of the nitrogen of the air into nitric acid. Alkalies seem to retard corrosion. Certain impurities, such as carbon, silicon and phosphorus, have a tendency to resist corrosion, which is why cast iron does not rust rapidly in air, while other impurities, like manganese and sulphur, tend to increase corrosion. Steel corrodes according to the amount and condition of carbon in it. It is known that steel may contain carbon in either a free or a combined condition. That is, the carbon may be present in steel in the form of graphite, when it is called free carbon; or it may be united with the iron in such a way that it cannot be separated, when it is called combined carbon. The free carbon prevents corrosion. When corrosion once sets in, it increases progressively. It is 50 per cent more rapid during the second than during the first year. This is due to the fact that in the process an acid is formed which tends to increase the rate of corrosion. For this reason corrosion should not be allowed to continue, or even begin.

Up to the present time, no process has been discovered that will completely prevent corrosion. There are various materials, like paints and oils, that may be applied to the surface of the metal and reduce corrosion to a minimum. But before any substance can be applied, the rust must be removed. Any vigorous treatment may be employed to remove the rust, and the process will not crack, injure and break the metal. Rust is usually removed on a large and economical scale by scraping and hammering. The scraping is done, on a flat surface, by vigorously rubbing a steel-wire brush, both lengthwise and crosswise, thus removing the loose scales and projecting masses of rust. A hammer, file, cold chisel and a painter's wall scraper should then be used. The wall scraper should be used to remove any thick formation of rust. After this treatment, the steel brush should again be used, and should be followed by coarse emery cloth or sandpaper. Sometimes steel wool or steel shavings are used for the final removal of all loose and scaly formation. The process of rust removal is completed by removing the finely powdered dust and wiping the surface clean with a dry cloth. Sometimes the removal of rust is made easier by the use of a painter's torch, as this evaporates the moisture in the iron rust and reduces the scaly corrosion to a powder. Of course, the best results are obtained with a sandblast, but this is often too expensive to use in the ordinary machine shop.

When thoroughly cleaned, the metal may be covered with the material that will prevent corrosion to a great degree. In order to be effective, the paint or oil that is to be used should not damage the metal and at the same time should not allow the oxygen and moisture of the air to come into contact with it. In fact, any material to be used for preventing rust on iron and steel should be easy to apply; must protect the metal, to a great extent, from the air; and must cost but little. Oils and greases are used to protect iron and steel surfaces only when the exposure is not permanent or severe. Machinery and tools are often "slushed" with grease during a period when the shop is closed. Various paints, varnishes and oils are used. They are very good as long as they prevent water from coming into contact with the metallic parts. Very often, though, the oil dries out of the pigment, leaving the dry paint porous enough to absorb moisture from the air. This is particularly true with regard to oxide paint pigment that is mixed with oil and used as a coating for structural steel and iron.

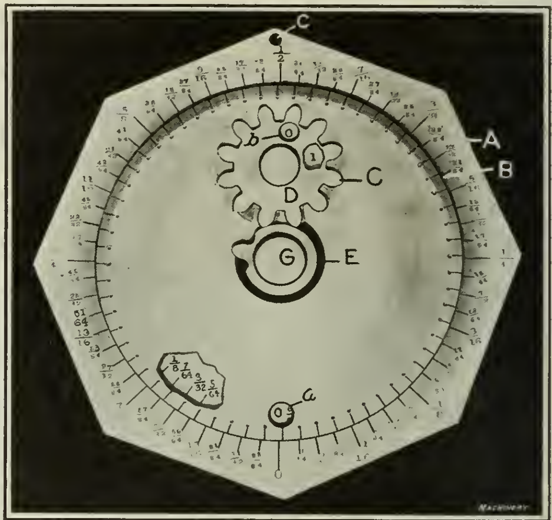
Progressive manufacturers and shop men are beginning to realize that it is absolutely necessary to have a definite arrangement whereby corrosion is removed from metallic surfaces at definite periods. A large number of men are constantly employed on large structures removing the rust and recovering with a suitable paint. If all owners would take due precaution, frightful accidents, causing the loss of life, such as the collapse of large steel structures, bridges, gas works and products of large railways, would be reduced to a minimum.

* * *

Extensive molybdenum deposits have been discovered near Mandal, Norway. The present production is about three tons per week.

PROGRESSIVE FRACTION ADDER

Fraction adders similar to that here described have for a long time been generally known, but this one contains some new features of interest. It consists of six parts, *viz:* base *A*, rotating disk *B*, pinion *C*, center stud *D*, one-tooth pinion *E*, and main stud *G*. *A* is divided into sixty-four graduations which line up accurately with the same number of graduations on disk *B*. Opposite each graduation on base *A* is a fraction. The graduations are marked 0, 1/64, 1/32, 3/64, 1/16, etc., up to 63/64 in a counter-clockwise direction. There is another set of figures on *A* underneath disk *B*, which can be seen through the hole *a*. These fractions also start with 0 and end with 63/64, but in this case they progress in a clockwise direction. The shoulder stud *D* extends only through *B*, thus giving it freedom to rotate. Shoulder stud *G* extends through *B* and is riveted to base *A*, allowing free rotation of part *B*. Pinion *E* is securely fixed to stud *G* which, being fixed to base *A*, holds it in a predetermined position. Through hole *b* will be seen the character 0 under pinion *C*. The figures 0, 1, 2, 3, 4 and 5 are stamped on disk *B* equal distances apart,



Device for adding Fractions up to Six Inches

and become visible through the hole *b*, as *C* rotates one-sixth revolution for every complete revolution of *B*.

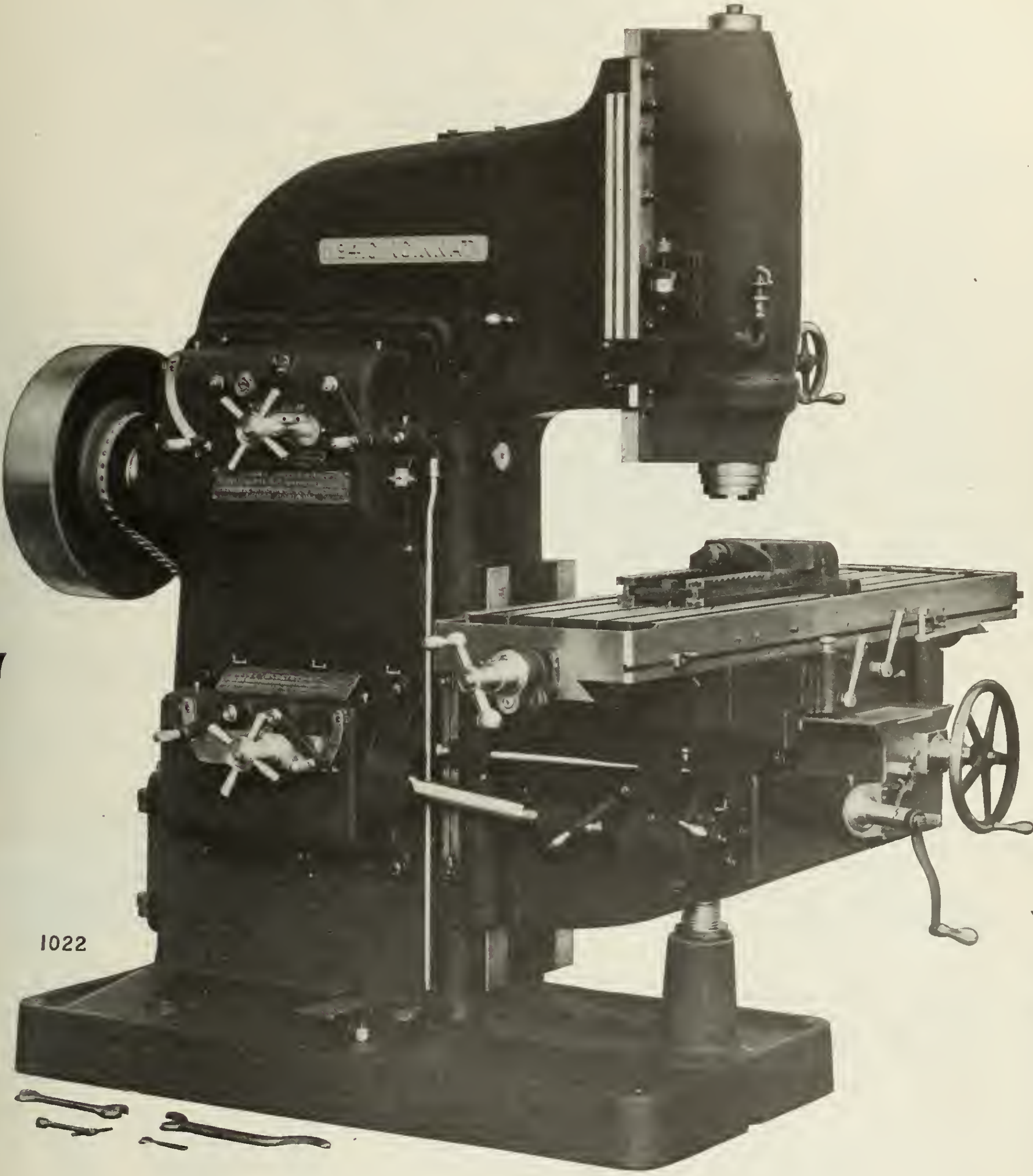
The operation of the device is simple and may best be understood by an example. The adder as illustrated is approximately in the neutral position. Suppose the fractions ¼, ⅜ and ½ are to be added. The point of a lead pencil is placed in the small hole on *B* corresponding with ¼ on *A*, and with the pencil as a lever, *B* is moved in a clockwise direction until the graduation at the point corresponds with 0 on base *A*. Then the pencil point is placed in the hole corresponding to ⅜ and *B* is rotated until the point lines up again with 0 on *A*. This operation is again repeated, placing the pencil point at the graduation corresponding to ½. Now the sum of these three fractions may be read directly. Through hole *b* the figure 1 is visible and through hole *a* ⅛ is visible, indicating that the sum is 1⅛. When the addition of fractions exceeds 1 it means that *B* is rotated somewhat more than one complete revolution, and in this case *C* engages with the tooth on pinion *E* and rotates one-sixth revolution, exposing the numbers 1, 2, 3, etc.

The hole c is for hanging up the adder. The principle involved in the rotation of *C* is the well-known Geneva movement. Except for the two studs this adder is made entirely of aluminum. The illustration and description were secured through the courtesy of F. J. Perry, Nashua, N. H. V. B.

* * *

The *Engineer* of London states that the British shipyards now have double the output that three years ago was considered maximum.

CINCINNATI VERTICALS



Unusual Spindle Power.
Heat Treated Alloy Steel Hardened Gearing.
Massive Spindle Head Construction.
Handy—Can mill around a rectangle without stopping feed or speed.

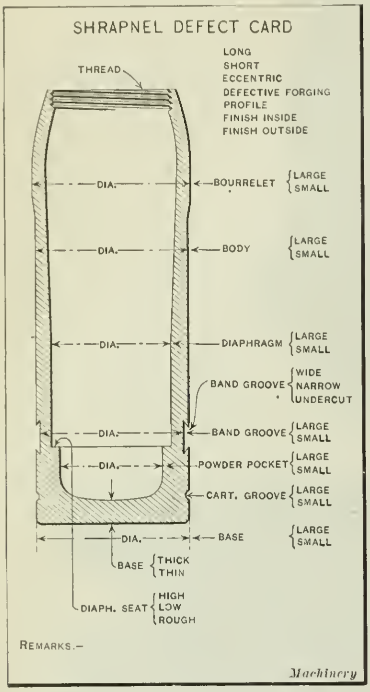
These are some reasons why you should use Cincinnati Verticals

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO, U. S. A.

SHRAPNEL DEFECT CARD

Any mechanical man will concede the value of a sketch for conveying a mechanical idea in preference to verbal explanation. It is difficult for mechanical men to express themselves without the use of a pencil, and sketching is really a great assistance in conveying thought. The Vermont Farm Machine Co., Bellows Falls, Vt., has taken advantage of this fact in connection with shrapnel inspection. The shrapnel defect card shown herewith has proved an effective way of conveying information from one inspector to another.



Reproduction of Shrapnel Defect Card

On these cards, which are printed in quantity, the inspector finding the body diameter large puts a check mark after the word "Large" and rolls the card up, slipping it into the shell. That shell is then sent along with the others to what corresponds to a repair department, where there are experts who pass on the advisability of scrapping or repairing the shell. The advantage of this defect card is the ease with which the repair men can determine which portion of the shell is defective. The expense of printing a card of this nature is not greatly in excess of any printed form card. For this reason the idea here incorporated should be applicable to the inspection of any kind of duplicate machine parts. V. B.

* * *

LARGEST GYRATORY CRUSHER

The largest gyratory crusher in the world has been installed at the plant of the Michigan Limestone & Chemical Co. at Calcite, Mich., by the Kennedy-Van Saun Mfg. & Engineering Corporation, New York City. It is 34 feet high, weighs 700,000 pounds, and has a capacity of 25,000 tons of limestone each twenty hours. The crushing space between the head and concaves holds 30 tons of stone; while the hopper, which flares out above the head and concaves with an outside diameter of about 22 feet, holds 35 tons more. The spider is made in a single casting and is within one inch of the railroad height limit even when shipped in a well-bottom car. On account of its weight, the top shell could not be shipped in one piece and was therefore constructed in two horizontal sections. These are connected by heavily flanged male and female tapered machine joints, securely bolted, so that the strength of the shell is increased instead of reduced. The crusher is driven by a 300-horsepower motor. As continuity of operation is of greatest importance, the English rope system is used. The 1¼-inch manila ropes lead over a 66-inch cast steel sheave having eighteen machined rope grooves.

The main shaft, which is made of hydraulically forged steel, is about 3 feet in diameter at its largest part and about 28 feet long. It is designed on the basis of a maximum fiber stress of 10,000 pounds per square inch. The eccentric is of the spherical ball-and-socket type and is self-aligning. Its steel bearing has a phosphor-bronze bushing that is constructed in two parts. The pressure between the shaft and the bearing is designed not to exceed 175 pounds per square inch. Eccentric and thrust collars carry the weight of the eccentric and are lubricated by a positive oil pump circulating system. As there is an oil strainer in circuit, a continuous supply of clean oil is secured. The spider is set clear of the concaves, so that the latter can be reset without disturbing the head or the spider. The concaves are made sectional and in four horizontal belts to facilitate handling the sections and so that only the worn parts need be renewed. The head is rigidly secured to the shaft on its smooth tapered part and thus reinforces the shaft at the place where the greatest stress is applied. It is held in position by a nut sleeve fixed to the shaft, but without threads on the shaft. This nut operates in a follower "zinced" in the top of the head. As a result, the tendency of the head to rotate on the shaft forces the head down tightly on the tapered part of the shaft, so that it is automatically locked in position. The head and concaves that take the principal wear from crushing are constructed of semi-steel castings of a special mixture and are deeply chilled on their working surfaces so as to have wear-resisting qualities. They have a maximum fiber stress of 3500 pounds per square inch.

PERSONALS

C. C. Cleland has been appointed sales manager of the Reliance Gauge Column Co., Cleveland, Ohio, succeeding F. Roberts.

H. F. Wright, formerly with the Weston-Mott Co., Flint, Mich., has been made factory superintendent of the Hannifin Mfg. Co., Chicago, Ill.

J. A. Nelson has resigned the position of vice-president of the East Jersey Pipe Corporation, New York City. Mr. Nelson is taking a short vacation and has made no plans for the future.

Joseph R. Greenwood has resigned his position of general manager with the Ballwood Co., and has associated himself with Charles H. Higgins, architect and engineer, 30 Church St., New York City.

E. Carlson, for the past two and one-half years assistant superintendent with the Stewart Die Casting Co., has resigned to take the position of chief engineer with the Indiana Die Casting Co., Indianapolis, Ind.

Spencer Weart, second vice-president of the Bound Brook Oil-less Bearing Co., Bound Brook, N. J., was recently elected president by the board of directors, and George O. Smalley, general manager, was elected treasurer.

G. W. Wagstaff, who has heretofore represented the Bethlehem Steel Co. in the northern Ohio territory, has associated himself with the Onondaga Steel Co., Inc., Syracuse, N. Y., and will represent this company in northern Ohio, northern Pennsylvania, Buffalo and Detroit.

H. L. Harrison has joined the Modern Tool Co., Erie, Pa., in the capacity of factory manager. Mr. Harrison was formerly connected with the Packard Motor Car Co., the Maxwell-Briscoe Co. and the American Car & Foundry Co. He has been for many years engaged in factory supervision and tool design.

George M. Meyncke, engineer with the Dayton Engineering Laboratories Co., Dayton, Ohio, has resigned, and joined the Hyatt Roller Bearing Co., Newark, N. J., as engineer in charge of machine tool design, with headquarters in Cincinnati, Ohio. Mr. Meyncke will devote his energies to promoting the use of Hyatt roller bearings in machine tools.

William H. Bennett, who for nearly a year has been advertising manager of the Searchlight Co., Chicago, Ill., has joined the force of the Service Motor Supply Co. of Chicago. The change was made because of the consolidation of the Searchlight Co. with the Air Reduction Co. of New York City, and the removal of the Searchlight interests to the East.

C. A. Call has been appointed assistant sales manager and advertising manager of the Gurney Ball Bearing Co., Jamestown, N. Y., succeeding Otto Bruenauer. Mr. Call was formerly manager of publicity of the Terry Steam Turbine Co., Hartford, Conn. and prior to that engagement was for five years connected with the advertising department of the General Electric Co., Schenectady, N. Y.

A. H. Ackermann, formerly vice-president and general manager of the U. S. Light & Heat Corporation, and C. C. Bradford, formerly sales manager of the same concern, announce the formation of the Bradford-Ackermann Corporation, with offices in the Forty-second St. Bldg., New York City, to represent manufacturers of electric apparatus, factory, automobile and railway supplies for domestic and export trade.

Frank M. Erb, formerly superintendent of production of the R. D. Nuttall Co., Pittsburg, Pa., has resigned, and will open an office in the Second National Bank Bldg., Pittsburg, early in March as a manufacturer's district representative. Mr. Erb will handle castings and forgings, and among the companies he will represent are the National Forge & Tool Co., Erie, Pa.; the Silver Mfg. Co., Salem, Ohio; and the Standard Steel Casting Co., Cleveland, Ohio.

W. S. Rogers has resigned as president of the Bantam Anti-Friction Co., Bantam, Conn., but will continue to fill the position of chairman of the board of directors, and will act in an advisory capacity. Miss Nellie Scott, who has been with the company since its beginning, was elected president and general manager; and Miss Ruth Edwards, who has been with the company for nearly eight years, was elected treasurer. Henry Edwards was elected vice-president and C. B. Heath, secretary.

E. B. Merriam, for several years assistant engineer of the switchboard department of the General Electric Co., Schenectady, N. Y., has resigned to head the industrial service department of the company, recently organized to supervise the education, employment and provision of opportunities for advancement of the employes at the Schenectady plant. Mr. Merriam has been connected with the General Electric Co. for sixteen years, starting as a student in the testing department, and later doing service in commercial, manufacturing and engineering development and research work.

Dr. W. F. M. Goss, for many years associated with the schools of engineering, Purdue University, Lafayette, Ind., and since 1907 dean of the college of engineering of the University of Illinois, Urbana, Ill., has resigned, to take the presidency of the Railway Car Manufacturers' Association. The Railway Car Manufacturers' Association, of recent origin, is made up of representatives of fifteen different concerns engaged in the manufacture of railway freight and passenger cars. It will seek to establish cooperative relations with the purchasers of cars and to aid especially in the matter of standardizing the design and specifications.

C. K. Lassiter has been appointed vice-president of the American Locomotive Co., 30 Church St., New York City, in charge of manufacturing. Mr. Lassiter entered the service of the Richmond Locomotive Works in 1892 as clerk in the piecework department. In 1894 he was made chief clerk to the late Joseph Bryan, then president of the Richmond Locomotive Works, and in 1902 was transferred to the Schenectady plant of the American Locomotive Works as chief clerk to the general manager. He was later appointed mechanical expert in charge of designing, developing and maintaining all shop equipment, shop systems and piecework departments. He developed and installed the new drop-hammer department for making forgings for all the company's plants and also standardized the small works department. In 1907 he was transferred to the New York office and made mechanical superintendent in charge of all betterments, designing, specifying and maintaining shop equipment and power-house operations for all the plants. Mr. Lassiter is also president of the Baush Machine Tool Co., Springfield, Mass., and president of the Quigley Furnace & Foundry Co. of Springfield.

OBITUARIES

F. E. Reed, formerly president of the F. E. Reed Co., Worcester, Mass., now part of the Reed-Prentice Co., died at his home in Thompson, Conn., February 18, aged sixty-nine years. Mr. Reed retired from active business in 1912.

Charles T. Schoen, who is given credit as being the originator of the pressed steel railroad car, died at his home in Moylan, near Philadelphia, Pa., February 4, of pneumonia, aged seventy-two years. Mr. Schoen began the manufacture of pressed steel specialties for wooden cars and established a small plant in Allegheny, Pa., now known as the North Side, Pittsburg. A few years later he organized the Pressed Steel Car Co., and was its president when he retired from that business fifteen years ago. He then built a plant at Butler, Pa., for the manufacture of the Schoen pressed steel car wheels, now known as the Standard Steel Car Co.

COMING EVENTS

March 29.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

May 21-22.—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 22-25.—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

May 26-June 2.—Industrial export exposition and conference, Springfield, Mass.

June 13-15.—Annual convention American Railway Master Mechanics' Association at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 13-20.—Annual meeting of the Railway Supply Manufacturers' Association at Atlantic City, N. J., in connection with A. R. M. M. and M. C. B. Associations' conventions. J. D. Conway, secretary and treasurer, 2136 Oliver Bldg., Pittsburg, Pa.

June 18-20.—Master Car Builders' Association's convention at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

August 30-Sept. 1.—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill., Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

SOCIETIES, SCHOOLS AND COLLEGES

Beloit College, Beloit, Wis. Catalogue 1916-1917, with announcements for 1917-1918.

Stevens Institute of Technology, Hoboken, N. J. Annual catalogue containing the names of the members of the faculty, course of instruction, requirements for admission, sample examination papers and lists of students and alumni.

Pratt Institute, Brooklyn, N. Y., will present its annual exhibit of evening work Wednesday evening, March 7. The shops, laboratories and drawing-rooms of the school will be open to visitors from eight to nine, to give all interested in industrial education an opportunity to observe the students at work in the various courses, and to inspect the results and methods as well as the equipment and general facilities of the institute for conducting industrial training.

NEW BOOKS AND PAMPHLETS

The Tractive Resistance on Curves of a Twenty-eight-ton Electric Car. By Edward C. Schmidt and Harold H. Dunn. 54 pages, 6 by 9 inches; illustrated. Published by the Engineering Experiment Station, Urbana, Ill., as Bulletin No. 92. Price, 25 cents.

Industrial Arts Index. By Marion E. Potter, Louise D. Teich and Helen M. Craig. 530 pages, 6¾ by 10 inches. Published by the H. W. Wilson Co., White Plains, N. Y.

This is the fourth annual cumulation of the subject index to a selected list of engineering and trade periodicals for 1916.

Condensed Report of the American Uniform Boiler Code Congress, held in Washington, D. C., December 4-5, 1916, under the auspices of the Industrial Commission of Ohio. 87 pages, 8 by 10½ inches. Published by the American Union Boiler Law Society, Erie, Pa. Thomas E. Durban, chairman, Erie City Iron Works, Erie, Pa.

National Pipe Standards. Appendix to 1913 Edition Book of Standards. Published by the National Tube Co., Pittsburg, Pa.

The purpose of the Appendix is to supply the latest information on the subject contained in the 1913 edition of the book of "National Pipe Standards." The information is for the most part supplementary, but in some cases replaces other data entirely.

The New New England. By Frank Trumbull. 24 pages, 5 by 8 inches. Published by the Chamber of Commerce of the United States of American Immigration Committee, New York City.

The booklet is a reprint of an address made before the New England Society in New York City, December 22, 1916, discussing some of the changes caused by immigration and the problems created by the influx of foreigners.

Steam Boilers—Their Theory and Design. By H. de B. Parsons. 377 pages, 6 by 9 inches; 157 illustrations. Published by Longmans, Green & Co., New York City. Price, $4 net.

This work, first published in 1903, has just appeared in the fifth edition. The author states in the preface that many changes have been made in the text in order to improve and bring the subject matter up to date, and that these changes have made it practically a new work. The contents by chapter heads are as follows: Physical Properties; Combustion; Fuels; Furnace Temperature and Efficiency of Boiler; Boilers and Steam Generators; Chimney Draft; Materials; Boiler Details; Boiler Fittings; Mechanical Stokers; Artificial Draft; Incrustation; Corrosion—General Wear and Tear—Explosions; Chimney Design; Smoke Prevention; Testing—Boiler Coverings—Care of Boilers and Superheated Steam.

Manufacturing Costs and Accounts. By A. Hamilton Church. 452 pages, 6 by 9 inches; illustrated. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $5 net.

This work was written for the purpose of gradually introducing students to the underlying principles on which manufacturing accounting of all kinds must rest. It is presented in three parts, dealing with a general outline of manufacturing accounts, cost accounting and factory reports and returns, respectively. The author has endeavored to make the principles of cost accounting as applied to manufacturing so clear that the cost man may intelligently apply them to his own peculiar problems no matter how involved they may appear to be. In view of the faulty methods of keeping costs of manufactured products so often employed there is undoubtedly need of a comprehensive work like this for the enlightenment of those responsible for cost systems.

Failure of Brass. 1. By Paul D. Merica and R. W. Woodward. 109 pages, 7 by 10 inches; 116 illustrations. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards No. 82.

This report is on the microstructure and initial stresses in wrought brasses of the type 60 per cent copper and 40 per cent zinc. An experimental investigation was made at the Bureau of Standards of the causes of failure of a number of articles, particularly bolts of wrought brass of this alloy with reference to the presence of initial stress. The investigation shows that an average initial stress of 5000 pounds per square inch is to be regarded as a safe limit for rods and bolts of this type of material, under ordinary service conditions, in which the service load is itself not greater than from 5000 to 10,000 pounds per square inch.

The Mechanical World Pocket Diary and Year Book. 453 pages, 4 by 6 inches; illustrated. Published by Emmott & Co., Ltd., Manchester, England, and distributed in the United States by the Norman, Remington Co., Baltimore, Md. Price, 35 cents; by mail, 40 cents.

This collection of useful engineering notes, rules, tables and data has been published for thirty consecutive years. Several new features have been introduced in this edition. The section on steam and steam engines has been largely rewritten, and new tables have been introduced, giving dimensions of piston rings, governors, etc., with notes on lubrication and anti-friction bearings. The heat-treatment of steel receives attention, this section including notes on annealing, hardening, tempering, etc. The contents of the year book are so extensive and varied that no comprehensive statement can be given in the limits of this notice. Suffice it to say, that it is a most valuable and comprehensive collection of engineering data which almost any machine designer or draftsman will find useful.

Weights and Measures. 264 pages, 7 by 10 inches; illustrated. Published by the Bureau of Standards, Department of Commerce, Washington, D. C.

This is a report of the eleventh annual conference of representatives from various states, held at the Bureau of Standards, Washington, D. C., May 23-26. Some of the principal matters contained are short reports on legislation and general conditions existing in the United States; suggestions, discussions and resolutions as to the proper method of sale of coke, fruits, vegetables, etc., and of wrapped meats; technical papers on the selection and maintenance of apparatus in industrial plants, on the inspection, test, installation and maintenance of railroad track scales, and on liquid measuring pumps; reports and discussions in relation to the adoption and use of the metric system of weights and measures, and of the Centigrade scale of temperatures; and discussions by manufacturers of weights and measures and weighing and measuring devices, of tolerances and specifications, of new types of scales and other matters of interest.

Manufacture of Artillery Ammunition. By L. P. Alford, F. H. Colvin, Robert Mawson, E. H. Suverkrop and John H. Van Der Venter. 705 pages, 6 by 9 inches; 669 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $6.

This work, which is largely a reprint of articles that have appeared in the "American Machinist," was published with the aim of preserving in permanent form a record of the work done in the United States and Canada in making munitions for the European countries at war. The foreword by Howard E. Coffin, member of the Naval Consulting Board, refers to the experience gained by American manufacturers in making munitions and the value of books that place on record the means and methods employed. The subject matter is presented in four main sections, and an appendix. The first section deals with shrapnel; the second with high-explosive shells; the third with cartridge cases; and the fourth with fuses and primers. The appendix takes up machine tools for munition manufacture; composition and properties of shell steel; heat-treatment of shells, painting of shells, etc. The book contains much excellent material, and doubtless could be used advantageously in planning and equipping for the making of shrapnel and high-explosive rounds.

NEW CATALOGUES AND CIRCULARS

Hendey Machine Co., Torrington, Conn. Circular illustrating and describing the Hendey 20-inch crank shaper.

Lees-Bradner Co., Cleveland, Ohio. Booklet containing formulas and operating instructions for the No. 5A Lees-Bradner gear generator.

Peter A. Frasse & Co., Inc., 45 Boulevard, Hartford, Conn. Leaflet of oxy-acetylene welding and cutting, illustrating some repairs made by this process.

St. Louis Machine Tool Co., St. Louis, Mo. Leaflet illustrating and giving specifications for self-contained countershafts and plain and pull countershafts.

Monarch Engineering & Mfg. Co., Baltimore, Md. Catalogue entitled "The Crucible Problem Solved," illustrating Monarch melting and refining furnaces without crucibles.

Strauss Transit System, Inc., 185 Jefferson Ave., E., Detroit, Mich. Catalogue illustrating the Strauss inverted elevated railway system for passenger traffic in and between cities.

Stanley Belting Corporation, 32-40 S. Clinton St., Chicago, Ill. Pamphlet describing and giving price list of Stanley belting, a solid woven cotton belting impregnated with a special compound.

Haynes Stellite Co., Kokomo, Ind. Catalogue 6, treating of the use and application of stellite and its value for instruments, fine tools, cutlery, etc. Price lists and stock sizes of stellite bars are given.

F. R. Blair & Co., Inc., 50 Church St., New York City. Circular descriptive of the "Loxon" lock-nut. It is claimed that these nut locks are as safe as a castellated nut and cotter-pin, and cheaper.

Bickett Machine & Mfg. Co., 1118 Richmond St., Cincinnati, Ohio. Circular descriptive of the Bickett No. 0 vertical milling and profiling machine which has a longitudinal feed of 6 inches, a vertical feed of 2 inches, and a transverse feed of 5 inches.

Mesta Machine Co., Pittsburg, Pa. Bulletin D describing Mesta automatic plate valves (Iversen patent) which are being used successfully in both new and rebuilt air and gas compressors, ammonia compressors, vacuum pumps, and blowing engines.

Powdered Coal Engineering & Equipment Co., 1903 McCormick Bldg., Chicago, Ill. Bulletin 3 on the carburization and burning of powdered coal as a fuel, being a paper read before the American Institute of Mining Engineers, Chicago Section, December 22, 1916, by Alonzo G. Kinyon, chief consultant of the company.

Fire Detecting Wire Co., Inc., 101 Park Ave., New York City. Pamphlet entitled "Fire Detection," treating of the fire detecting wire system for interior automatic fire alarms, which combines automatic and manual operations. It is claimed that this system positively and unfailingly alarms when the fire is insignificant, before it gets under dangerous headway.

New Departure Mfg. Co., Bristol, Conn. Sheets 87 FE to 90 FE, inclusive, for loose-leaf catalogue, showing some unusual methods of ball bearing installation of interest to the machine designer. The method of mounting ball bearings in a special machine worm-drive mechanism and the application of single- and double-row bearings on a vertical spindle adapted for heavy grinding work are also illustrated.

American Locomotive Co., 30 Church St., New York City. Bulletin 1018 on the Walschaert valve gear, illustrating and describing its principles in full detail. This bulletin which shows by diagrams all the principal events in a cycle for outside and inside admission valves driven by the Walschaert gear should be generally appreciated by designers, engineers, students and all who are interested in valve motion design.

Gripwell Pulley Covering Co., 157 Cedar St., New York City. Pamphlet descriptive of "Gripwell" pulley covering, which is a refined vegetable oil compound of great adhesive power. It is used in connection with a specially prepared canvas, which enables the belt to exert its maximum amount of power without the necessity of being tightened and without the use of idlers. Price list of "Gripwell" pulley covering and cement is included.

Vanadium-Alloys Steel Co., Pittsburg, Pa. Leaflet treating of "Vasco Special," "Vasco Electric" and "Vasco Latrobe" carbon tool steels. "Vasco Special" steel is particularly suitable for the finer grades of tools, such as taps, reamers, milling cutters, and lathe tools. "Vasco Electric" is recommended for all general tool purposes, being adapted for such work as shear blades, taps, reamers, milling cutters, etc. "Vasco Latrobe" is a low-priced steel suitable for cold chisels, granite, and similar tools.

National Safety Council is issuing monthly "Safe Practices" leaflets which contain the findings of fifty safety experts engaged in working out the maximum and minimum requirements in safeguarding. The three issued are entitled "Ladders," "Stairs and Stairways," and "Boiler Rooms." The National Safety Council was established to bring about an understanding of accident causes and find and apply remedial measures. Details as to the council's activities can be obtained from W. H. Cameron, general manager, National Safety Council, 208 S. La Salle St., Chicago, Ill.

Moore & White Co., Philadelphia, Pa. Pamphlet entitled, "Speed Changes Without Frictional Slip," which treats of the need for a progressive speed-change device and its application in various machines, the elimination of slip in the Moore & White speed-change device, and the use of the Moore & White speed-change device on paper machinery, laundry machinery, textile machinery, cement kilns, enameling and japanning machinery, and printing presses. The principle of the Moore & White speed-change device is described and illustrated, and tables of dimensions and prices are given.

Greenfield Tap & Die Corporation, Greenfield, Mass. Bulletin I, "How to Measure Screw Threads," the first of a series of treatises on threading and gaging problems to be issued by the company. The bulletin shows the wrong and right way of gaging tapped holes and the influence of variations in pitch diameter and lead on screw thread fits. The effect of wear on the accuracy of a thread micrometer is illustrated, and the defects of the ring or templet gage are shown. With these examples of erroneous and defective methods of screw thread measurements are contrasted the limit system developed by the company which tests the pitch diameter. The means for testing errors in lead are also shown. The bulletin concludes with tables of proposed tap hole limits for U. S. standard taps, S. A. E. taps and machine screw taps.

TRADE NOTES

Ogden R. Adams, 159 St. Paul St., Rochester, N. Y., has opened a new salesroom for metal-working machinery at the above address.

Canadian S. K. F. Co., Ltd., 47 King St., W., Toronto, Canada, has been organized under a Dominion charter, for the manufacture and sale of S. K. F. self-aligning ball bearings in Canada.

Evans Friction Cone Co., Newton Highlands, Mass., is the successor of G. F. Evans, Newton Center, Mass. The company manufactures the Evans friction cone for varying the speed of machines.

Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass., announces that its gear department will in future be represented in the field by H. A. Daniels, who is thoroughly familiar with this line of business.

Stroh Steel-Hardening Process Co., Pittsburg, Pa., has opened an office at 728 Monadnock Block, Chicago, Ill., in charge of F. Lloyd Mark, western sales manager. The Chicago office will take care of the business in the central and near western states.

Modern Tool Co., Second and State Sts., Erie, Pa., manufacturer of grinding machines and threading tools, has removed its district office in Detroit, Mich., to 1223 Dime Bank Bldg. The Detroit office will continue as heretofore in charge of H. T. White.

International Company, Inc., Fourth and Chestnut Sts., Philadelphia, Pa., has opened offices at this address in charge of J. Guattari, the founder and formerly president of the International Import & Export Co. The company has offices in Italy, France, Cuba and South America.

Machine Tool & Supply Co., 321-323 E. Second St., Davenport, Iowa, has been incorporated to deal in new and second-hand machinery. The company has secured a store and has a large stock of machinery on hand. The state of Iowa and a portion of Illinois in the immediate vicinity of Davenport will be covered.

Andrews & George, Tokyo, Japan, has been reorganized and the name changed to the Andrews & George Co. on account of the death of Ernest W. George. The paid-up capital of the company has been increased and the present company assumes all assets, obligations and liabilities of the former concern, which was established about twenty-two years ago.

General Electric Co., Schenectady, N. Y., has established an industrial service department for the purpose of supervising education, employment and the provision of opportunities for advancement of employes, at the Schenectady plant. The new department is in charge of E. B. Merriam, for several years assistant engineer of the switchboard department.

Burdett Oxygen Co., St. Johns Court at Fulton St., Chicago, Ill., announces that it began the operation of its Oklahoma plant, located at Stock Yards Station, Oklahoma City, in February, and is now in position to furnish oxygen to users in that territory. This is the twelfth plant installed by the company in the various industrial centers of the country.

Moline Tool Co., Moline, Ill., manufacturer of the "Hole Hog" line of multiple-spindle drilling machines, has moved into its new factory, which is a large sawtooth roof structure provided with modern equipment for the manufacture of machine tools. The company was obliged to expand its facilities beyond the capacity of the old plant in order to meet the demand for its machines and is now operating both new and old shops.

Trindl Machine Works, Fowler Bldg., 57-61 E. 24th St., Chicago, Ill., is a new concern, established by J. H. Trindl, formerly of Trindl & Ryser. The firm will engage in the manufacture and jobbing of pistons, piston rings, wrist-pins, crankshafts, valves, etc., as well as general machine work. Cylinder grinding will be made a specialty, several of the latest type grinding machines having been installed for this work.

Newman Mfg. Co., 719 Sycamore St., Cincinnati, Ohio, and 68 W. Washington St., Chicago, Ill., has added another floor, 40 by 175 feet, to its Cincinnati plant, which now comprises six stories. The company manufactures machine-tool attachments, adjustable electric light brackets, brass and bronze work, signs, etc. S. J. Newman of the company states that the business is expanding rapidly and that the prospects for 1917 are excellent.

Hannifin Mfg. Co., 621 Kolmar Ave., Chicago, Ill., maker of pneumatic chucks, pneumatic countershafts, air-operated vises, self-opening dies, etc., has just completed a large addition to its plant that will increase the floor space 8000 square feet. The company has doubled its equipment and will be able to double the output. A two-story office building has been erected and the shop has been provided with modern wash-rooms and shower baths for the employes.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., is planning the erection of a new plant in Essington, near Philadelphia, that will cost approximately $6,000,000. The new plant is being built outside the Pittsburg district for the reason that expansion in East Pittsburg is no longer possible on account of the limited space available. The company has acquired a tract in Essington of about 500 acres fronting on the Delaware River. About 100 acres will be utilized for the plant in the beginning.

Bosch Magneto Co., Springfield, Mass., and Plainfield, N. J., has reorganized its purchasing department. The purchasing for both factories is now done in Springfield. The purchases are classified as product—all materials and parts entering into product— and non-product—including equipment and supplies. The purchase of product material will be in charge of S. T. Plimpton, and of non-product, of P. G. Puffer. The purchasing agents will be assisted by John Pauly and C. E. Spalding, respectively.

Champion Tool Works Co., 2422 Spring Grove Ave., Cincinnati, Ohio, manufacturer of "Champion" lathes, has broken ground for a new plant which will be located at Winton Place, Cincinnati. The building, which will be 150 by 300 feet and afford 45,000 square feet floor space, will be equipped with the best facilities for manufacturing machine tools. The company expects to increase its line, making several larger sizes of lathes, and with these added facilities it will be able to make prompt deliveries.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa., announces the opening of two branch sales offices—one for the eastern portion of the country at 1974 Broadway, New York City, and the other for the central section, at 1036 Guardian Bldg., Cleveland, Ohio. H. E. Brunner is in charge of the New York office, and is assisted by H. A. Fonda. The Cleveland office is under the direction of R. E. Clingan, assisted by Walter Rippien and M. S. McNay. These offices were opened in order to give better ball bearing service to the trade than has heretofore been afforded.

Ford Motor Co., Detroit, Mich., has made plans for the construction of the first units of a mammoth plant on an eighty-acre tract near Newark, N. J., between the Passaic and Hackensack Rivers. Plans have been made for the immediate erection of a plant costing between $1,000,000 and $2,000,000, and the lay-out is so arranged as to permit expansion indefinitely. It is the intention to ultimately invest about $10,000,000 and to employ about 10,000 men. The annual capacity will be about three hundred to four hundred cars a day. The Detroit factory is now making 3000 cars a day, and the Canadian factory about half as many, yet the company is behind in its orders.

Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., is making extensive additions to its plant. A bay, 45 feet wide by 210 feet long, will be added to the east side of the structural shop, to be used as a punching and shearing shop, and a bay of the same dimensions will be added to the west side to accommodate the wash-rooms, smith shop, tool storage and machine shop. These extensions will be of brick, steel and glass set in steel sash, and will have sawtooth roofs. The additions to the machine shop will consist of an extension of the erecting and machine shop bays of about 200 feet and the construction of a new bay 85 feet wide that will extend along the entire length of the present shop and extension, to be used as a store-room. The power-room will also be enlarged. Part of the present boiler-room will be converted into a tool forging and hardening plant, while the space now used for the drafting-room and stores will be added to the tool-room. Considerable new equipment and machinery will be installed. A large brick building, located within a block of the shops, is being remodeled for an administration building.

Tool-Room Systems[1]

by

Franklin D Jones[2]

This article is a review of the different systems adopted in many well organized machine-building plants of various classes and sizes to insure proper care and promote delivery of tools, and to prevent loss of productive time resulting from misplaced tools or poor equipment. The article deals with the arrangement of the tool supply rooms, different types of tool storage fixtures, classes of tools that should be cared for systematically, checking systems or methods of accounting for tools when in use, general practice in regard to grinding turning and planing tools to standard shapes, and other essential features.

ONE of the problems connected with the management of machine shops is the care of the numerous small tools used on machine tools and in assembling departments. As the "business end" of a machine tool is the cutting end, it is important to use tools that cut effectively and to keep the machine on the job; and when the parts produced in these machines are being assembled it pays to use reamers that ream, wrenches that are right as to size and fit, and good tool equipment in every department. These are the principal reasons why modern machine-building plants have tool supply rooms and systematic methods of caring for the many different kinds of tools used in machine shops. A store-room for tools of certain classes is found in almost every machine shop, but there is considerable variation in regard to the types of tools that are stored, the cooperation between the tool supply and manufacturing departments and the extent to which systematic methods are applied to insure the prompt delivery of tools in good condition. For instance, the tool supply room may be merely a place for storing small or auxiliary tool equipment when not in use, or it may be so managed that such tools are not only stored but maintained in good condition and delivered to the different manufacturing departments in such a prompt and systematic manner as to add to the efficiency of the entire plant.

Location and Plan of Tool Supply Room

When a machine shop has only one room or department where tools are stored, this should ordinarily be located in a central position relative to that part of the shop requiring the largest number of tools, provided the general construction of the shop will permit. If the plant is large enough to be divided into separate departments, the usual method is to have a tool crib in each one; frequently the department supply rooms are auxiliaries of the main supply room, which may or may not be a tool-room as well as a place for tool storage. Some shop managers prefer, even for large plants, one main tool storage department from which all tools are obtained. This method, however, has only been adopted to a limited extent and chiefly where the nature of the work is such that many tools are not used exclusively on any one line of work, but are required in various departments. In connection with this plan, as applied to a large shop, the tools should be delivered to the workmen, in which case the accessibility of the tool supply room is not so important as when each employe must obtain the tools required.

The storage of tools is generally under the supervision of the tool-room foremen in plants having toolmaking departments, and where there is a single tool supply room, this is often a department of the tool-room, but it should be separated completely from it by a grating or partition, and should be under lock and key. One arrangement which has proved satisfactory for comparatively small shops is to have the tool supply room in such a location that one window or opening for the delivery or return of tools is connected with the tool-room and the other window with the machine shop. The tool-grinding department of a medium- or small-sized shop is usually adjacent to the store-room or is practically a part of it. This department usually contains a drill grinder, a tool and cutter grinder for sharpening reamers, milling cutters, etc., and a universal tool-grinding machine for sharpening forged turning and planing tools, provided such tools are kept in the store-room. In the larger plants where the different departments have separate tool supply rooms, the grinding of such tools as reamers, milling cutters, taps, etc., is generally done in the tool-room.

In locating the bins, drawers, or racks for tools or supplies, it is important to place the sections which are to contain the tools in greatest demand nearest the delivery and receiving windows. The extent to which different classes of tools are used varies, of course, in different shops and depends to some extent upon the nature of the manufacturing operations. In

[1] For previous articles on tool-room systems published in MACHINERY, see "Tool System of Cadillac Motor Car Co." in the June and October, 1916, numbers.

[2] Associate Editor of MACHINERY.

general, such tools as drills, taps, reamers, gages, jigs, milling cutters and files are used frequently. If blueprints are kept in the store-room, these should also be conveniently located with reference to the delivery window. Attention to this matter of tool location prevents needless delay in delivering tools to the workmen.

Classes of Tools and Supplies Kept in Store-rooms

Tool supply rooms are generally intended for tools such as drills, reamers, taps, milling cutters, form tools for screw machines, box-tools for screw machines and turret lathes, standard and special gages, jigs and fixtures (except those which are heavy and cumbersome), punches and dies, new files, wrenches, lathe dogs, soft hammers, sledges, pneumatic hammers, and many other small tools of the portable class. In addition, there may be a variety of general supplies, such as standard bolts, nuts and washers, taper dowel pins, cotter-pins, brass, copper, iron or steel wire, and so on. In the larger plants supplies of the general classes mentioned may be kept in a separate department, and the tool supply room be used exclusively for auxiliary tool equipment, such as is required either in connection with machine tool operation or in the erecting department. Another method of handling supplies which is quite prevalent is to keep the principal stock in a supply room and a small stock in the tool cribs, the material which is stored with the tools being of the class that is needed continually by the manufacturing departments.

Fig. 1. Drill and Reamer Cabinets

The variety of tools in any supply room naturally depends somewhat upon the class of work done in the shop or department with which it is connected. For instance, in some machine shops milling machines are used extensively, and consequently a large stock of milling cutters is required; other shops use a relatively small number of milling cutters, but a great many taps, reamers and drills, and there are many other similar variations.

Storage of Tools on Basis of Usefulness as Well as Value—When deciding what tools shall be placed in a tool supply room, several factors may be considered. In some shops the store-room is used only for tools which are valuable and which for the most part are products of the toolmaker. Such tools are cared for simply because they are valuable and perhaps easily deranged by careless handling. According to the modern idea of tool-room systems, however, tools are kept in a special store-room not merely because they are expensive to produce, but because of their usefulness and to insure prompt delivery of adequate tool equipment when needed, as well as to eliminate loss of productive time resulting from misplaced tools or fixtures. The rough bolts and clamps used on planers and other machines for holding castings and forgings to the machine table have little value so far as first cost is concerned; but if such equipment is not available when needed, or is in poor condition, the time of setting up a machine may be so delayed as to greatly increase the machining cost, and such delay may affect the work of other departments. In order to avoid difficulties of this kind, it is the practice in the more progressive plants to include in the stock of the tool store-room whatever small tools are essential to machining or assembling operations, even though they may not be expensive or of delicate construction. When the tool store-room is based on this plan, it is closely related to the various manufacturing processes and tends to increase the rate of production and general efficiency of the plant.

Storage of Large Jigs or Fixtures—While it is generally considered advisable to keep all small tool equipment in a special department, many shops, especially those in which heavy machinery is built, have jigs, fixtures or other tools which are too heavy and cumbersome to be moved to and from the tool supply room each time they are used; moreover, such large tools are often used exclusively in one department, and there is an advantage in having them near the machine to which they belong. Heavy tools that cannot be handled easily are often kept in a definite place on the shop floor, especially if they are used frequently or exclusively in one department; in other plants, auxiliary supply rooms are provided. It is a good plan to have all equipment of this kind, regardless of where it is stored when not in use, under the supervision of the tool supply department. While heavy jigs, fixtures, etc., may not be deranged as easily as smaller and more delicate tools, the fact remains that if no one is responsible for their upkeep, and systematic inspection is not provided for, minor defects often accumulate until, in some cases, the tool is in poor condition.

Storage of Clamps, Bolts and Packing Blocks—The clamps and bolts used for holding castings or forgings on the work-tables of machine tools, when special jigs or fixtures are not used, are kept at the different machines in many shops and often are moved from one part of the shop to another as they may be needed by different workmen. Ordinarily when such equipment is not cared for systematically, it is the direct cause of unnecessary delay in setting up machines. Bolts of the right length are often difficult to find and the threads become battered so that nuts must be run on or off with a wrench. Sometimes it will be necessary for a machine operator to re-cut a bolt with a hand die, and meanwhile the machine is idle.

Equipment of this kind should be kept in the tool supply room and be cared for the same as cutting tools, gages, etc. Where this plan is followed it is common practice to include, in addition to a stock of clamps and bolts of various sizes and lengths, packing blocks for the clamps. In some plants, a standard wrench is sent out with each set of bolts, clamps and blocks, so that the time for setting up a machine is reduced as far as possible. When bolts are returned to the supply room, each one should be examined to see that the nuts can be turned freely by hand.

Storage of Blueprints—Tool store-rooms are not only used for equipment of the general classes mentioned, but in many cases for keeping blueprints as well, especially in plants where duplicate machines are being built constantly. When blueprints are kept in this way they are usually given out in exchange for a check the same as a tool. A duplicate set of prints may be filed in the office of the machine shop foreman or superintendent for reference purposes only. These office prints should preferably be bound or filed together in sets, so that the foreman always has a complete set for his own use, instead of being obliged to refer to those which are scattered about the shop.

One method of handling blueprints which has proved satisfactory is to mount them on thin steel plates, heavy cardboard or wood. A thin material is preferable, owing to the relatively small space required for storage. Blueprints mounted in this way are protected while in the shop and they can easily be filed for future use.

In a great many machine shops blueprints are destroyed

when they are no longer needed in the shop for a certain job. The reason for destroying them instead of filing them away for future use is that in many cases the blueprints are either soiled or torn to such an extent that it is preferable to make new ones when they are needed again. Naturally the extent to which blueprints are soiled varies with the length of time they are kept in the shop, and may depend considerably upon the kind of work done, so that the practice of destroying them might not always be justified.

Storage Fixtures for Tools

The fixtures, such as racks, shelves, bins and drawers in which various kinds of tools are stored, should, so far as possible, be compactly arranged, in order to economize in space. The light should also be distributed evenly so that there are no dark shelves or bins, and it is important to arrange each fixture in such a way that the tools may be removed without difficulty. Each tool or tool set should have a definite place in the tool cabinet and provision be made for identifying and locating different classes of tools. A common method of marking different sections of a tool supply room is by means of letters and numbers, the letters indicating main sections and the numbers showing the location of racks, bins, drawers or other storage places in each section.

General Arrangement of Storage Fixtures—When designing storage fixtures of any kind, it is advisable not to conceal the tools any more than is necessary, although drawers or trays are often considered preferable for small drills, taps, reamers and other tools that might be lost or misplaced if kept in open bins or shelves. Shelves or box-shaped enclosures should be large enough to permit the hand to be inserted without interference. Trays or open shelves for small tools should have shallow or low partition strips for separating different sizes of tools, and if such receptacles slope toward the front the tools may be seen better and removed more easily. Edged tools, such as reamers and milling cutters, should be separated so that they will not strike against each other. Reamers, taps, etc., are sometimes held vertically by inserting the shanks in holes made in a special rack; such tools are also kept in trays or drawers having low partition strips to prevent direct contact between different tools. Fig. 1 shows reamer and drill cabinets in a tool supply room of the Cadillac Motor Car Co. The reamers are placed in separate pockets formed in crosswise strips so that they do not roll against each other and thus injure the cutting edges (see the three drawers to the left which have been removed).

The height of tool racks and cabinets usually varies from five or six feet to the height of the tool supply room ceiling. Low racks (see Figs. 2 and 3) are usually found in shops having plenty of space. A ladder supported by a track and rollers is convenient for high racks such as are found in many city shops, located where land and space have a relatively high value. (See Fig. 23.) Wood is generally used for tool racks and cabinets in tool supply rooms, although many of the new plants have steel shelving.

Unit System of Construction—Most tool store-rooms have fixtures which are of permanent construction. It is desirable, however, to so construct the storage equipment that it can be rearranged and expanded to accommodate a larger stock of tools, if this should be necessary on account of the growth of a plant. This unit system of construction, as applied to the tool supply room of the Tabor Mfg. Co., Philadelphia, Pa., is illustrated in Fig. 4. The tool cabinets consist of a main rack having square sections which may be sub-divided for storing different types of tools by means of boxes, trays and drawers of standard size. The sections or compartments of the main rack are 24⅝ inches square and 17 inches deep. These racks are made of wood and are rigidly constructed, as they sustain heavy loads when filled with tools. The boxes which are inserted in these square compartments for holding certain classes of tools are made in fifteen standard sizes, as given in Table I.

Fig. 4 shows some of the combinations that are possible with this construction; thus, section *A* is fitted with sixteen square sections or boxes, section *B* has eight rectangular boxes, section *C* four square boxes, and so on. The compartments are fitted with whatever combination of boxes is best adapted to the size and number of tools they are to contain. The tool rack shown in Fig. 5 also illustrates the flexibility of the unit system of construction. When drawers can be used to better advantage than open boxes for the storage of small tools, cutters, etc., these are inserted in double vertical rows as shown.

Racks for Clamping Bolts and Packing Blocks—Fig. 6 shows the form of storage racks used by the Tabor Mfg. Co. for clamping bolts such as are often required for holding castings or forgings on the work-tables of machine tools. The bolts are suspended from T-slots formed in the standard storage boxes used at this plant. The symbol for each size of bolt and the hooks for the workmen's checks are placed adjacent to the various compartments. The method of keeping packing blocks is shown in Fig. 7. Standardizing equipment of this kind is of especial importance in shops doing general work for which special fixtures have not been constructed.

Cabinets and Racks for Milling Cutters—Many tool supply rooms have cabinets of the general type shown near the delivery window in Fig. 8 for storing milling cutters. These particular cabinets are of octagonal form and each of the eight sides is covered with cutters suspended on pegs. As the cabinet can be revolved about a vertical axis, any side may be reached easily. The swinging or folding door type of cutter rack illustrated in Fig. 10 is now used quite extensively. These swinging doors are hinged to a vertical shaft and each door provides two sides for the storage of cutters. Another compact design is similar in construction to the familiar sliding barn door. Each door of the cabinet has wheels above and below it which engage horizontal tracks for guiding the doors as they are rolled in or out. There are several parallel doors arranged in a group with a space of about twelve inches between them. The cutters are suspended upon pegs or hooks. Fig. 9 shows milling cutters stored on shelving. Different types are grouped together, and these groups are plainly

Fig. 2. Collet Rack

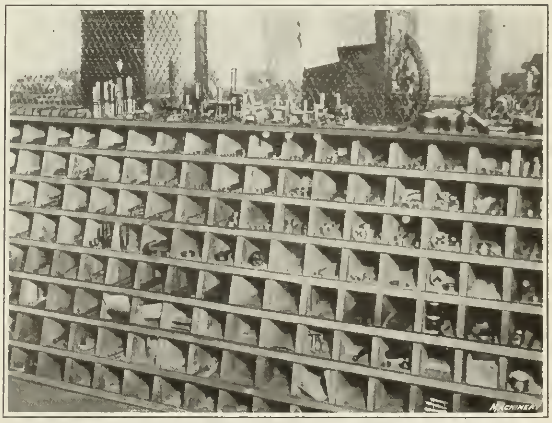


Fig. 3. Tool Rack of Open-bin Type

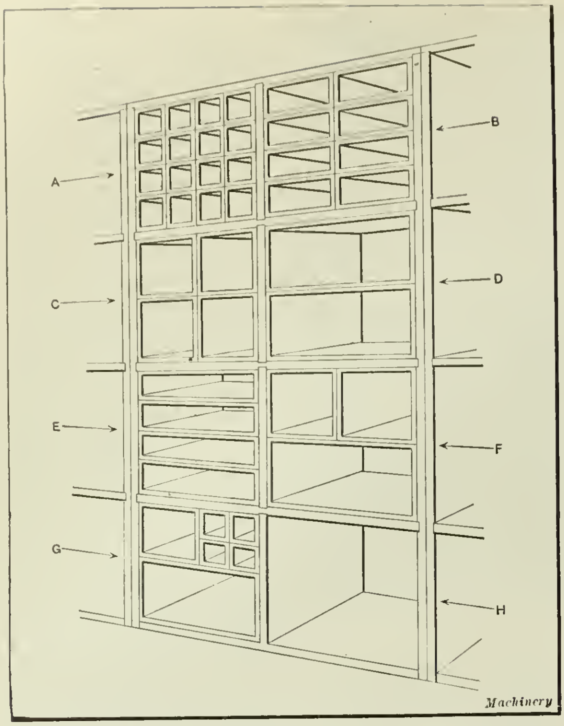


Fig. 4. Diagram illustrating Unit System of Construction for Tool Racks

marked. Instead of placing the cutters loosely on the shelves, they are provided with removable holders consisting of base blocks and vertical pegs which pass through the cutter-arbor holes.

Racks for Taps and Dies—The rack for taps shown in Fig. 11 is so arranged that the taps are held in position by their shanks, which are inserted in holes of suitable size. This form of rack (which is used by the Cleveland Automatic Machine Co.) prevents taps from being nicked or otherwise injured by striking against one another. Each tap has a label giving its size, and there is also a hook for receiving the workman's check when the tap is in use. A rack for spring screw-threading dies is shown at the left of Fig. 11. The hollow shanks of the dies fit over pegs on the rack which hold them in position.

Racks for Snap Gages—A good type of rack for snap gages is shown in Fig. 13 (see upper part of cabinet). Metal partitions are used to separate different gages, the height of these partitions and the space between them being varied in accordance with different gage sizes. These partitions extend across the shelf at the bottom, but curve backward toward the top, so that the upper ends of the gages project far enough to be easily gripped for removing them from the cabinet. This form of rack is found in the tool supply rooms of the Cadillac Motor Car Co. Incidentally, this illustration shows how steel partitions can be used to form compact bins or compartments of the general type shown just below the gage rack. The consecutive numbers of the bins are stamped on circular checks or tags suspended from rings so that they are free to swing and do not interfere with the insertion or removal of the tools. Fig. 11 shows (at the right of the tap rack) a form of snap gage rack used by the Cleveland Automatic Machine Co. The gages are held in place by boards having slots on the edges into which the gage jaws are inserted.

Rack for Storing Blueprints—When blueprints are kept in the tool store-room they are often filed in drawers, but this is an inconvenient and troublesome method and requires more room than is necessary. When the drawers are filled with blueprints it is difficult to prevent them from curling up and catching when the drawer is pulled out, and occasionally a blueprint will slide out at the rear end. In a shop where considerable trouble had been experienced with blueprints stored in shallow drawers, the rack illustrated in Fig. 12 was installed and proved very satisfactory. This rack is made of 2- by 4-inch timbers to which are secured a large number of sheet steel strips upon which the blueprints are suspended as indicated by the illustration. The lengths of these steel strips are varied in accordance with the size of the blueprints, the largest prints being at the bottom of the rack and the smallest ones at the top. The numbers of the prints were written on "stickers" and pasted on the steel strips or arms.

Tool Checking Systems

In every tool store-room it is essential to have some systematic method of determining what tools are in use and where they are located in the shop, to prevent loss of tools and to enable any tool to be found readily if necessary. The method which has been adopted almost universally is to use brass checks which are numbered to correspond with numbers given to different workmen. These checks may be placed in the store-room tool cabinet where the tool belongs, or they may be filed on a board in the store-room, so that the number of tools in the possession of any particular workman may readily be determined. There are various modifications of this checking system which are intended either to simplify

TABLE I. DIMENSIONS OF STANDARD BOXES AND TRAYS[1]

Number of Box	Outside Dimensions, Inches	Number of Box	Outside Dimensions, Inches
1	24 by 24	9	12 by 4
2	24 by 12	10	8 by 8
3	24 by 8	11	8 by 6
4	24 by 6	12	8 by 4
5	24 by 4	13	6 by 6
6	12 by 12	14	6 by 4
7	12 by 8	15	4 by 4
8	12 by 6	..	....

Machinery

[1] The length or depth is 17 inches or less in all cases.

Fig. 5. Rack illustrating Flexibility of Unit Construction

the system, or to make it a more effective means of accounting for tools and of preventing mistakes or fraudulent practices.

Single Check System—The single check system, as commonly applied to tool-rooms, is so arranged that each workman has a certain number of checks which he receives when first employed. These checks, as previously mentioned, are stamped with the employe's number, and whenever he obtains a tool from the store-room, a check must be given to the tool-room attendants as a receipt. This check, according to the usual method, is placed on a hook located where the tool belongs in the bin, rack or drawer of the cabinet. When the tool is returned to the tool-room the check is given back to the workman. If the tool should be sent from the tool-room to the grinding department or forge shop, a special tool-room check is either put in its place or a written record is kept; consequently, the location of every tool not in the store-room is shown either by the number of the workman's check or by a tool-room check or a separate record.

Use of Checks and Tool Tags—Instead of placing the employe's checks in the tool racks where the tools belong when not in use, they are placed on a check board in some tool supply rooms. One system which has proved satisfactory in a large plant where there are many tool supply rooms for the different departments is as follows: The bins or other storage places for all tools are numbered consecutively and for each special tool there is a card in the tool supply room and also a tool tag. These tags and the cards are used in connection with the delivery of the tools to the employes. The cards show the names and numbers of the parts on which the tools are used, the names and numbers of the tools, and the bin numbers for locating the tools in the supply room; these cards are filed numerically according to the part numbers. The tool tag for each special tool is marked with the name of the tool and its number. There is a check board for special tools and another for commercial or standard tools. The tool tags are filed on the check board for special tools. Whenever an employe receives a special tool, his check is placed on a hook of the check board over a tool tag marked to correspond to the number of the tool. Numbers stamped on the different

Fig. 6. Rack for Clamping Bolts of Various Lengths

Fig. 7. Packing Blocks kept in Tool Supply Room

tools may be used to identify them or determine their location in the supply room by referring to the card file. The commercial tool check boards are arranged in alphabetical order according to the names of commercial tools, using the noun in each case; different hooks may represent different sizes, as in the case of drills.

All Checks Kept in Tool Supply Room—The most common objection to giving checks to workmen is that they are sometimes lost or borrowed. A lost check may cause considerable trouble, especially if it is found by some other workman who uses it in a fraudulent way. Deception might be difficult in a small shop, but in a large plant the store-room attendants might not know whether the proper check was received or not. In order to prevent checks from being misplaced or lost, it is the practice in many plants to charge a certain amount for each check that is missing when the workman leaves the employ of the company.

In order to avoid the difficulties resulting from losing them, checks are not given to the workmen in many shops, but are permanently kept in the tool store-room. Each man is allowed a certain number of checks, which are usually kept on a check board in the store-room. This board has a hook or slot for each man who may require tools, and there is some kind of record or card file showing the names of the workmen corresponding to each check number. The names, in many cases, are on the check board. When a man calls for a tool, one of his checks is removed from the board and is put in the place occupied by the tool, for which a hook is usually provided. When the tool is returned by the workman, the check is removed from the tool cabinet and is replaced on the tool-room board. While this system prevents the loss of checks by workmen, it is not faultless, as carelessness on the part of the tool-room attendant will sometimes result in misplaced checks, or failure to return checks to the board when the tools are returned by the workmen.

There is another method of keeping all checks in the tool-room which differs from the one just described in that the checks are placed on the check board when the tools are delivered instead of being hung in the vacant places of the tool cabinet. A board large enough to receive tags bearing the names of all the men requiring tools is placed in a con-

Fig. 8. View in Tool Supply Room showing Revolvable Racks for Milling Cutters

Fig. 9. (Upper Section) Method of storing Milling Cutters on Shelves by Means of Special Holders

venient location and opposite each name there is a hook for receiving checks whenever tools are delivered. The tools are all numbered and the checks are numbered to correspond. When a tool is delivered, the check which bears its number and hangs near it is removed and placed on the board opposite the name of the man to whom the tool was delivered. When this tool is returned the check is removed from the board and hung in its place in the tool cabinet.

Checks having Different Exchange Values—When a number of tools are required by one workman, special checks are sometimes used, one arrangement being to have the workman's number on one side and numerals on the other side indicating the number of tools received. For instance, the reverse side of checks may be numbered 2, 3, 4, 5, etc. If the workman's number is 50 and he should require four tools, the check given to the tool-room attendant would have the number 50 on one side and 4 on the reverse side, the latter number showing that he has four tools of the kind belonging in that particular section of the tool cabinet where the check is placed. These special checks should be of a different size and shape from those ordinarily used so that the attention of the tool-room attendant will be directed to the numeral on the reverse side of the check when the tools are returned. The exchange value of the check may depend entirely upon the shape instead of numbers.

Double Check System—When a single check is exchanged for a tool and is placed where the tool belongs in the tool cabinet, it might be impossible for the man in the tool supply room to determine how many tools a workman has in his possession without examining the entire stock of tools, providing there were no separate record. The double check system shows the number of tools received by each workman and for that reason is preferred in some plants. Double check systems vary somewhat as to details, but the methods here described give the general principles.

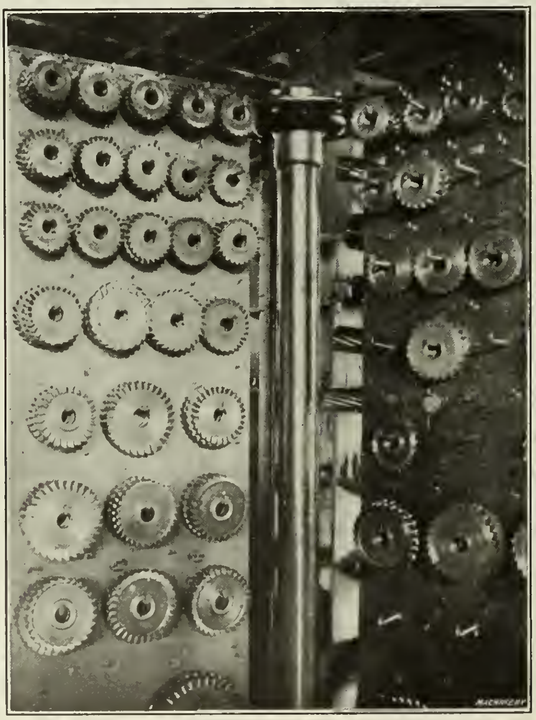


Fig. 10. Swinging-leaf Type of Milling Cutter Rack

With one system there is a board in the tool store-room which has two check hooks for each employe and near each pair of hooks there is a label giving the name of the employe and the corresponding check number. When a man is engaged by the concern he is given a certain number of round checks, and a corresponding number of square checks are hung on one of the hooks opposite his name on the store-room board. Whenever a workman receives a tool, he gives a round check in exchange for it and this check is placed on the hook adjacent to the man's name and number. At the same time, a square check from the opposite hook is removed and inserted in that part of the tool cabinet from which the tool was taken. When this tool is returned, the square check is replaced on the board and a round check on the other hook is given back to the workman. With this system the number of round checks hanging opposite each name shows how many tools that particular man has in his possession, without searching through the tool cabinet. The square checks, which are also numbered, show who received the tools that are not in the tool racks.

Another double check system, which is a modification of the one just described, differs from it in regard to the method of filing the checks. Each employe receives a certain number of checks bearing his number, and there is a check for each tool in the store-room which hangs near the tool when the latter is not in use. In the store-room there is a board with each employe's number on it and a single hook adjacent to each number. Upon the receipt of a tool from the store-room, the workman gives a check which is placed on the hook in the tool cabinet where that particular tool belongs. At the same time, the tool check from the cabinet is hung on the hook adjacent to the employe's number on the tool-room board. When the tool is returned the exchange of checks is made in the reverse order. If a tool that is out in the shop is wanted by some other workman, the man in the store-room can readily

Fig. 11. Racks for Taps and Snap Gages

Fig. 12. Rack for Storage of Blueprints

tell who received it and the tool-room board also shows how many tools are in the possession of each employe, which information might be of considerable importance in case a man were leaving the employ of the company. A double check system is sometimes preferred in large shops, especially where men are leaving constantly.

An Exchange of Checks—There is another modification of the double check system which is based on an exchange of tool checks and employe's checks. Each workman is provided with a certain number of checks, the same as in the system just described. Near each tool in the store-room, checks of special shape are kept on suitable hooks. The name and size of the tool is stamped on each of these tool checks. When a workman requires a tool he exchanges his check for the tool, which is also accompanied by the tool check. This system is intended to prevent mistakes on the part of the store-room attendant, such as placing the wrong check on the hook of some missing tool and holding the wrong man responsible for it, because the check accompanying each tool is a receipt for the man who obtains the tool.

Double Check System with All Checks in Tool-room—The double check system, as well as one requiring a single set of checks, may be so arranged that no checks are allowed in the possession of the employes who are thereby prevented from losing them. One method requires the use of two check boards, each having a number of hooks corresponding to the number of employes using tools. Each hook on what is known as the "in-board," contains the same number of checks, the number usually being ten or fifteen. The hooks on the "out-board" are intended to receive checks representing the number of tools delivered. As each man is engaged by the company, he is given an identification number which establishes his identity in the tool supply room. Every tool in this room is identified by a small check which is kept with the tool when the latter is not in use. If, for example, employe No. 50 is given a reamer, a check from hook No. 50 on the "in-board" is transferred to hook No. 50 on the "out-board," and on the same hook on the "out-board" is placed the check for identifying the tool. With this system, the man in the tool-room can readily determine how many tools are out, the type of tool and to whom they were delivered. When a man leaves the employ of the company, a receipt from the tool-room showing that all tools have been returned must be presented to the time-keeper before the man is paid.

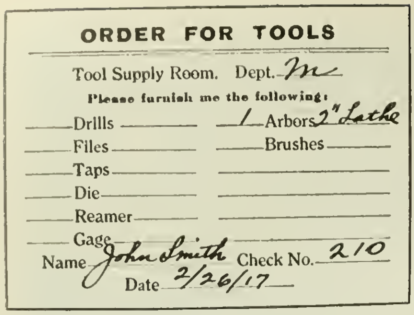
Fig. 13. (Upper Section) Rack for Snap Gages. (Lower Section) Bins formed of Steel Partitions

Checks which show how Long Tools have been Out—In order to determine the length of time tools are kept by workmen, special checks may be used in conjunction with the regular checking system. These checks, which are of special form and kept in the store-room, are numbered from 1 to 31 to correspond with the days of the month. When an employe receives a high-grade or expensive tool, such as a standard gage, his check is filed where the tool belongs, and a special check showing the day of the month on which the tool was delivered is placed in the tool cabinet. If the tool has not been returned at the end of the month, the workman is notified, and if he still needs the tool it must be taken back to the store-room before he uses it again; another "date check" is then placed in the tool cabinet, thus indicating that this particular tool was again delivered on the first of the month.

Written Receipts for Tools

Written receipts are preferred to metal checks in some shops. One method is to place printed slips or forms in suitable boxes which are conveniently located about the shop. When a tool is required, the workman writes the name of the tool on the slip, his check number, the date and his signature. When a tool has been received, the slip is given to the store-room attendant. One method is to file these slips in numerical order according to check numbers, back of guide cards showing the various classes of tools. When the tool is returned the slip is removed from the file and given to the workman who destroys it. A sample order blank for tools used in connection with a system of this kind is illustrated in Fig. 14. The names of tools most commonly used are printed on the order and the names of other tools are written on the blank lines provided.

In some plants the receipt is not given back to the workman when the tools are returned, but is transferred


ORDER FOR TOOLS

Tool Supply Room. Dept. M

Please furnish me the following:

Drills	1 Arbors 2" Lathe
Files	Brushes
Taps	
Die	
Reamer	
Gage	

Name John Smith Check No. 210

Date 2/26/17

Fig. 14. Written Order for Tools which is used instead of Brass Checks

from one file to another and is kept as a permanent record. In case the workman receives supplies which are not returnable, such as pipe fittings, etc., a different order blank is used and instead of transferring it to a permanent file, as is done with the receipts for returnable tools the order or requisition is sent to the accounting department so that the supplies can be charged against the particular department which receives them.

Delivering Tools to Workmen

In most machine shops tools are obtained from the supply room by the workmen who use them, but tool-room boys are sometimes used for delivering the tools and returning them to the supply room. In connection with this system an annunciator or other electrical signaling device should be used. An annunciator is placed in the tool supply room and connected by suitable wiring with push-buttons located throughout the shop. When an employe wants a tool he presses the nearest button and may hang his tool check on a hook near this push-button. The annunciator shows which one of the buttons was pressed and a tool-room boy goes to that part of the shop and finds out what tool is required. If the tool is of special design it is the general practice for the workmen to designate it by a number or symbol of some kind which is found either on the blueprint or on a list of operations accompanying the blueprint. This number or symbol enables the man in the tool supply room to locate the tool or set of tools, as the case may be, either directly or by referring to a card file or other record.

Delivery of Tools in Sets

In shops where machines and parts are manufactured in duplicate it is economical to provide some systematic method of issuing tools in sets which include all the tools required for a series of operations on any part. In some cases special tools are kept in sets permanently, but usually such sets are made up of both standard and special equipment and the standard or commercial tools are used singly as well as in sets. For instance, a set of tools may consist of a drill jig, several drills and reamers and one or more taps. In this case the jig and possibly a reamer might be special and the other tools of standard or commercial forms and sizes. When a great many duplicate parts are produced, if sets of tools are kept together permanently, obviously a large stock will be necessary. To reduce the stock of tools, the standard types are often used either separately or in conjunction with the different special tools to form sets which may be needed for manufacturing operations.

In connection with the delivery of tools in sets, it is essential to have records that will enable the man in the tool supply room to collect the tools quickly for any regular manufacturing operation. If the operations are on a new part or on a series of parts, the department which decides what tools are to be used should provide the tool supply room with a list which may be used as a guide in collecting that particular set of tools, provided they are not kept permanently in sets. The tools used for screw machine operations, such as box-tools, form cutters, etc., are often kept in sets with a record of the "set up" for future reference. In the plant of the Tabor Mfg. Co., the planning department, which decides the kind of tool equipment for each job, issues a list of tools which is sent to the tool supply room prior to the time that these tools will be required in the shop. With this system (which will be described in detail later) the set of tools is made up in advance so that no time is lost when the tools are actually needed in the shop.

Special Boxes for Sets of Tools—With the system of issuing tools in sets adopted in the plant of the Cadillac Motor Car Co., many sets of tools for different manufacturing operations are placed in boxes (see Fig. 18) which are delivered to the workmen in exchange for checks. If the special and commercial tools for operations on any part are of such a nature that the use of a box is practicable, this box is given a number and a list of its contents is placed on the inside of the cover. These box numbers are listed upon cards representing special tools which are arranged in files under the part numbers. Part numbers are given to every part of the automobile and are used, in conjunction with tool numbers, to identify different special tools. For instance, if the foreman of the drill press department wants to begin work on part No. 12,800, this number is given to the man who goes to the tool supply room after the tools for whatever operations are to be performed on this part. The attendant in the tool supply room refers to a card in the file of special tools which is marked with this part number and shows the number of the box containing the set of tools. These boxes are stored in numerical order and on racks built for the purpose (see Fig. 15) so that any box can be found readily. The tool list on the box lid shows what tools remain in the box and what tools belong in the regular tool racks. Ordinarily, the special tools are kept in the boxes while in storage and the commercial tools are distributed, although some commercial tools are also kept in the boxes permanently.

If it is not practicable to keep a set of tools in a box, a tool list is used which shows all the special and commercial tools required for any part number or operation number. These lists are made out in duplicate, one copy being for the tool supply room and the other for the department foreman. (See Fig. 19.) The tool lists which are on file in the tool supply room (arranged under the part numbers) are kept in linen envelopes, and when tools of any list are in use, the employe's check is placed in the envelope with the list. All the tools on a list may be covered by one check and all must be accounted for before this check is given back to the work-

Fig. 15. (Right-hand Section) Storage for Boxes in which Sets of Tools are delivered to Manufacturing Department

man. The tools handled in this way are asked for somewhat before they are actually needed, so that the tool supply room attendant will have time to collect the tools in a tray before they are called for.

Many of the tools (probably half) are not handled by either of the methods previously referred to. To illustrate, we will assume that a drill jig and a drill are required. The part number on which the jig is to be used would be given and the drill would be called for by simply giving the name and size.

Sets of Tools for Tapping Operations—The tools used for tapping operations are commonly kept in sets and are given in exchange for one check, the same as a single tool. A typical set of tools of this kind is illustrated in Fig. 17, which shows the form of "tap block" used by the Brown & Sharpe Mfg. Co. These tap blocks equipped with tools for tapping holes of all sizes are kept in the tool supply rooms. They contain a tap drill; a "size drill" for drilling a clearance hole; a set of three taps; a counterbore to enlarge the hole, if desired, from the tap size to the body size of a screw; a counterbore for the screw head; a gage showing to what depth the screw head counterbore should be sunk; and a tap wrench. If a workman desires to drill and tap holes of a certain size, he asks for a tap block corresponding to that size, which is delivered in exchange for one check.

Portable Cabinets for Sets of Tools—The portable cabinet or cupboard of the form shown in Fig. 16 is used by the Brown & Sharpe Mfg. Co. for delivering tools in sets. The particular cabinet shown in the illustration contains the jig for a 10-inch spiral head and the necessary cutting tools, such as drills, reamers, etc. This cabinet is mounted on casters so that it can easily be rolled along the shop floor to whatever machine is to do the work. The jig is kept in the bottom part of the cabinet and is on a platform that runs on a track, so that when the door is lowered, the jig can be pulled out easily, after which it is hoisted from the platform and placed on the table of the machine. The upper section of the cabinet, which is shown with the door open, contains all the drills, counterbores, reamers, etc., that are used in connection with the jig.

Storing Heavy Sets of Tools on Skids—Sets of tools for certain machining operations are kept together in boxes in the shops of the T. B. Wood's Sons Co., Chambersburg, Pa., and the larger and heavier sets are placed on skids when not in use so that an elevating-platform type of truck can be pushed under the tool box when it is to be moved. The boxes rest on a platform which has skids on each side that are high enough to permit rolling the truck beneath the platform. A view of the storage place for these tool boxes is shown in Fig. 20, which also shows a truck in position beneath one of the boxes. The lighter boxes are placed on shelves.

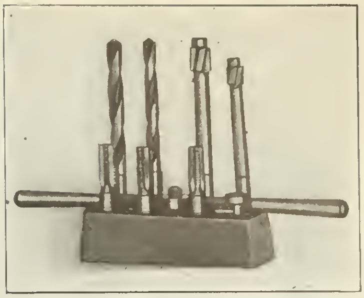


Fig. 17. Block containing Set of Tools for Drilling, Counterboring and Tapping

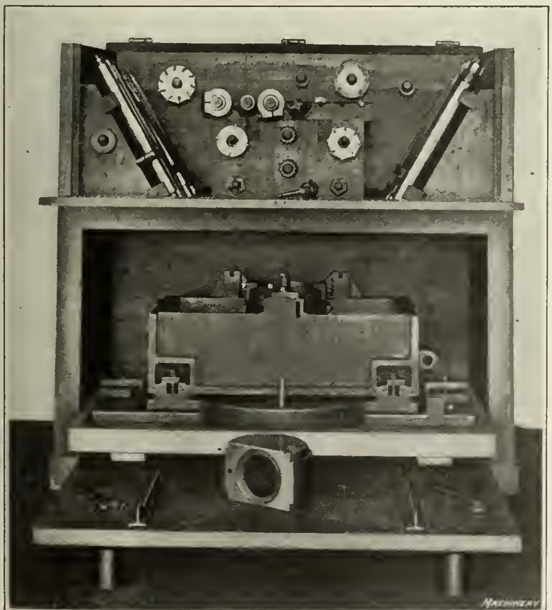


Fig. 16. Portable Cabinet containing Jig and the Necessary Cutting Tools

Tool Lists Stamped on Jigs and Fixtures—The record of the small tools used with jigs and fixtures, such as drills, reamers, milling cutters, etc., is generally on a blueprint or separate list of operations, for the guidance of the foremen or to enable the tools to be selected readily by the attendant in the supply room. At the Newark works of the Westinghouse Electric & Mfg. Co., all jigs or fixtures have stamped on them the sizes or names of whatever small tool equipment may be required and this practice has been adopted in various other plants. For instance, if a jig is used for drilling a number of different size holes, the diameter of the drill for each hole is either given directly or is indicated by a number or letter, in accordance with the different methods of indicating commercial twist drill sizes. The size of each drill is marked near the hole in the jig to which the drill belongs. If a jig is needed for drilling a certain part, the employe gives the item or part number and the tool number, which may be obtained from the blueprint. A card index file in the tool supply room shows where this particular jig is located. When the jig is obtained, drills of the different sizes stamped upon it are collected and any other tools, such as counterbores, reamers, etc., that may be included in the list. With this method, the jig or fixture itself serves as a permanent record of all the small tools required.

Storing Special Tools Separately instead of in Permanent Sets—The practice of keeping special tools permanently in sets for duplicate manufacturing operations, is not followed in some shops, especially when the work is diversified instead of being confined to the manufacture of a standardized product. At the works of the American Machine & Foundry Co., where a variety of work is done, the tools for different series of operations are stored separately in whatever part of the tool supply room each type of tool belongs. This method is followed regardless of whether the tool is special or a standard commercial type. For instance, a special reamer which may have been intended primarily for use with a certain jig is not kept with that jig, but with other reamers, because, even though the reamer is special, it may, in many cases, be used for other parts that are designed later; therefore, the special reamer, tap, or other tool, is not regarded as a special type in the sense that it is to be used exclusively for any one part. The prompt delivery of tools to each machine is insured by the following system: Each machine manufactured by the company is given a symbol and all the parts of this machine have numbers assigned to them. The foremen of the departments receive cards for the different parts which they are required to produce. These cards are marked with the machine symbol and the part number, and give a complete list of the tools needed for machining each part. To illustrate the method, assume that a drilling machine will soon be ready for drilling part No. 1726. Before the machine has finished the work on which it has been employed, the department foreman refers to the card file and removes the card bearing the part number 1726. This card, together with the blueprint for the job, which has the same symbol and part number on it, is taken to the tool supply room by one of the men who attends to the delivery of tools to the machine. All the tools listed on the card are then

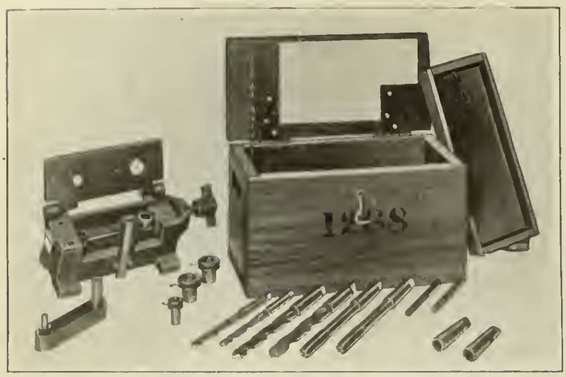


Fig. 18. Set of Tools and Box in which they are sent to Manufacturing Department

collected by the man in the supply room so that they are ready for use when needed and there is no delay at the machine. If a special tool like a drill jig is required, it can be located readily in the storage rack by the jig number on the card.

Tools that are to be used exclusively for one operation are marked with a tag. For instance, a reamer which must be kept to a certain diameter within close limits has a tag tied to it which indicates that it is not for general use.

Sets of Tools Kept by Workmen

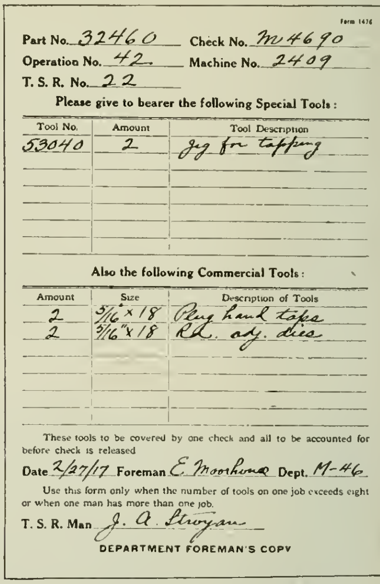
In every shop there are employes who use certain tools daily, but these tools are of the class usually furnished by the company. If they were kept in the tool supply room it would be necessary in many cases to obtain them every morning, which would mean loss of time. In many shops it is the practice to give out sets of tools of the class needed continually and these are kept by the employe permanently or until they need to be replaced. A record of the tools that are given out is kept in the tool supply room and when a man leaves the employ of a company the stock of tools he returns must agree with the record, which is modified from time to time to suit any changes which have been made during the period of employment. Such tools as cold chisels, files and file cards, scrapers, bench brushes, oil-cans, etc., are commonly issued in this way. The number of tool checks originally given to each employe is usually marked on his card and if for any reason this number should be either increased or decreased, the number on the card is changed accordingly. When a man leaves the employ of the company if the number of checks turned in to the supply room does not agree with the number on the record card, an investigation is made and the lost checks accounted for, if possible, before the employe is paid. If the missing checks are found in the tool racks, thus indicating that the employe still has tools in his possession, the cost of these tools, or some part of the cost, may be charged against him.

The method adopted by one manufacturer is to provide a printed list of tools which may be kept permanently by employes. Each foreman has a conductor's punch and the shape of the perforation serves to identify the foremen of different departments. Before tools are issued to a new employe, a punch mark must be made by the foreman in the space provided on the card opposite each tool which may be needed by that particular workman; if more than one of the tools is required, the number is marked on the card. This tool list is given to the tool-room attendant in exchange for the tools and is kept as a permanent record so that if the man should leave the employ of the company the card shows what tools should be returned to the tool supply room. Tools that are worn out, such as files, are exchanged for new ones, which does not interfere with the record on the card.

Identification of Special Tools

When an employe calls for a tool at a tool supply room, the tool may be identified either by name or in some other way, the practice varying in different shops. The necessity for a systematic method of identifying the tools needed for various operations depends to some extent upon the class of work manufactured and the extent to which special tool equipment is needed. Standard commercial tools such as reamers, drills, and taps, may readily be identified by the name and size, but the use of names for special tools would, in many instances, cause confusion and mistakes and result in a waste of time. For instance, if several special tools were used on some part, it might be difficult to give these tools names which would clearly distinguish one from the other, even though the men in the supply room were familiar with the various classes of tools.

Special tools may be identified either by a number given to the tool, by a number assigned to the part on which the tool is to be used, or by a part and tool number combined. If a part requires only one special tool, the part number and name of the tool might be used to identify the latter, but when several special tools are needed both part and tool numbers are preferable. In some cases the part number and the operation number are used. With the Taylor system of classification, all tools are given symbols composed of letters (with numbers added when necessary to indicate tool sizes) which indicate the type of tool and its location in the tool supply room (this system will be referred to under the heading "Tool Classification"). The number or symbols used to indicate the tool equipment may be on the blueprints or on special sheets or cards that contain a list of all the operations.



Form 1476

Part No. 32460 Check No. M4690

Operation No. 42 Machine No. 2409

T. S. R. No. 22

Please give to bearer the following Special Tools:

Tool No.	Amount	Tool Description
53040	2	Jig for tapping

Also the following Commercial Tools:

Amount	Size	Description of Tools
2	5/16 × 18	Plug hand taps
2	5/16" × 18	Rd. adj. dies

These tools to be covered by one check and all to be accounted for before check is released

Date 2/27/17 Foreman E. Moorhouse Dept. M-46

Use this form only when the number of tools on one job exceeds eight or when one man has more than one job.

T. S. R. Man J. A. Stroyan

DEPARTMENT FOREMAN'S COPY

Fig. 19. List showing what Special and Commercial Tools are required for Operations on a Given Part

Tool and Operation Lists Kept by Department Foremen—At the plant of the Intertype Corporation in Brooklyn, N. Y., the tools required for operations on different parts are shown by cards which are sent to the foremen. The card in each case gives the part number, the name of the part, the name and number of the assembled unit to which the smaller part belongs, the various operations in their successive order, and the tools required for these operations. These cards are kept permanently by the department foreman who refers to them in order to determine what tools are needed for different operations. For example, if part No. S-60 is to be machined, the foreman refers to this particular card in the file, finds out exactly what the different operations are and the name of the special tools, such as gages, arbors, fixtures, etc., which may be needed for the different operations. The employe who is to do the work is given the part number and the operation number, so that the tools may be located in the tool supply room. There is one of these tool supply rooms for each separate department. A card file in the tool supply room contains a card for each part that is machined in that particular department. These cards are filed consecutively by the part numbers, so that it is a simple matter to locate any of the tools by referring to this card file. For instance, if a workman calls for the tools for machining part No. U-47, operation 6, card No. U-47 is located in the file for operation 6, and on this card is found the name of the tool or tools and the shelf

number. All the tools, such as drill jigs, dies, special milling cutters, etc., have heavy cardboard tags attached to them. These tags, which are plainly visible, are marked with the part number, the name of the tool, the operation number, and also the equipment number which is used when taking an inventory of the tool stock. When the tool is located by referring to the shelf number shown on the card file, the tag is removed from the tool and, together with the employe's check, is left where the tool belongs. The check identifies the workman and the tag shows what tool is out and also exactly what operation it is used for.

Tool Symbols Based on Class of Work—The method of identifying tools such as jigs, fixtures, dies, etc., at the factory of the Ellis Adding-Typewriter Co., Newark, N. J., is by means of symbols on the tools and blueprints which are based on the general class or part of the mechanism for which the tools are used. The symbol, except in the case of special tools, is composed of a letter and number; the letter indicates the general section of the typewriter or adding mechanism to which the part belongs, and the number shows whether this part is a shaft, screw, collar, casting, drop-forging, punched part, spring, or a miscellaneous piece not belonging to the more common classes mentioned. The meaning of the symbols will be more apparent after referring to the following list of some of the letters used and the general classes of mechanism they represent: A, accumulator mechanism; B, base, frames, case, spring barrel, carriage ways; C, carriage, (non-shift parts); D, left-hand operating parts, governor; E, escapements; F, tabulating mechanism; G, tally roll and carriage return.

The different parts which the numbers represent are as follows: 0-9, shafts; 10-29, studs, pins, and screws; 30-44, collars (screw machine parts having holes); 45-49, castings; 50-74, punched parts; 75-79, drop-forgings; 80-89, springs; 90-99, miscellaneous parts not in above classification.

To illustrate the method of using these letters and numbers, assume that a symbol is required for a shaft in the accumulator mechanism. The symbol for this shaft would be composed of the letter A and some number between 0 and 9. If the part were a stud, pin, or screw for the accumulator mechanism, the letter A would be followed by some number between 10 and 29, as shown by the list previously referred to. This symbol or part number is marked both on the blueprint and on any special tool that may be required, such as a jig, fixture, or die.

The symbol or part number makes it possible to locate readily a special tool in the supply room. To illustrate, suppose a jig is required for part A8. This tool will be found in section A of the supply room, and as the tools are filed numerically in that section tool A8 can readily be located. If a tool is used for one of a series of operations, the particular operation, in each case, is shown by another number which is added to the symbol. For instance, if a die is marked E55-2, the letter E shows that it is for some part of the escapement, the number 55 indicates that it is a punched part,

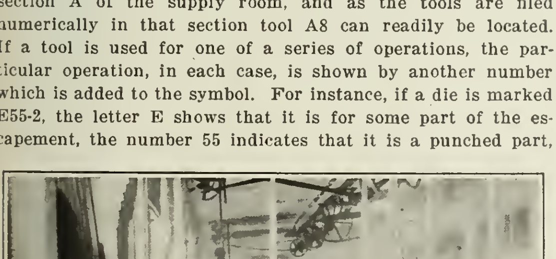


Fig. 20. Sets of Tools stored in Boxes with Heavier Boxes on Skidded Platforms to facilitate Removal with Elevating-platform Type of Truck

and the figure 2 following this symbol shows that the die is used for the second operation. Similarly, the die for the preceding operation would have 1 after the symbol, and if the third or fourth operation were required, the additional dies used would be marked 3 and 4, respectively, after their classification symbols.

As it has been necessary to manufacture many special parts which differ from the standard parts of the adding typewriter, a different method of marking the blueprints and tools is used for the special pieces. The part number consists of a whole number and a decimal. The whole number is used instead of a letter to avoid confusion or interference with the regular symbols, and the decimal has the same meaning as a whole number preceded by a letter. For instance, No. 25.7 represents some kind of special shaft, whereas 25.46 would represent a special casting, since 7 comes between 0 and 9 which, according to the preceding list, are numbers assigned to shafts, and 46 is between 45 and 49 which are the casting numbers.

Cabinets for Identifying Files—When files are obtained from the tool supply room, the usual method of identifying them is by the names given to different classes of files. This method of identification frequently results in confusion and delay owing to the fact that the correct names are not always given by the employes. In some cases the man receiving the file asked for but not the kind wanted, does not like to admit that he was in error and the result is that a file is frequently used when it is not exactly what is required for the job. In order to insure prompt delivery of files of the size, form, and grade wanted, sample boards or cabinets are used in some shops. A cabinet in the tool-room of the Taft-Peirce Mfg. Co., is shown in Fig. 21. Every size and shape of file in the tool supply room is represented in this cabinet and each file is numbered so that the workmen, after determining the size and style required, can order it by number instead of using a name, or a manufacturer's number in the case of toolmakers' files. On some sample boards the name of the file is given instead of the number.

Numbers for Identifying Lathe and Planer Tools—Forged tools, such as are used for turning and planing operations, are sometimes identified by numbers to insure the delivery of a tool of the required shape. The different forms of tools are shown on a chart and each form is given a number which may be used instead of a name when an employe obtains tools from the tool supply room. In one shop where such a tool chart is used, the names of the different tools corresponding to the numbers are also given.

Check Boards for Tool Supply Rooms

When employes' checks are placed on a board in the tool supply rooms as a record of tools in use, the board usually has hooks which are numbered consecutively to correspond with the numbers given to different workmen. The board or cabinet illustrated at *A*, Fig. 22, has vertical rows of inclined slots for receiving the checks. While this cabinet is more expensive than a plain board with hooks, the design is compact and a door is provided so that the cabinet may be locked if desired. There are ten vertical rows of slots which are numbered along the top, as the illustration shows. Each horizontal row of slots is also given a number. By combining these numbers at the left-hand side of the board with those at the top, any check may readily be located. For instance, check No. 61 is placed in column 1, opposite 6 at the left-hand side of the board. In a similar manner, the number of any slot may be determined quickly. This method eliminates a confusing mass of numbers and permits placing the check slots close together so that the board requires a relatively small space. As the end view shows, the check slots are at an angle of 45 degrees, so that all checks will be retained in their respective positions. The slot should be somewhat less in depth than the diameter of the check so that the latter may easily be lifted out of the cabinet.

The check board illustrated at *B* has sixteen sides arranged as shown in the plan view. This board or cabinet is provided with hooks and will hold 1600 checks of ordinary size, when made to the dimensions given on the illustration. It is

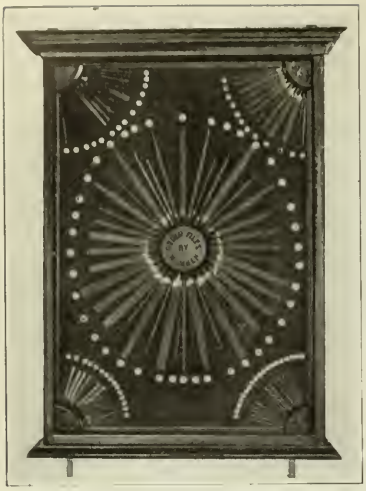


Fig. 21. Cabinet containing Sample Files which are identified at Tool Supply Room by Number instead of Name

mounted on a ball bearing so that any one of the sides may easily be turned to a convenient position for removing a check. Another check holder of the revolvable type is shown at *C*. This is simply a wooden cylinder 6 inches in diameter by 24 inches long, provided with 100 hooks. Two balls held between the cup-shaped ends of the screws shown facilitate the rotating of the cylinder.

The cabinet for tool checks shown in Fig. 24 is the type used in the tool supply rooms of a large automobile factory. This cabinet is composed of several check boards which are hinged together. One board remains in a fixed position and the others are opened like the leaves of a book. All employes' checks are placed on the hooks when tools are obtained instead of being deposited in different parts of the supply room.

Grinding Turning and Planing Tools to Standard Shapes

The grinding of the class of tools used on turning and planing machines is considered an important function of the tool store-room in many plants where this system has been put into use. There are a number of reasons why machine operators are not permitted to grind those tools that are adapted to be ground by hand. In the first place, numerous experiments have proved that slight changes in the shape of a tool of the type used for turning, planing, etc., may have a decided effect on its cutting qualities and upon the length of time that the tool can be used before regrinding is necessary; therefore, it naturally follows that these tools should all be given whatever shape has proved to be most effective. In other words, tools should be standardized, especially as regards the shape of the cutting ends. The development of special tool-grinding machines and the establishment of tool-grinding departments in many shops has made it possible to have all the cutting tools uniform and ground according to approved principles.

Disadvantages of Grinding Tools by Hand—When each man is independent as to the grinding of tools, the results depend upon his experience, skill, or interest in doing things the right way. Some workmen grind their cutting tools properly and others violate every principle of tool grinding. Correct grinding is not always done even when the workman knows how different tools should be formed. Sometimes the shape of the tool is sacrificed in order to grind it quickly or easily. The way an old shopmate used to grind thread tools illustrates this point. The plan followed was to bevel the top of the face downward toward the front because the narrow point of the tool could easily be ground away. The scheme worked well and the edge was sharp, but the "negative rake" neither improved the cutting qualities of the tool nor the form of the thread cut with it. This man was an old shop foreman and knew how, but was not particular about details.

Another important reason why hand grinding by machine operators is not regarded favorably by many manufacturers is that machines are frequently idle while the tools are being ground. The amount of productive time lost in this way varies with different classes of work and also with the percentage of hustle in the operator. Some operators grind dull tools while cuts are being taken, but the extent of this practice depends upon conditions. The time taken to sharpen a tool is sometimes increased considerably because the grinding wheel is naturally more or less of a social center.

Tools that lie about machines deteriorate in many instances, their condition often depending upon the initiative of the man operating the machine; moreover, in many shops where individual sets of tools are found, there is little incentive for keeping tools in good condition. For instance, an operator who understands tool grinding may, as the result of his own efforts, secure a set of lathe or planer tools that have been carefully forged and ground, but such tools are often borrowed permanently by other workmen, so that attempting to keep up a set of tools is rather discouraging.

When tools of the class referred to are kept in the tool supply room with the other tool equipment, but the grinding of such tools is done by the machine operator, the results may depend largely upon conditions. In comparing this system with the one which provides for grinding all tools to standard shapes by means of a special grinder, instead of by individual workmen, the size of the plant and general nature of the work should be considered. In a relatively small shop where a great variety of work is done by competent machinists, the tools are often ground to suit different operations and there may be advantages in allowing the workmen to grind their own tools. Whether or not the size of the plant will warrant the installation of a special tool-grinding department for forged tools is another point to be considered, some contending that such machines should be used in small shops as well as in those of larger size.

Economy of Tool-grinding Department—In a plant employing about 2000 men it was estimated that a saving of over \$5000 a year was effected by standardizing the grinding of small tools and doing this work in a special grinding department, instead of allowing the employes to grind some of the tools by hand. This method of grinding was applied not only to milling cutters, gear-cutters, reamers, drills, taps and dies, but to lathe and planer tools, chisels, scrapers, boring-bar cutters, box-tool cutters, etc. Every day the dull tools were put in boxes and sent to the grinding department. The dull tools were first replaced by sharp ones and then ground by men who were kept at this work exclusively.

Location of Tool Grinder—The grinding machine used for

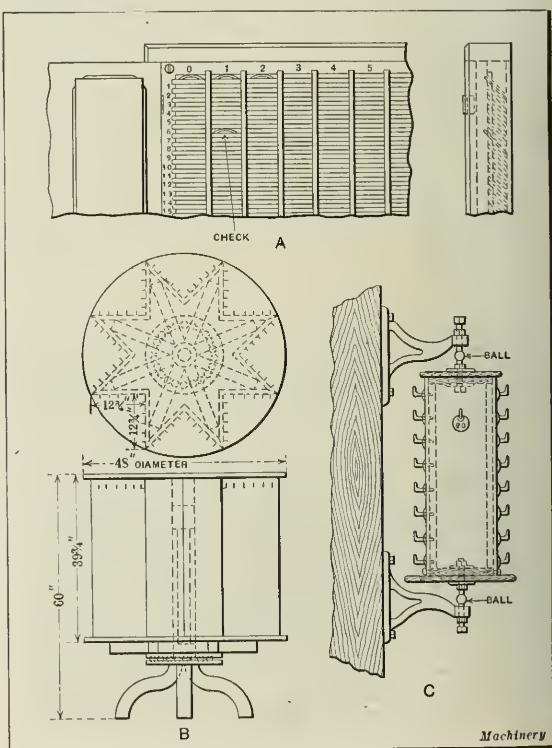


Fig. 22. Three Forms of Check Boards or Cabinets for Tool Supply Rooms

sharpening forged turning and planing tools is usually located either in the tool supply room or in a separate section of this room; it is also sometimes put in the tool-room or out in the shop. If there is not enough tool grinding to keep one man busy, the grinder is generally located where it will be convenient for the operator whose time is partly given to other work.

In some shops the grinding of forged lathe and planer tools is done in the department where the tools are forged and dressed. One method is to first forge the tools to standard shapes and then rough-grind them on a universal tool grinder before hardening; after the hardening operation the tools are finish-ground and are then stored in racks until needed in the shop. This practice of grinding forged turning and planing tools in the forging department has been adopted by the American Machine & Foundry Co. with satisfactory results. All dull tools are collected daily and one man grinds nearly all the tools of the class mentioned. The shops are equipped with grinding wheels so that the employes may grind their own tools, although this practice is not encouraged by the management. It might be assumed that hand grinding would prevail generally, but the fact is that the wheels in the shop are only used occasionally by men operating the machines because they consider that the tools ground to standard forms in a tool grinder designed for that purpose are superior to those ground by hand; consequently the wheels are used principally for sharpening tools that have been dulled slightly or for making slight changes in tools to adapt them to special operations.

Stock of Sharp Tools—When sharpened tools are issued from the tool store-room, it is advisable to have a sufficient number of each size and shape to last, say, two days before the supply is exhausted. As the dull tools are returned, they are allowed to accumulate so that a number can be ground at one setting of the machine. Tools of the same size and form should be ground successively in order to reduce the time required for adjusting the tool grinder. Fig. 23 shows the rack in which sharp tools are stored in the tool supply room of the Tabor Mfg. Co.

Maintenance of Tools

A tool store-room where tools are kept while not in use soon contains many tools that are not fit for service or that,

Fig. 23. Rack in which Forged Turning and Planing Tools are kept in Tool Supply Room

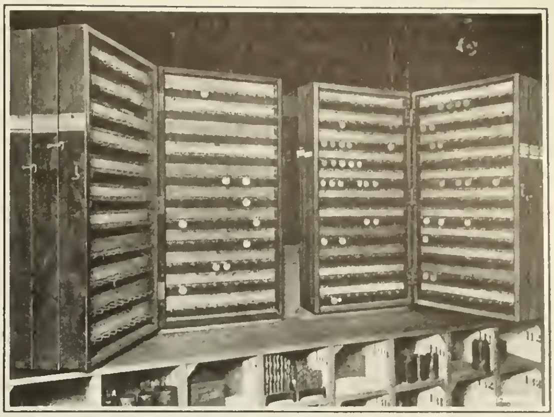


Fig. 24. Check Boards of Folding Type

at least, seriously interfere with the efficiency of manufacturing processes. One of the important functions of the tool supply department is to see that all tools are kept in good condition and that there are enough tools of each type requiring duplicates to meet the demands of the shop. This involves sharpening dull cutting tools and replacing or repairing any tools that may be partly or entirely deranged, either because of wear or breakage. In large shops, especially, it is also important to have some systematic method of investigating defective tools to determine whether or not they are worth repairing and the cause of tool breakage, so that the design or construction may be altered if it is apparent that such changes are necessary.

A tool maintenance system which has proved satisfactory in a large manufacturing plant is so arranged that the replacement and repair of tools is done on as systematic a basis as the regular manufacturing work. If a tool needs to be replaced because of breakage or excessive wear, the employe must first have his foreman sign a "tool release card"; the employe may then return the tool to the tool crib, where he either receives another one or the tool check, if another tool of the same kind is not needed. The release card and the damaged tool are kept together in the store-room, pending a weekly examination by an inspector who determines whether or not the tools should be repaired or discarded. In many cases, the tools become defective on account of long usage, but if it is apparent that the damage is the direct result of faulty construction or gross carelessness on the part of the user, steps are taken either to modify the design or stop the careless practice.

In case regrinding or repairs are necessary it is essential to record in the tool supply room what tools are sent out and to see that they are returned to the right place. The card or form used in such cases gives the number of the department in which the tool is used, the name of the man in charge of the tool crib, the name of the tool, the nature of the repairs or operation required, the number of the tool crib, and the order number against which the time needed for the repairs and any material that may be required is charged. A copy of this form accompanies the defective or dull tool and is kept in the tool-room where the repairing or sharpening is done, as a record of this work; a second copy is kept in the tool crib to show what tools have been sent to the tool-room, and the office also receives a copy, which is held temporarily as a reminder that the work is being done.

When files need to be replaced as a result of wear, a special order is used. The worn file is taken to the department foreman, who examines it and then makes out an order for another file, if in his judgment the old file should be replaced. On this order is written the name of the file, the size, the number of files needed, the department number, the tool crib number, the date, and the number of the employe to whom the file should be delivered. This order also bears the signature of the department foreman. The same order is used to obtain new files.

Determining Causes of Tool Breakage

The number of tools which must be replaced because of breakage can often be reduced considerably by instituting a systematic method of determining the cause of breakage in each case. A plan which has proved successful requires the use of printed forms or slips (see Fig. 25) which are given to all foremen. When an employe breaks a tool he must obtain one of these slips from the foreman in order to secure another tool or the check which has been deposited in the tool supply room. The printed slip contains a list of tools commonly used and blank spaces in which the names of other tools may be written. If a half-inch tap, for example, is broken, the size of the tap is marked in the space opposite the word "tap" on the card. The cause of breakage is indicated by a cross made by the foreman opposite whatever term on the card indicates the cause. These forms are filed back of each man's "record card" and are examined at the end of each week or month to determine what workmen are breaking the most tools and the causes for such breakage.

Check No. 45 Foreman John Smith Dept. 17

All Broken Tools Must Be Returned

Name of Tool	No.	Size	Name of Tool	No.	Size
Drill Tap Reamer File Hacksaw Blade	1	½"	Wrench Milling Cutter		

Cause of Tool Breakage

____Carelessness
_X_Accident
____Defective Design
____Defective Construction
____Defective Machine
____Defective Jig

Fig. 25. Form used when Tools are broken by Workmen

Ideal Tool Supply Room System

The ideal tool supply room system does not exist, if by system we mean a complete plan or organization which, without modifying any of the details, may be applied universally. A system that would be ideal in one plant or machine shop might require some modification in another shop to suit local conditions. The variation may be a slight change of detail or a reduction of the entire system to a more simple form, whenever the manufacturing conditions and problems are relatively simple and do not require the more complex system necessary when a great variety of work is produced. While such changes are often essential, there is a tool supply room system which may be considered ideal in principle. Such a system would include not only the care, maintenance and accounting for all tool equipment of the classes previously referred to, but prompt delivery of such tools to various manufacturing departments before the tools are actually needed. While systematic methods of issuing tools and of maintaining them in good condition are common, the tool supply rooms of a great many machine shops are either partly or entirely independent of the manufacturing department, instead of being so interwoven with the entire system of shop management that they are controlled the same as any other department. If turning, planing and milling operations are necessary in manufacturing a certain machine, the departments doing the work will be so controlled in a well organized shop that they will act in unison, so that the maximum output of the finished product may be obtained. Inasmuch as the efficiency of any department or of an entire plant may be affected considerably by the condition of the small tool equipment, it is also important that the tool supply room be controlled with reference to the work of manufacturing, instead of placing this department in the same class as a safety deposit vault and regarding it merely as a place of storage. If a certain machine will soon complete a job, considerable delay may be avoided if the tools for the next successive job are collected in advance and placed at the machine. It is evident, however, that these tools will be useless to the machine operator unless the parts to be worked upon are also at the machine, together with the necessary blueprints and whatever additional instruction regarding the sequence of operations, etc., may be necessary; therefore, it is apparent that there should be some form of centralized control to insure prompt delivery not only of tools but of raw material, such as castings, forgings or bar stock. Naturally the details of any special system will be subject to more or less variation and may be affected by such conditions as the arrangement of the shop or factory and the uniformity or diversity of the product.

Tool Supply Room System under Scientific Management

The method of controlling the delivery and maintenance of tools adopted by the Tabor Mfg. Co. of Philadelphia will be described as a practical example of a system based on the principle that all the departments of a manufacturing plant should be so closely allied that they are like the different parts of a machine which move in perfect unison and accomplish results by concerted action. The control of the entire plant is centralized so that every department, including the

Fig. 26. Bulletin Board of Tabor Mfg. Co. for controlling Manufacturing Operations and Delivery of Tools

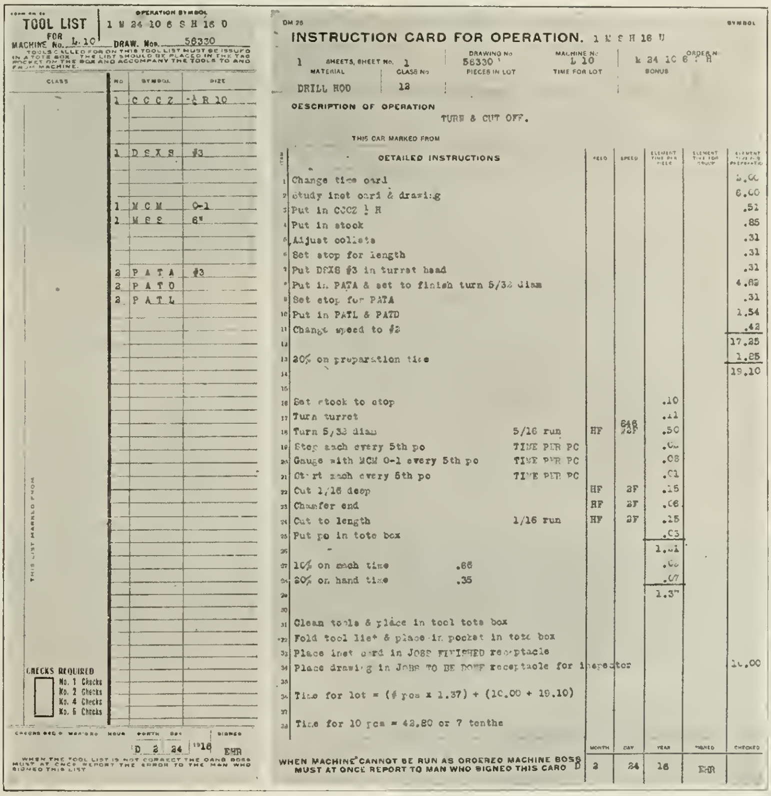
tool supply room, is governed with reference to the work of the entire manufacturing organization. The planning department decides how and when work should be done and governs the operations on every machine as well as the work of the assembling department; in addition, the planning department specifies the time in which each operation should be completed, and provides for supplying the necessary tools and materials in advance so that all delay is avoided. The foreman has nothing to do with the kind of work done on different machines nor with the methods of machining or assembling parts.

Before referring to the tool supply room system, a general outline of the methods of utilizing and controlling these various departments will be given. After a machine is designed it is divided into general groups which can be assembled as units, the aim being to so plan all work that the various parts of a machine may be finished in a successive order which conforms to the natural and most direct way in which the machine would be built. The successive order of all operations, as well as the tools and machines to be used, is determined beforehand, and the exact methods of procedure are outlined in detail so that all parts not only conform in size and shape to the approved design, but all work is done in the manner prescribed. A route chart is first made up which shows graphically every step in the building of a machine. This chart may be compared to a river and its tributaries, the main river representing the complete machine, and the tributaries the different units and parts which, when united, form the machine. Every operation and tool is listed and these lists are so arranged that the parts which form units and the different units which make up main groups are merged together graphically on the chart just as they would be made and assembled if all the work were done in a systematic and orderly manner from start to finish. In addition to this route chart, there are smaller route sheets for the different parts which also show what operations are required and their successive order. On these route sheets there is a record of all work which must precede the manufacturing operations, such as making the necessary detail drawings or special tools that may be required, ordering the material, recording the delivery of material, etc.

When all the material and tools are ready, the work of manufacture may begin, but the order in which machines and parts of different machines are built is also governed systematically and in accordance with their relative importance. The route chart previously mentioned may not be needed for minor manufacturing operations, in which case there is only a route sheet. An operation order or slip is made out in triplicate for each job. These three slips are of different colors, which indicate where each slip belongs when they are transferred, as described later. On each order there is a special symbol, the letters of which indicate the exact nature of the operation. The machine number, the drawing number, the number of pieces required, the amount of bonus, and the time within which the work must be finished to earn the bonus, are also given on each operation order.

Bulletin Board Controlling Manufacturing Operations and Delivery of Tools

In the planning department there is a large bulletin board (see Fig. 26) containing three pairs of hooks for each machine, vise or other working places in the various departments. A symbol shows which machine, vise, etc., each set of hooks represents. The three duplicate operation orders are first placed together on the lower pair of hooks to show that the work represented by these slips is to be done. The operation orders are perforated so that they may readily be placed over the hooks. We shall assume that the operation order is for a casting which is to be planed. Before the planer on which the work is to be done is ready for it, an order is issued to move the casting from the place of storage to the machine. When the casting or any other material required has been placed near the machine (suitable storage racks or spaces are provided), the operation orders are transferred to the set of hooks marked "jobs at machine ready to be done." When the work is started, one slip is placed on the hooks marked "job on machine." This slip is left on the bulletin board in the planning department, and, as other slips are made out for each job passing through the shop, a thorough knowledge of working conditions throughout the entire plant may be obtained by studying the board and noting the location and number of the various operation orders. One of three order slips previously referred to is transferred to a separate bulletin board in the planning department to show that the list of tools and the card of instruction for that particular job should be transferred from the file to the machine or wherever the work is to be done. The third operation order is placed on a bulletin board (see Fig. 28) in whatever department is to do the work. This bulletin board shows the department foreman or "gang boss" what operations have been assigned to each machine, bench vise or other working place, and the order in which they are to be completed. It is the duty of the foreman to see that each man has whatever tools may be needed from the tool supply room for at least three jobs ahead of the one on which the man is working at the time, or more than three if the total time for three jobs requires less than three hours. The order in which the various parts are to be machined is shown by the relative positions of small index slips seen at


TOOL LIST
OPERATION SYMBOL 1 W 24 10 6 S H 16 0
FOR MACHINE No. L 10 DRAW. No. 58330
TOOLS CALLED FOR ON THIS TOOL LIST MUST BE ISSUED IN A TOTE BOX. THE LIST SHOULD BE PLACED IN THE TAG POCKET ON THE BOX AND ACCOMPANY THE TOOLS TO AND FROM MACHINE.

CLASS	NO	SYMBOL	SIZE
	1	C C C Z	¼ R 10
	1	D E X S	#3
	1	M C M	0-1
	1	M E S	6"
	2	P A T A	#3
	2	P A T O	
	2	P A T L	

THIS LIST MARKED FROM
CHECKS REQUIRED
No. 1 Checks
No. 2 Checks
No. 4 Checks
No. 6 Checks
D 2 24 1916 EHR
WHEN THE TOOL LIST IS NOT CORRECT THE GANG BOSS MUST AT ONCE REPORT THE ERROR TO THE MAN WHO SIGNED THIS LIST

DM 26
INSTRUCTION CARD FOR OPERATION. 1 W S H 16 0
1 SHEETS, SHEET No. 1 | DRAWING No. 58330 | MACHINE No. L 10 | ORDER No. W 24 10 6 ? H
MATERIAL DRILL ROD | CLASS No. 12 | PIECES IN LOT | TIME FOR LOT | BONUS
DESCRIPTION OF OPERATION: TURN & CUT OFF.
THIS CARD MARKED FROM

ITEM	DETAILED INSTRUCTIONS		FEED	SPEED	ELEMENT TIME PER PIECE	ELEMENT TIME FOR GROUP	ELEMENT TIME FOR PREPARATION
1	Change time card						2.00
2	Study inst card & drawing						6.00
3	Put in CCCZ ¼ R						.51
4	Put in stock						.85
5	Adjust collets						.31
6	Set stop for length						.31
7	Put DEXS #3 in turret head						.31
8	Put in PATA & set to finish turn 5/32 diam						4.82
9	Set stop for PATA						.31
10	Put in PATL & PATO						1.54
11	Change speed to #2						.42
12							17.25
13	20% on preparation time						1.85
14							19.10
15							
16	Set stock to stop				.10		
17	Turn turret				.11		
18	Turn 5/32 diam	5/16 run	HF	646 #2F	.50		
19	Stop each every 5th pc	TIME PER PC			.0[illegible]		
20	Gauge with MCM 0-1 every 5th pc	TIME PER PC			.08		
21	Start each every 5th pc	TIME PER PC			.01		
22	Cut 1/16 deep		HF	2F	.15		
23	Chamfer end		HF	2F	.06		
24	Cut to length	1/16 run	HF	2F	.25		
25	Put pc in tote box				.03		
26					1.[illegible]		
27	10% on mach time .66				.0[illegible]		
28	20% on hand time .35				.07		
29					1.37		
30							
31	Clean tools & place in tool tote box						
32	Fold tool list & place in pocket in tote box						
33	Place inst card in JOBS FINISHED receptacle						
34	Place drawing in JOBS TO BE DONE receptacle for inspector						10.00
35							
36	Time for lot = (# pcs x 1.37) + (10.00 + 19.10)						
37							
38	Time for 10 pcs = 42.80 or 7 tenths						

WHEN MACHINE CANNOT BE RUN AS ORDERED MACHINE BOSS MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD
D | MONTH 2 | DAY 24 | YEAR 16 | SIGNED EHR | CHECKED

Fig. 27. List of Tools and Instruction Card for Machining Operation

the left-hand side of the bulletin board shown in Fig. 28. These slips are numbered in accordance with the numbered positions of the operation orders on the board, and, as previously mentioned, the sequence in which work is done is regulated entirely by the planning department in accordance with the class of work and its importance.

Up to this point the work has been controlled entirely by the planning department which has attended to ordering and delivering the necessary material and has specified just how and where the work is to be done. Each operation order on the shop bulletin board shows the number of the machine, vise or other working place to which the work has been assigned. The tool list indicates what auxiliary tool equipment is to be used, the different tools being indicated by symbols which will be explained later. The instruction card contains not only detailed instructions regarding the exact method of doing the work, but also specifies the time for each of the elements which make up the complete operation and gives the speed and feed to be used whenever machine work is to be done. A sample tool list and also an instruction card are shown in Fig. 27.

Importance of Establishing Standards

The data pertaining to speeds, feeds and the time for each element in the work represent a vast number of experiments and tests which have been made previously and under certain standard conditions; therefore it is necessary for the management to maintain standards which are, at least, equal to those existing when the tests were made, because if this were not done, it would obviously be impossible for the men in the shop to duplicate the time and the speeds and feeds listed on the instruction card. For instance, after the best combination of speed and feed has been determined for turning a given material in a lathe when using a tool that is properly ground and a driving belt capable of supplying the necessary power, it is apparent that such data would be of little value as a guide for similar turning operations unless the same or better conditions were maintained. In other words, the management assumes certain responsibilities and prescribes the exact conditions under which work must be done; consequently standards must be established and maintained. This means that cutting tools must be kept sharp, that forged tools

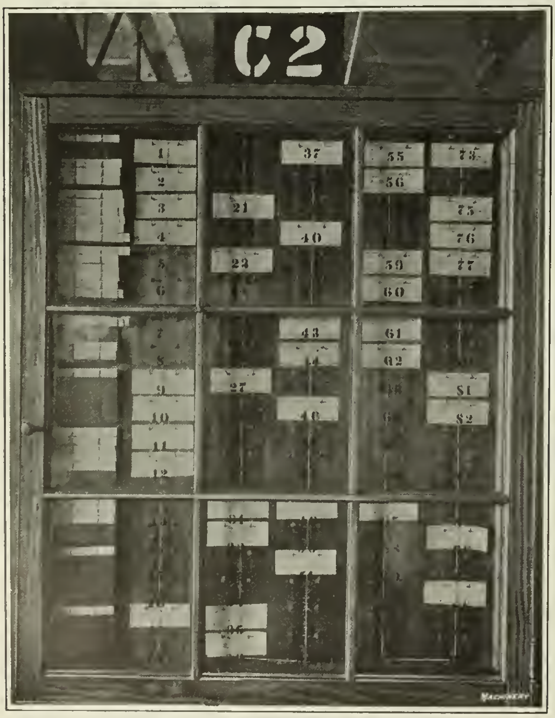


Fig. 28. Shop Bulletin Board which shows Department Foreman what Work is to be done

Fig. 29. View in Tool Supply Room of Tabor Mfg. Co.

such as are used on turning and planing machines must be ground in accordance with approved principles and to standard shapes, that bolts, clamps and packing blocks be standardized, that belts be kept at a tension which will enable the necessary power to be transmitted, and that the tool equipment in general be maintained in good condition.

Much of the foregoing may be considered irrelevant to the subject of tool supply room systems, but what follows will show how closely this department at the plant of the Tabor Mfg. Co. is related to the manufacturing departments, and how the storage, delivery and maintenance of tools are done in a systematic way and in accordance with the demands of the planning department. Before explaining in detail the methods of handling the tool equipment, a description of the system of tool classification will be given.

Classification of Tools

While it is the general practice to place tools of the same class together in the supply room to facilitate finding different tools as they are called for by the workmen, the classification ordinarily is not intended to include the system of identifying tools. In most shops the part number or tool number on a drawing or list of operations is simply given to a certain machine part or tool arbitrarily, but does not of itself indicate to what class the tool belongs.

With the system of tool classification devised by F. W. Taylor and adopted by the Tabor Mfg. Co., the symbol for each tool is composed of letters, each of which indicates something definite about that particular tool. When the tool cabinet is arranged to correspond with this system of classification, it is easy for anyone to locate a tool readily in a large supply room, after a brief explanation of the system, due to the fact that the location of any tool depends on the system and not upon the memory of the man in the supply room. This system is based on a general classification for all tools and the dividing of these general classes into divisions and sub-divisions, down to a tool of a certain type, form and size. For instance, the symbol might be composed of letters which show that the tool is used for turning, has a round nose or cutting end, and is bent to the left. A number added to this combination of letters would show that the tool was made of stock of a certain width. The general classification is as follows:

A—Miscellaneous tools, not elsewhere classified.

B—Bending tools. All tools for producing changes in shape by bending, folding, spinning, etc.

C—Clamps and holding devices of all kinds, including bolts and screws.

D—Drilling and boring tools. Tools that remove metal from the interior, such as drills, boring-bars, cutters, and all appliances relating to them, and lathe boring tools, etc.

E—Edge tools. Edge tools for working wood, and tools for working plastic materials, such as clay, molding sand, putty, etc.

F—Heating tools. All kinds of tools used for heating, lighting, melting and molding, oil tempering, annealing, drying, cooking, etc.

H—Hammers and all tools that work by striking or being struck, such as sledges, tups, etc., chisels, sets, flatters, etc.

L—Transportation tools. All tools used in moving materials from one place to another, such as buckets, boxes, etc., trucks, shovels, wheelbarrows, bogies, brooms, riggers' tools, slings, chains, etc.

M—Measuring tools. All instruments of precision, weights, measures, gages, etc., electrical instruments, etc.

P—Paring tools. All tools that remove metal from the surface by cutting, except slotter and milling tools. (See class D for lathe boring tools.)

R—Milling tools. All tools for milling or sawing metal.

S—Slicing tools. All parting tools and slotter tools.

T—Templets and all instruments for duplicating work, including jigs and fixtures.

U—Abrading tools. All tools used for rubbing, scraping, filing, grinding, shearing, punching, breaking, etc.

W—Wrenches and all tools used for causing rotation.

X—Painting tools. All tools used for covering a surface with an adhesive foreign material, and any for removing same.

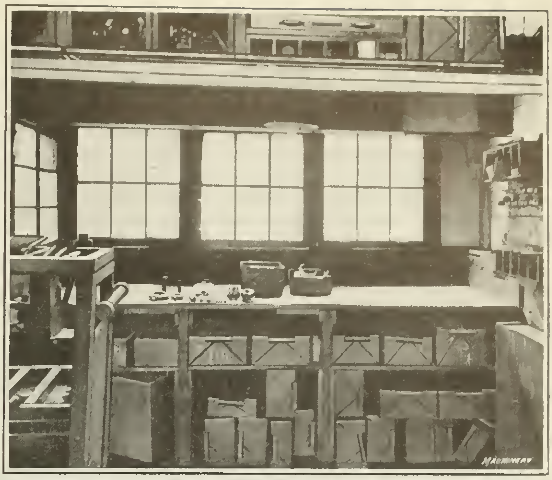


Fig. 31. Receiving Bench where Returned Tools are examined and sorted

TABLE II. KEY FOR SUB-CLASSIFYING STANDARD SHAPE CUTTING TOOLS

First Letter	Second Letter	Third Letter	Fourth Letter
Class	Shape of Cutting Edge	Sub-classification of Second Letter Shape of Nose	Straight, Bent and Hand
Paring .....P From general classification	Parting ....C Round .....R Square .....S Side ....U V-shape V	Sharp ......S Blunt ......B Broad .....W Beveled ....A	Straight ....A Straight .. right B Straight .. left C Bent 30° to right D Bent 30° to left E Bent 45° to right F Bent 45° to left G Bent 60° to right H Bent 60° to left J Bent 90° to right K Bent 90° to left L

Machinery

These general classes of tools are divided and sub-divided, and as each division and sub-division is represented by a letter, the combination of letters indicates the exact type and form of tool, although the man in the shop or tool supply room does not need to know the meaning of the various symbols because the list of tools previously mentioned insures the delivery of the proper tool equipment. The man in the tool supply room, however, should understand the system of classification so that he may readily locate any tool by means of the symbol. In connection with this system there is a record in the form of a loose-leaf book which contains symbols for the general classes of tools, as well as all sub-classes. This book is not needed for locating tools in the supply room, but it shows what symbols should be given to a new tool and enables a tool, the symbol of which is unknown, to be located if the name is given.

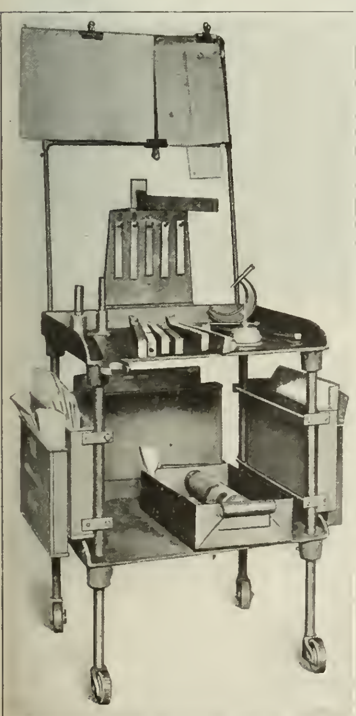


Fig. 30. Shop Tool Stand for holding Tool List, Instruction Card, Blueprints, and Sets of Tools

Table II illustrates the arrangement of the different classes of cutting tools under the general class designated as "paring tools," and by the letter P. The symbol for a turning tool having a blunt round nose and a cutting end bent 30 degrees to the left will illustrate the principle of this system of classification. Turning tools belong to class P, since they are included, as shown by the previous list, in the general group used for removing metal from a surface by cutting, except slotting and milling tools; therefore, P would be the first letter of the symbol. The next letter is found by referring to another sheet indexed under the letter P. On this sheet is a list of the different shapes of the cutting edges (see Table II), and as R represents a round nose or cutting edge, the symbol becomes PR. Each symbol on this sheet P has another sheet marked PC, PR, and so on. Sheet PR would be referred to, in this case, and it would show what letter should be added to PR to indicate that the round cutting edge is of blunt form. This letter is B, so that the symbol is now PRB. Sheet PRB is next examined to find the letter for a tool having a cutting end bent 30 degrees to the left. Letter E represents such a bend, and the symbol PRBE thus obtained is completed by adding a figure to it, which, in the case of forged tools, shows the width of the tool shank as measured on the long side. For instance, the symbol 7/8PRBE shows that the tool is a 7/8-inch blunt, round-nose tool bent 30 degrees to the left. The classification sheets show definitely that this symbol is complete, because no sheet will be found indexed under PRBE, which indicates that there is no other sub-division.

Arrangement of Tools According to Classification

The tool racks are of standard form, as previously explained under the heading "Storage Fixtures for Tool Supply Rooms." All tools are placed in the different compartments of these standardized racks in the exact order indicated by the symbol. For instance, the symbol 7/8PRBE for a turning tool would be used for locating this tool in the rack in practically the same way that the name of the tool would be determined by referring to the book of tool classifications. Symbols at the end

of each rack along the aisle illustrated in Fig. 29 show the first and last symbol included, so that a glance at these "keyboards" enables one to determine whether or not a certain symbol or tool is in that particular rack section. (One of these keyboards may be seen above the tool rack in Fig. 23.) On one of these boards will be found the symbol DBG–DDTT (up to 1 17/32"). This particular symbol shows that all tools listed in the inventory between these letters are in this rack. For example, tools having the symbol DCBG are in this rack, because DCBG comes between DBG–DDTT, according to the alphabetical order; a symbol like DDTS would also be included in this rack, because S precedes the last letter T of the symbol DDTT.

Each twenty-four-inch unit or compartment of a rack also has a symbol which serves the same purpose for this department as the keyboard previously mentioned does for the entire rack. Thus, if the symbol DDTT is over a twenty-four inch unit, it shows that only tools of this classification are in that particular department, although there may be different

The standard twenty-four-inch compartment at the upper left-hand corner of a rack at one end of the tool supply room corresponds to the first page of a dictionary. The next rack, or the second one to the right of the first, represents the second page; the third is directly below the first, the fourth to the right of the third, and so on as shown by the order of the letters on the diagram Fig. 4. These twenty-four-inch units are read from left to right down to the eighth or last rack of a standard section. In this particular tool supply room most racks are composed of two sections, each containing eight twenty-four-inch compartments, and the second section is read like the first one, beginning at the upper left-hand corner and reading each horizontal pair of units or compartments from left to right. When the twenty-four-inch units are subdivided with boxes or drawers, these are also read from left to right, as in reading a book.

To illustrate the method of locating a tool from the symbol, we shall assume that the tool having the symbol DDTT 1" is required. (This happens to be the symbol for a one-inch taper

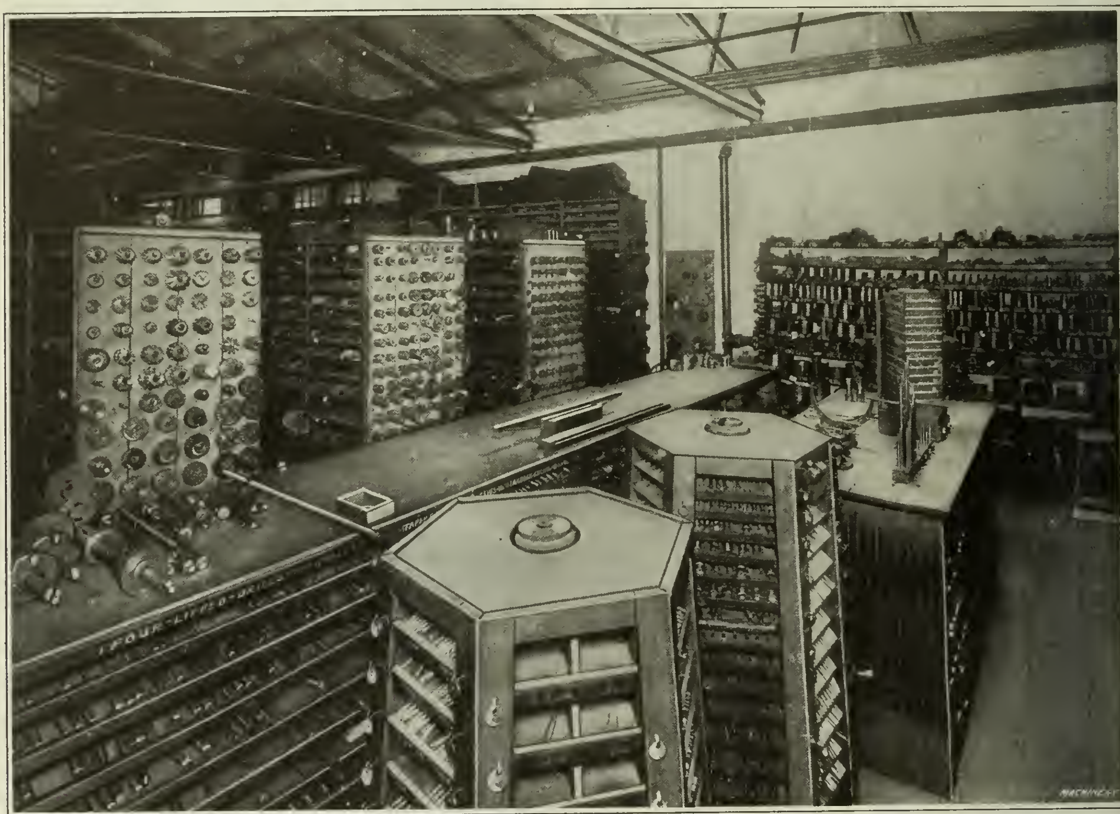


Fig. 32. View of Tool-room of Gisholt Machine Co., Madison, Wis., showing Section used for Milling Cutters, Reamers, Drills, Counterbores, Gages, etc. Note Revolving Tool Cabinets in Foreground

sizes of these tools, as in the case of drills, reamers, etc. If there were two symbols over a twenty-four-inch compartment, as DCBG–CFN, this would mean that all tools between DCBG and DCFN were in this twenty-four-inch section, although part of the tools included under the end symbols might, in some cases, be in the preceding or successive compartment of the tool rack. Boxes or drawers within the twenty-four-inch compartments are labeled with brass tags (painted black with letters filled in with white), each bearing the symbol and size of the tools in each box, tray or drawer. For example, a drawer marked 1" DDTT means that only one-inch taper shank twist drills are in it.

In order to locate a tool quickly when its symbol is given, it is essential to know the order in which the racks are arranged. The general classes of tools represented by various letters from A to X, according to the list previously given, are stored in the racks in alphabetical order. The tools in the general class A are followed by those in the B class, and so on.

shank twist drill, but it is not necessary to know this in order to locate the drill.) The main rack is first located by looking for the letter D the same as when locating a word in a dictionary. This leading letter D may not always locate the right rack, because more than one of the racks may have symbols beginning with D. The two symbols on the keyboard at the end of the rack containing this tool will be such that the first one precedes the tool symbol and the second one follows it, according to the alphabetical order. The rack marked "DBG–DDTT up to 1 17/32"," shows that it contains the tool DDTT 1". The symbol on the twenty-four-inch compartment containing this particular tool is next located, this serving the same purpose as the word at the top of the column in a dictionary, which shows that the word is somewhere in that particular column. The keyboard at the end of the rack indicates that symbol DDTT is not at the beginning of the rack, so that the first few sections are skipped and the heading DD is looked for, the same as de or dee would be in searching

for the word deed in a dictionary. If the symbol DDTS is found, evidently DDTT is farther along. After finding DDTT above a twenty-four-inch division, the box, drawer or bin containing one-inch tools, in this particular case, is found. Whenever tools of one kind or type are kept in a variety of sizes they are arranged according to the size, the small tools coming first. By this plan the tools can be located without delay.

The exact method of obtaining the tools for a certain operation in the shop will be explained. We shall assume that the tools are those shown by the symbols on the tool list illustrated in Fig. 27. These tools are intended for a certain operation on machine L-10. (Incidentally these tools correspond to the ones used for the operations given on the instruction card shown in the same illustration.) The foreman or gang boss, as previously mentioned, is guided in assigning work to the men under him by the shop bulletin board in his department. (See Fig. 28.) The foreman waits until machine L-10 is two or three jobs ahead of the particular operation under consideration; the tool list for that particular operation is then sent seen in Fig. 29.) The two lower shelves contain the tote boxes in which different sets of tools are placed, and the upper shelf is for holding the tool lists, which are temporarily attached to suitable boards having spring clamps. With this arrangement several tool lists may be made up at one time, the tools called for on each being placed in a separate box. Each tool that is removed from a box, drawer or rack is replaced by a workman's check, which is placed either on a hook or in a pocket provided for that purpose, in the case of a drawer. As each tool on a list is obtained, it is checked off the list by extending a pencil line or mark along a heavy white line at the left of the column showing the number of tools required. (These tool lists are small blueprints, so that the heavy checking line seen on the tool list in Fig. 27 is white against a blue background.) This checking of the tools is done to insure the delivery of the complete set called for on the list. When a set of tools is made up, the tool list is placed in a pocket of the metal tote box and then the tools are ready to be sent out to whatever machine or other part of the shop

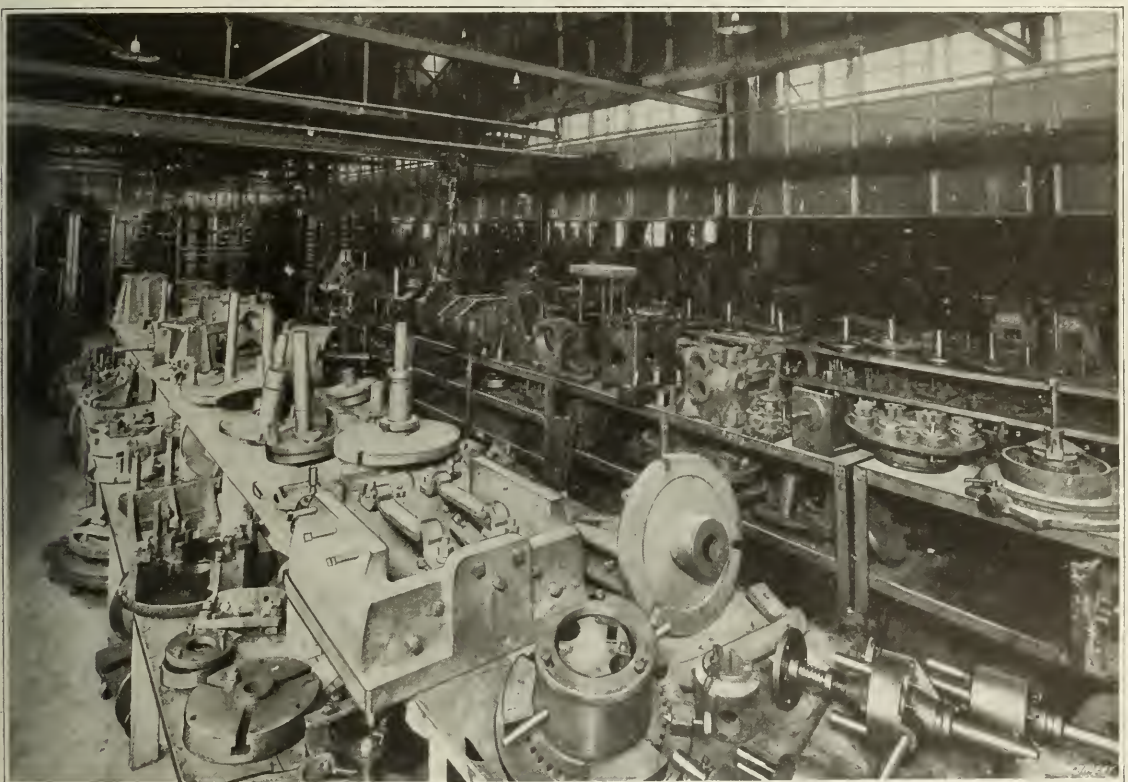


Fig. 33. Jig and Fixture Storage Section, Gisholt Machine Co. Note Hand Power Traveling Crane for lifting and carrying Heavy Fixtures

to the tool supply room by one of the boys who transfer tools.

The tool list is accompanied by enough brass checks to cover the number of tools required. These checks bear the workman's shop number, and there are four different shapes representing a corresponding number of exchange values, the same as four coins of different denominations. For example, a round check may be given in exchange for one tool, a square check for two tools, an octagonal shaped check for four tools, and a scalloped edge check for six tools. The use of these different shapes reduces the number of checks to be handled.

Method of Collecting Sets of Tools

When the tool list and checks covering the number of tools required are brought to the tool supply room, one of the attendants, using the tool list as a guide, starts to collect the tools, beginning first with those which are farthest from the delivery window. In connection with this work an "issuing truck" is used, which has three shelves. (This truck may be is marked on the tool list. (Wooden boxes fitted with compartments to protect the cutting edges are used for tools that might be injured if placed together in a metal box.

Signal Lights for Tool Delivery

Inside the tool supply room window there are three red lights arranged in a vertical row, which represent the three floors of the machine shop. Each of these lights is connected with a similar light on the first, second, and third floors, so that they can be used for attracting the attention of the boys who deliver and return tools. For instance, if a set of tools is ready for some machine on the first floor, the lower light is turned on and one of the boys comes for that set of tools.

Tool Stands for Machines

When the box containing the set of tools is brought to a machine, it is placed on the lower shelf of one of the portable tool stands illustrated in Fig. 30. The particular tool stand

shown has only one box of tools, but ordinarily there are three boxes containing the tool equipment for a corresponding number of jobs which are to follow the one on which the machine is working at the time. In this way all delay due to waiting for tools is entirely eliminated, and as soon as one job is finished, the foreman or gang boss sees that the machine is properly set up for the next operation. This tool stand is provided with pockets for holding the necessary blueprints, tool list and instruction card. When these lists and cards are brought from the planning department they are placed in the pocket marked "jobs to be done," and they are put in the pocket on the opposite side when the work is done.

Return of Tools to Place of Storage

As soon as a certain operation is completed, all of the tools, including any clamps, bolts, or blocking that may have been needed, are returned to the tool supply department with the list used in making up the tool set. Even though some of the tools are to be used on the next successive job they must first be returned to the tool supply room for inspection to show that all the tools are in the proper condition. If this plan were not followed tools might be used that were not up to the required standard. When the tool box reaches the delivery window, the tool list is removed and placed in a small compartment near the window provided for that purpose. The tools are then taken to the "receiving bench" shown in Fig. 31, where they are carefully examined so that all dull tools may be separated and placed in boxes on a shelf just beneath the receiving table. All tools that are to be sent out for sharpening are replaced by checks marked to indicate the department to which the tool has been sent. The remaining tools, after being assorted to facilitate distributing them, are placed on the "putting away truck."

The truck used when distributing tools is similar to the one employed for collecting them in sets, except that the two upper shelves are spaced or partitioned so that when tools are assorted on the table, they can be transferred to these spaces, which will keep the different types in order. As each tool is returned, the workman's check is removed from the tool rack and placed on a check ring which keeps the checks together and prevents their being lost. For each tool that is sent out to be ground or repaired, the workman's check on the tool rack is replaced by one of special form showing to which department the tool is sent.

When the tools of a set have been put away, the workman's checks and the tool list are sent back to the place where the work was done, the tool list being placed in that pocket of the tool stand representing jobs that have been finished. These lists are then removed and filed away in the planning department for future use.

Outgoing Grinding and Repair Racks

All tools that have been dulled in use and need grinding or sharpening are transferred from the receiving table to a nearby compartment marked "outgoing grinder rack." The boxes for such tools as dull drills or forged turning and planing tools are kept at the receiving table until enough tools have collected to warrant issuing an order for grinding them; they are then transferred to the "outgoing" rack and are taken from this rack by a "move man," to whatever machine or department is to do the work.

The "outgoing repair rack" serves the same purpose as the other rack referred to, except that it is for tools requiring repairs other than grinding. There is also an "incoming tool rack" for holding tools which have either been ground or repaired; new tools are also placed in this rack before being filed away in one of the regular compartments. At the time tools are ordered, the proper symbol is given to them according to their class and sub-class and this symbol is stamped on the tool. The forged tools used for turning, planing, etc., have symbols stamped on the shanks, which show the size and classification, the name of the steel, and the lot number in which the steel was received. The brand of steel is represented by letters which are an abbreviation of the trade name. These symbols are stamped in a definite place, the classification symbol being on the top of the shank near the end, the lot number on one side, and the symbol for the brand of steel on the opposite side. Incidentally, the grinding of dull tools is controlled by the planning department the same as manufacturing operations.

Summary

In order to determine what tool supply room system has been adopted most widely by manufacturers in various parts of the United States, information pertaining to the more important features has been obtained from a great many machine-building plants which differ widely in size and also as regards manufacturing conditions. This investigation showed that while details vary considerably to suit local conditions, there are certain methods of handling small tool equipment which have been employed quite generally. A brief review of the system which seems to be the most prevalent will be given.

When a man is first employed he is given a set of tools which are kept permanently. This set may include files, cold chisels, bench brushes, or whatever equipment the employe uses in connection with his daily work. A record is kept which shows what equipment should be in the possession of any employe, especially if he is about to leave.

The tools which are kept in the tool supply room are accounted for when out in the shop by means of brass checks, in 93 per cent of the shops previously referred to. Ordinarily a certain number of these checks (usually ten or fifteen) are given to each employe requiring tools, the number being recorded on the tool record previously referred to. When these checks are exchanged for tools they are usually placed where the tool belongs when not in use. In some of the shops the checks are filed on check boards, in which case a tool tag may be placed with the check to show what kind of tool is out; a double set of checks is also employed in a few shops, different methods of using them having been explained previously. In 7 per cent of the selected list of shops, some form of written receipt is given in exchange for tools.

When tools are called for at the tool supply room, special tools such as jigs, fixtures, dies, etc., are ordinarily identified by a number or a letter and number combined, which represents either a part number or a tool number; the operation number may also be included if separate operations are necessary. Sets of tools such as a jig with its drills, etc. or a milling fixture and the necessary cutters are commonly delivered to workmen in single boxes. The special tools of a set are usually kept together, whereas the standard commercial tools, such as twist drills, standard taps, reamers, and so on, are kept with other tools of their class and are collected (in advance of the time needed in some shops) to form a set when necessary. In many shops that are continually manufacturing duplicate parts, all the tools of a set, whether special or standard, are kept together permanently in suitable boxes, and a list shows what tools form a complete set.

When a shop is large enough to have a tool-room (where new tools are made) and one or more tool storage rooms, most cutting tools, such as milling cutters, reamers, drills, etc., are sharpened in the tool-room. Drills are frequently sharpened in the tool storage room even when there is a separate tool-room. In the shops of the selected list previously mentioned, 22 per cent of the drill grinding is done by the machine operators, either by hand on an ordinary grinding wheel, or by means of a drill-grinding machine. The tools for general turning and planing operations are ground by the employes using them in 84 per cent of the shops. The grinding of tools to standard shapes in universal tool grinders is done in the remaining 16 per cent of the shops. In most cases where tools are ground by hand, individual sets of tools are kept at the different machines, although the practice of keeping the main stock of tools in the supply room and issuing them in exchange for checks is quite prevalent. When tools are ground by the employe, the practice varies somewhat in different shops. For instance, in some cases sharp tools are obtained from the supply room and are ground by men until they need redressing when they are exchanged for other sharpened tools. In other shops rough tools are delivered to the workmen to be ground.

EMPLOYER'S INDEMNITY INSURANCE

BY CHESLA C. SHERLOCK [1]

Two questions arise under employer's indemnity insurance: What injuries are covered by an indemnity policy? and, What employes are covered? As to injuries, it seems that the first consideration is whether or not the employe was engaged in the usual course of his employment at the time the injury was received. Indemnity policies generally specify this requirement, so it is of prime importance to settle that question first of all.

The manner in which the courts apply this principle of law can be determined by an examination of a few specific cases. In a Missouri case, it was held that where a policy undertook to protect a wooden-box manufacturer from liability for damages on account of bodily injuries to his employes while on duty in his factory, arising in the course of operation of the business described in the policy, recovery could be had for injuries caused by the fall of an elevator even though such elevator was not mentioned in the policy. This decision was on the theory that the use of an elevator in the business described was sufficiently within the usual course of employment to come under the trade named in the policy.

In another Missouri case, the court went to the extreme when it allowed a recovery by an employer for kidney disease contracted by the employe in the handling of infected rags and paper in the usual course of her employer's business. The court held this to be an injury "accidentally suffered" within the meaning of an employer's liability policy. It is a general rule, under the workmen's compensation acts, however, that there can be no recovery for a purely occupational or industrial disease. In this case, it is presumed, the disease was not deemed to be an occupational disease so recovery was allowed.

In a Wisconsin case, where a workman employed in an iron and steel works was injured by the fall of a girder, which was being raised by an independent crew building an addition to the works, it was held to be within the terms of an indemnity policy against claims for compensation for injuries in "all operations connected with the business of iron and steel works." A Minnesota contract held that there could be no recovery, when insurance was taken on a special building, if injury resulted while additions or alterations were being made in said building, and further provided that the insurance was not to be in force until said building was fully completed and ready for occupation. The court said, however, that when an employe was injured by a defective elevator which was not fully completed, there could be a recovery under the terms of the policy contract.

The Federal courts have not been so liberal in their views. In one case, where a policy provided that the insured was to carry no explosives on the insured premises, and it was shown that the injured employe was injured by an explosion, there was no recovery. It was held in a case where an ice company sought to indemnify itself against injuries to its employes, who were engaged in cutting ice, where the company had warranted in the policy that such was their only employment, that when the employes received injuries in the fall of an ice house, there could be no recovery. Where a policy described an assured's business as that of "wholesale dry goods and stock of merchandise" and stated that the machinery used was that usual to such buildings, it was held that injuries to an employe engaged in running machinery for polishing rusted cutlery, put in the building after the issuance of the policy, were not covered by it. It has been held in two identical cases, where a policy sought to indemnify one for injuries arising through a violation of statute, that there can be no recovery on such a policy. An employer must obey the law and not seek to relieve himself of liability by insurance.

It seems to be a well settled rule that where an insurance company assumes to conduct the defense when a company is sued by an injured employe, the insurance company cannot later attempt to escape its liability on a policy claiming that the injury was incurred in violation of the terms of said policy. This reasoning is along the line that the company, knowing the full facts of the case, is estopped to later deny its liability.

Where a lumber company described its business in a policy as operating a "sawmill, planing mill, mill yards, kilns, sheds, woodsmen, and teamsters" it was held that an employe injured while boring an artesian well did not come within the terms of the policy and hence there could be no recovery. In Massachusetts the compensation law makes no reference as to the liability of companies for injuries caused outside the limits of the commonwealth. It has accordingly been held that where an insurance company agreed to indemnify a manufacturer against loss either within or without the commonwealth, but where the policy made reference to the statute, the insurance company was not liable for a death caused by injuries received outside the limits of the state. These decisions show that the injury for which recovery is allowed must occur within the scope of employment, must not be the result of failure of the employer to obey the law, and must be within the terms of the insurance policy.

There is often a marked difference of opinion as to what employes come under an indemnity policy and the importance of this proposition cannot be over-estimated. In fact, it has caused the courts as much trouble as the question of what injuries are included within the terms of the policy. It is quite generally settled that an employe or his representative has no right of action against an insurance company, when based upon a policy issued to the employer; especially is this true of one who was not employed by the insured at the time when the policy was issued.

Where the names of the employes are entered on the face of the policy at the time the policy was issued, the courts have held that there can be no recovery in favor of an employe whose name was not shown on the policy. It was proved in one case that the employe killed had been employed several times and that a portion of his earnings was applied along with the rest toward the payment of the premium on the policy. But in the face of these facts, the court held that there was no remedy for the employe whose name was not shown. Where a policy is issued to cover employes of a certain building and the building is sold and the policy transferred with it, it has been held that the policy does not cover the case of employes who were not employed at the time the policy was issued. These considerations are of marked importance to every employer of labor and no man in such circumstances can afford to neglect consideration of them.

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* * *

EFFECT OF AUTOMOBILE DEVELOPMENT ON THE RAILROADS

During the past two years many railroad presidents have called attention, in their annual reports, to the fact that great inroads are being made by automobiles in the passenger business. Yet the railroads have found that the development of the automobile and automobile truck has been of great financial benefit to them. According to the *Railway Age Gazette*, this development has prevented the building of many branch lines. As good roads built by the state or county serve as feeders for all railroads that they cross, many rural districts are sending, by automobiles, to railroads forty or fifty miles away as much freight and passengers as the railroads would receive if branch lines were built. This makes it possible for the railroads to spend on the betterment of the existing lines the money that would otherwise have had to be spent for the building of the branch lines, and also prevents incurring interest charges that might be as large as the profits on the lines.

* * *

The number of electric steel furnaces in the world has about doubled in the past three years, and is now nearly three hundred. Thirty furnaces have been built in Great Britain since the war began, though it is said that this nation must have cheaper electric current to make the best use of them. Fifty were constructed in the United States in 1916, while Germany's output of electric steel rose from 90,000 metric tons in 1914 to 130,000 tons in 1915.

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THE TIME HAS COME FOR EVERY AMERICAN, DUG FROM WHATEVER CLAY, CAST IN WHATEVER MOLD, TO STAND UP AND BE COUNTED, FOR OR AGAINST HIS COUNTRY.[1]

AN ECONOMIC ALLIANCE OF NATIONS [1]

"The war after the war" is a phrase in common use to represent future conditions which some business men look forward to with anxiety and which others think will not come to pass. One financial authority says:

> The competition after the war between Europe and the United States is not going to be the bitter commercial struggle that is talked of.

The control of a large share of the world's trade by a gigantic political and financial combination is foreshadowed and will doubtless be effected, not by a futile trade war, nor by the setting up of high tariff walls; but through an economic alliance of nations, by carefully organized reciprocal trading arrangements, by eliminating wasteful competition and all expense that can be saved. "The war after the war" will be team work by a group of nations—a peace campaign conducted by centralized authority. The vital necessity of working together for their own protection during the war has been so clearly evident to the Allies that they would be foolish not to profit by their experience.

The overshadowing alliance will comprise the British Empire; France, already in close working relations with Great Britain; Russia, which has been financed during the war almost entirely by Great Britain and France; and some of the smaller nations. The moment peace is declared Germany will begin to work for the Russian trade—greatly aided by her proximity to Russian markets, her intimate commercial relations with Russia, and by the powerful influence of many Russians with German blood or affiliations.

We are the farthest away from all European markets, our productive costs are the highest, our war policy has established no claim to the gratitude, not even to the respect, of any European nation. We can enter into no combination; we cannot even make a working arrangement to protect our markets under present laws, for we have no margin to bargain with. Our tariff is now the lowest (average) since 1789.

In trying to forecast the future, two years seems a safe minimum period to allow for the closing of the war and for such adjustments as must be made by the fighting nations before conditions in Europe become normal. Important changes in public sentiment may take place in that time. War has revolutionized the attitude of the English people and their representatives toward many economic questions, and it may have a similar effect here. Incredible as it seems, Congress may even divorce the tariff from politics and reframe it on business principles. The Tariff Commission and the anti-dumping amendment represent a beginning.

[1] By Alexander Luchars, Publisher of MACHINERY.

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TOOL-ROOM SYSTEMS

The tool-room is the solar plexus of the manufacturing plant; disorganize the tool-room and the plant is knocked out. A good workman is judged by his tools, and by the same token one familiar with manufacturing practice can generally "size up" a shop as regards efficiency and excellence of product by an inspection of the tool-room equipment. Many of the troubles of apparently well equipped plants are due to lack of small tools and care of the tools provided. The tool-room is a comparatively new feature in the shop world, dating from the recent period when the journeyman began to use tools furnished by the master as well as those carried in his own tool-chest. In the early days the journeyman carried with him everything needed in his trade, but with the development of the manufacturing system this was no longer possible. When the master's tool-chest could no longer hold the extra equipment required by the workmen, the common tool-room came into existence. Then the shop began to furnish all the tools required on the machines, such as milling cutters, taps, drills, counterbores, reamers, saws, gages, and so on. The development of the plan of furnishing tools has been carried much further, and in some plants hammers, micrometers, try-squares and other personal tools are supplied to the men on checks, the same as the tools required for machining, fitting, testing and gaging.

The leading article in this number on tool-rooms is a review of the methods of caring for tools representative of the practice of American plants, the aim being to present a study of the typical tool-room and to include features of special merit found in a few.

* * *

GOVERNMENT DRAWINGS

Drawings furnished by the United States government to concerns undertaking the manufacture of shells, fuses and other munitions of war leave much to be desired. Those responsible for government drawings apparently have not seen fit to take a leaf from the practice of up-to-date manufacturing concerns, and their draftsmen are still making drawings of the form common in manufacturing plants thirty years ago. Instead of making detail drawings on small sheets convenient to handle and read, they still follow generally the practice of showing all details on one sheet. This means that unnecessarily large blueprints must be handled when studying details of the parts, and that each workman must be given a large blueprint, or that it must be cut up and handed out in a mutilated condition. The practice is inefficient and time-wasting to a degree; it should be avoided in manufacturing practice altogether.

Another bad practice common in government drawings is making very fine lines, which, when poorly blueprinted, are almost undecipherable. This, coupled with the fact that the draftsmen seem to have a deep-rooted aversion to drawing more lines than are absolutely necessary, makes the study of government drawings anything but a pleasant task. We recently saw drawings of the U. S. Navy 14-inch armor piercing shell, and were able only after a long study to understand its comparatively simple structure. The draftsman had shown in one view what properly should have appeared in two or three views. What valid reason there can be for practices like this is not easily comprehended. It leads to the question, how can government departments be kept up-to-date? How can they be kept from becoming fossilized and behind the times? It is a big, vital question that concerns the welfare of every citizen.

ADVANTAGES OF DIRECT SELLING

BY JAMES N. HEALD [1]

In marketing machine tools, there are both advantages and disadvantages in selling direct, and these must be weighed in connection with the kind of machine being handled when determining which method is better. If a manufacturer is building a machine like a lathe or a sensitive drilling machine, in which case there are likely to be many competing manufacturers whose products go into shops of all kinds from a machine-tool factory to a small repair or job shop—it is probable that the wisest plan would be to secure the best machine-tool dealer available in any given section and assist him as far as possible by doing good advertising work. If, on the other hand, a manufacturer is building a special machine for a particular line of work, such as a grinding machine or an automatic turret lathe, in the sale of which considerable engineering information is desirable, it is probable that selling direct through the manufacturer's own representatives will be preferable. Persons who are considering the purchase of such machines will want detailed information with regard to the output that can be expected or guaranteed, the method of tooling up the machine, the best way of chucking or holding the work, etc. They may also want a demonstrator to get them started properly in the operation of the machine.

When a manufacturer contemplates buying a lathe, drilling machine or planer, he usually feels that, if the tool appears to be properly made and of good design, his men will get out of it all that he can properly expect; but in the case of a special machine—and this is particularly true in regard to grinding machines—he wants to secure the greatest possible amount of information concerning the output that the manufacturer will guarantee, the amount of stock to be left for grinding, the best way of chucking the work, the type of wheel-head that will best cover his range of work, and so on. This information can satisfactorily be given only by the manufacturer's own representative, who has assembled these machines in the factory, run them in under belt, and has operated them for weeks or months on regular commercial work in the company's own factory. Furthermore, the manufacturer's representative in going from shop to shop, sees a great variety of work being handled on these machines and various methods and schemes in operation for handling it. He can, therefore, give the prospect he is calling upon valuable information and suggestions in connection with the work; and there is hardly anything more convincing to a person who is considering the purchase of a machine than definite and exact information as to how work of similar character is being handled in another factory and exactly what results are being secured, both as regards output and quality.

There is another aspect of this proposition. The manufacturer of a lathe, for instance, in a certain territory secures the best representative possible and then takes the business sent him by that dealer as the amount that he can properly expect from that section. In other words, the manufacturer must be content with the business that the dealer receives from his own clientele. The manufacturer of a specialty, however, cannot be satisfied with the orders that would come from the regular customers of one dealer only. Instead, he feels that he is entitled to the business that would come from all the customers in that territory who could use his machines. These, of course, are not the regular customers of any one dealer, but are divided up among all the dealers in a certain territory. In many cases, the buyers are in the habit of making most of their purchases from the dealers with whom they are on most intimate terms. Therefore, the specialty manufacturer who is pushing his business to the limit to secure everything that he thinks should come his way, wants the business that will come from all the customers in that territory and not from those that are natural traders with some one machine-tool dealer, no matter how good an organization or how satisfactory any particular dealer may be to do business with in the regular lines.

The ordinary machine-tool salesman is trying to sell thirty, or more, different tools and when asked in regard to numerous details of different machines, he must perforce refer to his catalogues and literature to seek the answer—he cannot carry all these details in his head. In the case of a special line, like grinding machines, should the prospective buyer pick up a bushing and ask one of these salesmen how many he will guarantee to grind per hour, how much stock should be left for grinding, and whether this or that operation should be done first, about all the salesman can say is that he knows "it is a mighty fine machine," and that he will take up the matter with the manufacturer and will let the buyer know as soon as he can hear from the factory. When the machine-tool builder is selling direct, his representative can answer such questions promptly because he has been in the factory and has seen the machine built; he has taken it apart and has put it together; he has been in other shops where work just like this is being done and, perhaps, has ground similar pieces in his own factory before going on the road. He can therefore give the customer information regarding the machine, its operation, and its output that is absolutely convincing; and because in the case of grinding machines a great amount of information is needed among the trade, this knowledge of the manufacturer's representative is always exceedingly welcome.

The manufacturer's representative, as he is passing along, will often see work lying on the floor of the shop that ought to be put on a grinding machine instead of being finished as it is, and oftentimes his suggestions lead to a sale of machines for work that the customer or his superintendent had never thought of finishing in this manner, and which proves to be a most economical change in manufacturing methods.

The manufacturer's representative is always looking for points in connection with the sale of grinding machines and grinding machines only, while the ordinary machine-tool salesman is likely, upon meeting the purchasing agent or the superintendent, after passing a few remarks about the weather, to ask, "What is on your mind today?" and so far as the salesman is concerned, it does not matter whether it is arbor presses or milling machines. He is willing to talk about either and will finish his call and go away perfectly satisfied without having mentioned grinding machines at any time during his call. Therefore, the method of direct selling has a good many of the advantages that we get in a single-purpose machine tool, so far as efficiency in that particular direction is concerned.

It may be argued that the manufacturer can send out a representative to work in connection with the dealer and his salesmen, and in that way the advantages of both systems can be secured. This plan, however, does not work out satisfactorily, as experience has proved. In the first place, the writer repeatedly has seen the condition develop of the dealer's salesman giving the customer insufficient and incorrect information rather than asking the manufacturer's representative to go with him to see the person making the inquiry. The dealer's salesman seems to think that it is a reflection upon his selling ability if he asks the manufacturer's representative to go with him and assist in giving the information wanted. He will run the risk of losing the order on account of insufficient information rather than to ask assistance from the manufacturer's representative. In many cases this is not knowingly done, because the salesman does not appreciate how incomplete the information really is that he furnishes.

Another difficulty in this scheme of working together develops in this way. When the manufacturer's representative goes to a certain city, he calls at the dealer's office and inquires what he can do for him in that section. The dealer will probably tell him of some places where it would be well for him to go, but they are all among the dealer's regular customers—none among the people who regularly buy of the other dealers in that section; yet those are really the ones who need going after the most.

If however, the manufacturer's representative starts out independently to canvass the territory, street by street and shop by shop, what is the result? He will, after a time, run across a person who becomes interested in the machine. They talk over the advantages and various points, and the pros-

[1] Treasurer and General Manager, Heald Machine Co., Worcester, Mass.

pective customer becomes interested in having one of these machines in his factory. He then says, "Now what is the best price and terms you can give me?" The manufacturer's representative is then at the end of his rope; he is not supposed to quote prices and give terms; he does not know what terms that particular customer usually receives from the manufacturer's agents in that section. He may have been getting a certain period of time in the past, or the agents may insist on his paying cash, or they may require a lease before they will sell him machinery, or they may have had trouble in regard to other sales and are not anxious to sell him at all, and finally, he may be a person who has not bought machines from them before. The manufacturer's representative can only say, "I will have one of our agent's salesmen see you about the matter of terms, etc.," which is exceedingly unfortunate because the time to make a sale is when the customer is in the mood, and a day or two later when the other salesman comes around, probably alone, the prospect has changed his mind, or other questions have come up that the manufacturer's representative could answer satisfactorily, but the dealer's man cannot, and then the sale hangs fire and often falls through entirely. Therefore, the company with which the writer is associated feels that after its man has gone out and brought the prospect to the point where he is ready to place an order, the salesman might as well take the order, as for him to drop the matter at the most vital point and turn it over to another person who must be paid a commission greater than what it then costs to carry out the remainder of the deal.

Another objection to selling through a machine-tool dealer is that sometimes the customer is sore on account of having had something "put over on him" by the dealer a month or a year previous with regard to the sale of a second-hand machine, or on account of some dispute as to settlement of account, or concerning equipment that was not furnished on a machine, and does not want to buy from that dealer. Direct selling obviates this difficulty, and in many cases the customer feels that if trouble should develop with the machine, he can, perhaps, get fully as prompt service in buying direct from the manufacturer as he would if bought in a less direct manner.

With regard to the cost of direct selling, the writer would say that the company with which he is connected has found that the selling expense has been considerably less than the commission allowed the dealer for selling in the same territory. He believes, however, that the advantages of working directly among the users in any section are great enough to warrant paying more money for this service, if necessary, than the dealer's commissions would amount to, because it is difficult to measure exactly the value of work of this kind, and the general results obtained over a period of years are really the only test.

In closing it will be proper to mention one limitation of this proposition, which is, that it is not advisable to carry the direct-selling plan into effect in districts where the number of machine purchasers is small, or a great distance from the factory, such as in the South and on the Pacific Coast. In such sections it is more convenient for the manufacturer to work with the regular machine-tool dealer; but in thickly settled sections the method of direct selling, under certain conditions, seems to the writer to produce more satisfactory results, and to be more advantageous in many ways if one is manufacturing a special tool similar to those mentioned.

* * *

MACHINE HOUR RATES

BY C. C. GRAY [1]

The records of machine-tool operating expense included in the article on "Reversing Planer Motors" in the November number of MACHINERY were obtained from machines operating on entirely different work, in various sections of the shop. The widely varying cost of supervision and clerical work is due not alone to the fact that the machines were doing different work, but also to the fact that they occupied varying areas of floor space, on which basis the proportion of salaries, etc., is estimated. The following explanation of how to compute machine hour rates, as practiced by a number of companies in this country, may serve to illustrate the point.

Every shop, in addition to workmen's wages, has other expenses, such as interest and depreciation on cost of buildings and accessories; repairs and renewals to existing equipment; general operating expenses, including losses due to defective workmanship, design, and material; and salaries of supervisors, engineering staff, and clerks. These overhead charges must be included in the cost of every article manufactured. A method frequently employed is to determine, from time to time, the percentage that the total charge bears to the cost of the total or actual productive labor and then obtain the total labor charge by multiplying the actual labor cost by 1 plus the percentage to be added for overhead charge. This is an easy way to take care of overhead, but is inaccurate and does not show the relative importance of different types and sizes of machines, especially where a great variety of materials is manufactured in shops using a large number of different types and sizes of tools. Under such conditions, the percentage varies within wide limits for different kinds of work.

One of the most satisfactory methods of distribution is to set off against each machine its proportion of the total overhead charge. The portion chargeable to each depends entirely on local conditions, and thorough familiarity with the conditions is needed in order that the charges may be apportioned equitably. In a shop where only one type of article is manufactured and castings are passed directly from one machine to the next, a simple and logical plan is to divide the total overhead charge among the machines in proportion to the floor space charged to each. Such conditions, however, do not exist in the majority of shops, as usually several sizes and kinds of articles are turned out and various sizes and types of machines, differing greatly in their operating characteristics, are used. In most cases, not only must the floor space be considered, but also the time each machine is actually in operation, the nature of the work being done, and the amount of supervision and engineering attention needed. Large shops that handle different classes of materials, as a rule, are divided into departments or sections, each of which may be considered as a separate smaller factory. Thus the overhead charges against each department or section may be apportioned among its tools in proportion to the floor space occupied, proper allowance being made for special local conditions or supervision and engineering attention. In making an analysis of the method for determining the hourly overhead charges, or machine hour rates, per machine tool, it will be found that these overhead charges may be grouped into three main classes, as follows: charges against the entire factory, charges against each section or department of the factory, charges against each machine tool.

Charges against the entire factory are: fixed charges, or interest and depreciation, taxes and insurance on buildings, grounds and accessories; variable charges, or repairs and renewals on building and accessories (omitting all charges that can be set off directly to a particular section of the factory); charges against store-room and tool-room, defective design, material, or workmanship; and salaries not chargeable to a definite section, including cost of superintendence, engineering and drawing, and clerical force, including office boys and general laborers.

Charges against each section or department of the factory are: fixed charges, which include an equitable portion of the total factory fixed charge, and interest and depreciation on auxiliary apparatus located in the section; variable charges, which include a portion of the variable charges as well as similar charges belonging to the section, such as repairs and renewals, store-room and tool-room charges, defective design, material, and workmanship, lubricants, and manufacturing supplies; and salaries, including a portion of the total salaries as well as those belonging exclusively to the section; that is, formen, clerks, errand boys, laborers, crane-men, etc.

Charges against each machine tool are: a portion of the fixed charges, of the variable charges, of the salaries charge, interest on cost of machine-tool taken at 6 per cent, depreciation in value of machine-tool, and cost of power to operate tool, including lighting and crane service.

[1] Address: Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.

GAGING AND INSPECTING GEARS[1]

FIXTURES FOR TESTING PITCH, PITCH DIAMETER, TOOTH SHAPE, TOOTH THICKNESS AND CONCENTRICITY

BY DOUGLAS T. HAMILTON [2]

GEARS are inspected during the process of manufacture to determine if the shape, diameter, width, tooth forms, etc., are correct within the required tolerances, and they are also given concentricity tests. Gears in which the teeth are not concentric with the hole or are unevenly spaced are noisy, especially when they are operated at high speeds. The teeth, therefore, receive the most careful attention in the inspection department, as the efficiency of a gear under actual working conditions is governed more by the shape and accuracy of the teeth than any other one factor. In this connection, the tooth shape, pitch and pitch diameter are the three most important points to consider. In the following, attention will be directed chiefly to the testing of the teeth in spur, helical, bevel and worm gears.

Inspecting Gear Blanks

The methods of testing blanks for spur gears do not differ from those for testing many other interchangeable parts, in which plug gages, snap gages and regular micrometer calipers are used. For inspecting bevel gear blanks, these tools are employed in connection with properly shaped templets. The type of inspection tool, of course, is governed to a large extent by the character and shape of the work. An important point in machining blanks for spur gears is to have the sides finished accurately in relation to the hole, so that the arbor on which the gears are held, especially when several are mounted together, will not be sprung out of truth. A satisfactory means of testing this is to place the gear blank on an accurate arbor held on centers, and rotate it past the spindle point of a dial test indicator. In testing the shape of gears, when a bevel surface, etc., is to be produced, a templet is generally employed if great accuracy is not essential.

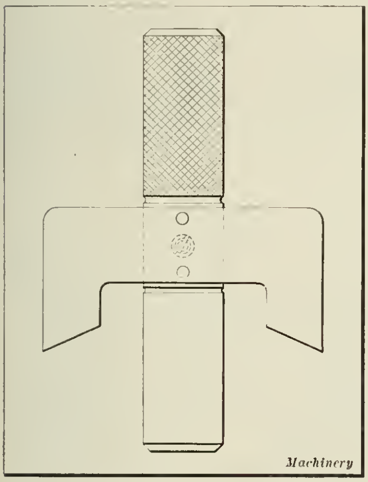

Fig. 1. Combination Plug and Templet Gage for inspecting Bevel Gear Blanks

Templets for Gear Blanks

As has been previously mentioned, spur gear blanks are inspected by regular plug and snap gages or micrometer calipers. Bevel gear blanks, on the other hand, require some form of templet for testing the relation of the angular faces to the hole and to each other. One form of templet gage for bevel gear blanks is shown in Fig. 1. Reference to this illustration will show that this gage comprises a central plug which fits in the hole in the gear blank, and a templet fitting in a notch cut in the plug. This notch is cut to the center so that the flat gaging face of the templet and the axis of the plug coincide. With this device it is possible to test the truth of the hole with relation to the angular face of the gear, and at the same time inspect the angle of the face.

A convenient form of miter gear templet is shown in Fig. 2. This is made of sheet steel, and completely encloses the gear,

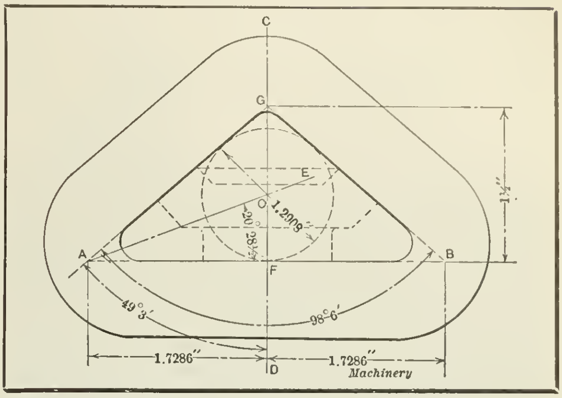

Fig. 2. Templet for inspecting Miter Gear Blanks

thus controlling both the angular face and the over-all length. In laying out this form of templet, the first step is to find the center of a circle which will touch all three sides of the isosceles triangle as shown by the dotted outline. This is a simple problem in trigonometry, as is shown by the illustration.

Bevel Protractor for Testing Bevel Gear Blanks

The ordinary bevel protractor familiar to all mechanics is commonly used for testing bevel gear blanks. A special application of this principle is shown in Fig. 3. This device consists of two hinged bases carrying sliding blocks, in which studs are held for supporting the gear blanks being tested. In addition to having regular protractor graduations for setting the gear axes to the required angle, graduations are provided for showing the longitudinal settings of the sliding blocks on the two arms. These longitudinal graduations, however, cannot be used to advantage as a measurement of the center distances of bevel gears, but by swinging the movable arm back to an included angle of 180 degrees, the device could be used for spur gears. As the angular face of a bevel or miter gear is of prime importance, two blanks could be held in this fixture and rotated together, to test for concentricity and correctness of angular face.

Gear Tooth Templets and Calipers

The simplest form of gear tooth templet is shown at *A* in Fig. 4. This is a piece of sheet steel with a slot in its lower end equal in width to the thickness of the tooth at the pitch line and of a depth equal to the height of the tooth from the pitch line. The chief objection to this templet is that it wears quickly at the sharp corners *a* and soon becomes inaccurate. *B* shows a form of templet which is used chiefly for bevel gears and is more like a scriber than a templet. It is used to scribe

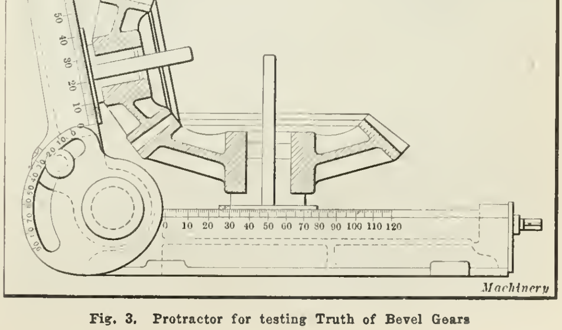

Fig. 3. Protractor for testing Truth of Bevel Gears

[1]For previous articles on gaging and inspecting, see "Gaging and Inspecting Threads" in the February and March, 1917, numbers of MACHINERY and articles referred to in connection with the first installment.
[2]Address: Fellows Gear Shaper Co., Springfield, Vt.

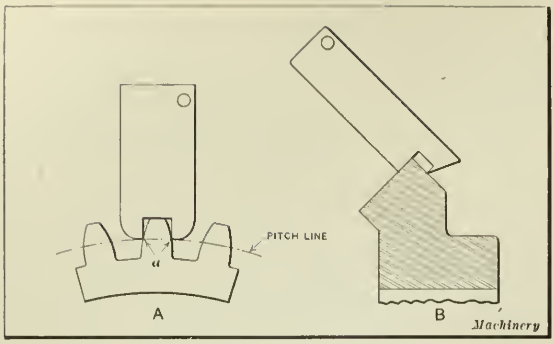

Fig. 4. Templets used in cutting Gear Teeth

a line on a gear indicating the depth to which the teeth are to be cut at the rear or large end. It is used only when a few gears of one size are to be made.

Gear Tooth Caliper

The gear tooth caliper shown in Figs. 5 and 6 is a widely used tool in the shop for measuring gear teeth, especially after cutting the first tooth. This test is especially desirable if there is any doubt about the accuracy of the blank diameter. (The outside diameter of a gear blank can be found by adding 2 to the number of teeth and dividing by the diametral pitch.) To test the tooth thickness, two trial cuts are taken for a short distance at one side of the blank until a full tooth is produced. The vernier scale of the caliper is set so that when

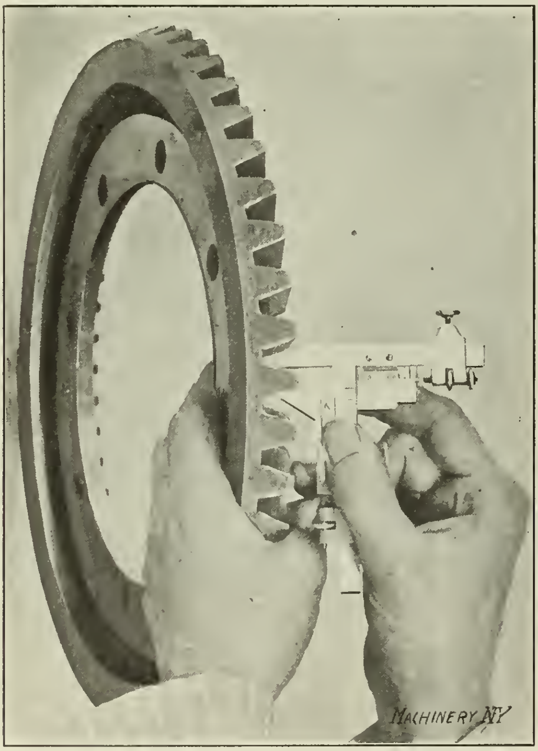

Fig. 5. Brown & Sharpe Gear Tooth Caliper in Use measuring Tooth of Bevel Ring Gear

it rests on the top of the tooth, as shown in Fig. 6, the lower ends of the caliper jaws will come to the pitch circle. The horizontal scale then shows the chordal thickness at this point. When a gear tooth is measured with this caliper, the chordal thickness T (see detail of the tooth) is obtained, and not the thickness along the pitch circle. Hence, when measuring teeth of coarse pitch, especially if the diameter of the gear is small, dimension T should be obtained. It is also necessary to find the height x of the arc and add it to the addendum S to obtain the correct height H, in order to measure the chordal thickness at the proper point on the sides of the tooth.

If a = one-half the angle subtended from center of gear by one gear tooth; N = number of teeth in gear; T = chordal thickness of tooth at pitch line; and R = pitch radius of gear; then:

$$a = 90 \text{ deg.} \div N; \; T = 2R \times \sin a$$

The height x of the arc equals 1 minus the cosine of angle a, multiplied by the pitch radius of the gear, or expressed as a formula, $x = R\,(1 - \cos a)$. The vernier scale is therefore set to the dimension H, or x + addendum S.

Tolerances for Spur Gears

The three most important factors in a gear are the profile of the teeth, pitch diameter and center distances. The outside diameter is not so important, as there is always clearance provided at the bottom of the teeth. Tolerances should be

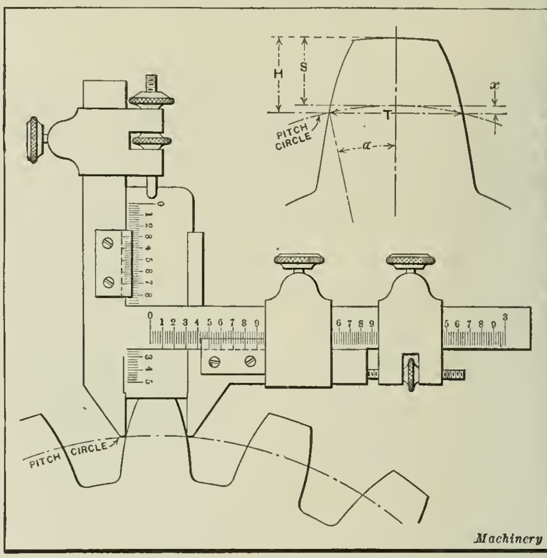

Fig. 6. Diagram illustrating Calculation Necessary to determine Thickness of Tooth with Caliper shown in Fig. 5

based on the pitch, and the accompanying table gives the tolerances for gears from 16 to 4 diametral pitch. The tolerances on the shape of the teeth when they are of the involute form depend upon several factors. In the first place, if the gears are to transmit a heavy load at comparatively high speeds, and the noise is to be reduced to a minimum, the tooth curves must be as accurate as it is commercially possible to make them. On the other hand, if the gears are to run at slow speeds and noise is not objectionable, much wider tolerances are permissible. On the average run of good gears, especially for automobile transmissions, an endeavor is made to hold the involute curve to tolerance of 0.0005 inch. The variation in tooth spacing should not exceed 0.002 inch if the best results are to be expected. Gears having ground teeth, however, are held to closer limits than this for spacing, usually 0.0005 inch. This is especially true of gears used in torpedoes.

MANUFACTURING TOLERANCES FOR SPUR GEARS

Pitch	Center Distance	Pitch Diameter	Outside Diameter Blanks.
16	± 0.002	— 0.003 to — 0.005	0.000 to — 0.005
14	± 0.003	— 0.004 to — 0.006	0.000 to — 0.005
12	± 0.0035	— 0.0045 to — 0.007	0.000 to — 0.006
10	± 0.004	— 0.005 to — 0.008	0.000 to — 0.006
8	± 0.005	— 0.006 to — 0.009	0.000 to — 0.007
6	± 0.006	— 0.007 to — 0.010	0.000 to — 0.008
5	± 0.007	— 0.008 to — 0.011	0.000 to — 0.010
4	± 0.008	— 0.009 to — 0.012	0.000 to — 0.015

Machinery

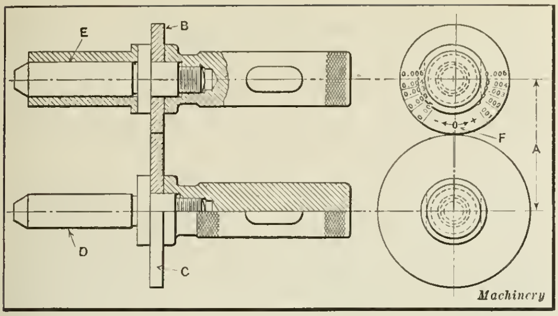

Fig. 7. Special Plug Gage for gaging Gear Center Distances

Tolerances for Bevel Gears

In mounting a bevel pinion which must run in proper mesh with a ring gear, it is essential that backlash be provided for to prevent crowding the teeth. The apex angles of the pinion and ring gear are frequently held to limits as close as 0.005 inch. For gears that are hardened, however, it is necessary in some cases to allow a greater tolerance than this to take care of warpage which causes a change of the angle of the bevel gear. When this is done it is usual to allow for a reasonable amount of backlash between the teeth, the limits varying from 0.005 to 0.007 inch, and never exceeding 0.010 inch. This means that a bevel gear must be straightened before being assembled if the warpage is in excess of the amount given; otherwise, it will be noisy in action and inefficient.

The tolerances on the teeth of bevel gears are dependent upon the uses to which the gears are to be put. Generally the tooth curves are held to within 0.002 inch and the spacing of the teeth to the same tolerance. As previously mentioned, however, when a gear is hardened, the tolerance, of necessity, must be greater than this to provide for warpage of the teeth.

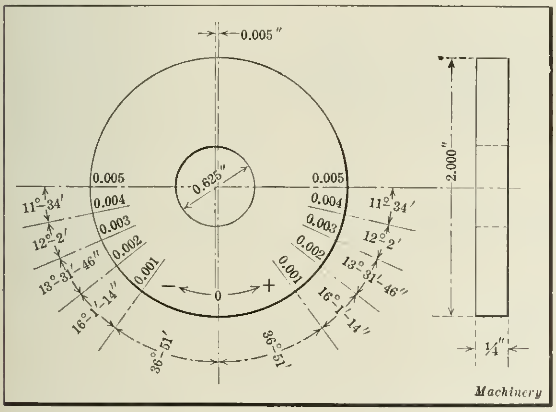

Fig. 8. Enlarged View of Graduated Disk B shown in Fig. 7

Bevel gears of the straight-tooth type, when used in automobile transmissions, are generally run in, using emery and oil to grind down any slight irregularities in the teeth due to warpage in hardening.

Testing Center Distances of Spur Gears

As has been previously mentioned, the center distances of spur gears which must run quietly is an important consideration in the cutting of gear teeth. Fig. 7 shows a simple but effective gage for testing the center distances of spur gears. The gage consists chiefly of two accurately ground collars *B* and *C*, which are held on plug gages *E* and *D*, as shown, the former being provided with bushings to suit the diameters of the holes in the gears.

To illustrate the use of this tool, we will assume that the center distance *A* is 5 inches. The collars *B* and *C* are made so that the sum of their combined radii will equal this amount. In other words, collar *B* could be 2 inches and *C* 8 inches in diameter. Referring now to Fig. 8, which shows the angular spacing for variations in the center distance of the gears, we will assume that *F* represents the zero or datum line from which the center distances are measured. It is now evident that if we turn graduated collar *B* through an angle of 36 degrees, 51 minutes in a clockwise direction, the center distance is + 0.001 inch. Similarly, if collar *B* is turned the same amount in a counter-clockwise direction, the center distance will be — 0.001 inch. If the collar is rotated through an angle of 90 degrees in either direction, the center distance will be + 0.005 inch or — 0.005 inch, depending upon the direction in which the collar is turned. By making a series of plain collars to replace collar *C*, any required center distance can be measured to very accurate limits.

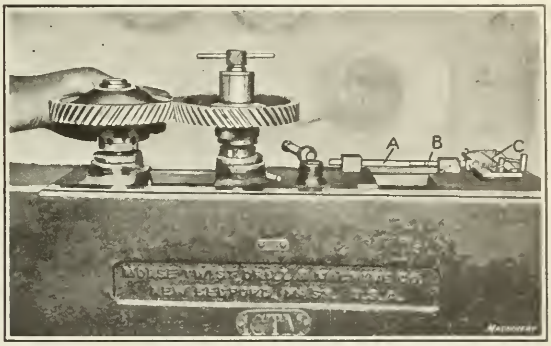

Fig. 9. Standard Fixture for testing Concentricity and Center Distances of Spur Gears

Testing Pitch Diameter and Concentricity of Spur Gears

Many interesting fixtures have been devised for testing the pitch diameter, center distance and concentricity of spur gears. A standard fixture used for this purpose which is built by the Morse Twist Drill & Machine Co., New Bedford, Mass., is shown in Fig. 9. This fixture consists principally of a base carrying one fixed and one movable slide, each slide carrying a stud on which the gears to be tested are held.

The gear held on the stud in the fixed slide is usually a carefully cut, and sometimes ground, master gear, which is brought into mesh with the gear to be tested. The movable slide carries a rod *A*, which contacts with a rod *B*, the latter operating an indicating needle *C* through a multiplying lever arrangement. When the center distance as well as the concentricity of the gear is to be tested, the movable slide is set to the required center distance by means of a vernier scale on the bed; then when the gears are rotated, any inaccuracies in either center distance or concentricity are noted on the scale over which the indicating needle moves. If it is desired to test concentricity only, no attention is paid to the vernier, and the gear to be tested is kept in contact with the master by a spring, not shown, the latter being rotated and the fluctuation of the needle noted.

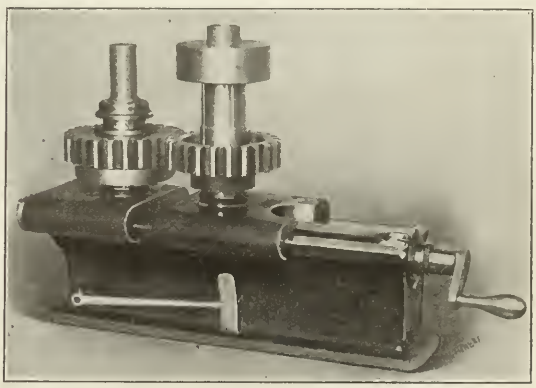

Fig. 10. Fixture for testing Pitch Diameter and Concentricity of Spur Gears

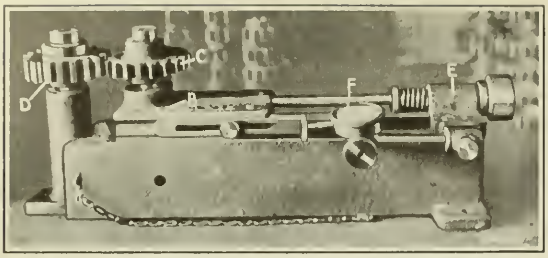

Fig. 11. Fixture for testing Concentricity of Transmission Gears

Fixture for Testing Pitch Diameter and Concentricity of Spur Gears

Another simple but accurate fixture for testing the pitch diameter and concentricity of spur gears is shown in Figs. 10 and 12. The fixture consists of a cast-iron base upon which two accurately fitting slides are held, each slide being provided with a stud for holding the gears being tested. The right-hand slide is moved by means of a long adjusting screw, while the left-hand slide has only a limited movement, but transfers its motion greatly magnified to the indicating needle shown. The sectional view, Fig. 12, shows how the motion is transferred to the indicating needle, which measures the difference in concentricity and errors in mesh to 0.00039 inch.

To detect differences in eccentricity, it is most convenient to place the gear to be tested on the spindle carried in the left-hand slide, and to use a blank with a single tooth on the other. This single tooth is then meshed in succession with all the teeth of the gear under test, and by observing the different positions of the indicating needle, it is possible to determine the eccentricity with great accuracy.

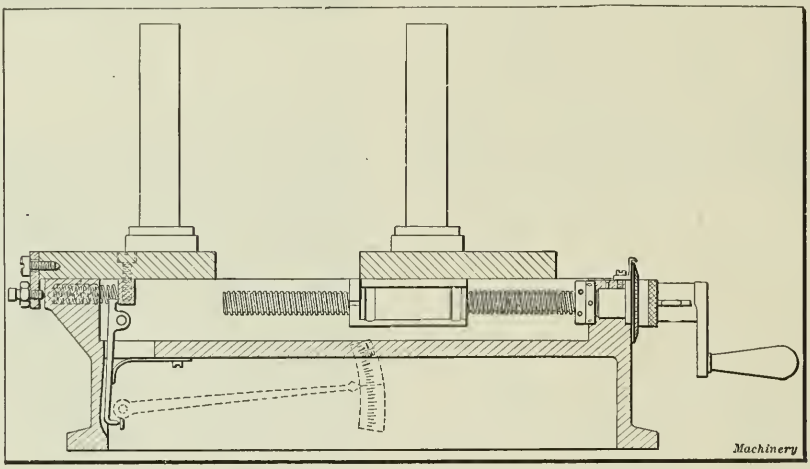

Fig. 12. Sectional View showing Construction of Fixture shown in Fig. 10

Another spur gear testing fixture differing only in a few minor details from that shown in Fig. 9 is illustrated in Fig. 11. This fixture comprises a base A carrying a slide B on which a stud is mounted for holding the gear C to be tested. The master gear D is carefully ground all over, and is held on a fixed stud on a projection boss of the fixture. Slide B is adjusted by a screw to bring the gears into mesh, the screw being a sliding fit in the boss E of the fixture. This screw carries a washer as shown, and between it and boss E is a stiff open-wound spring which serves to keep the gears in mesh with the required tension. The movement of slide B, which indicates irregularities in the teeth or lack of concentricity, is read off on the dial test indicator F, mounted as shown and operated by a bracket adjustably mounted on the movable slide B. Transmission gears for automobiles are generally held to a maximum eccentricity of 0.003 inch.

Power-driven Gear Testing Fixture

Another gear testing fixture for automobile transmission and timer gears is shown in Fig. 13. In this case the fixture is power-driven. Briefly, it consists of a cast-iron plate A ribbed at the bottom and machined on the top surface; a cast-iron plate B with a projecting arm C on which is secured a shoulder stud D; a cast-iron segment plate E drilled and reamed at one end to fit fulcrum stud D, and having at the opposite end a shoulder stud F on which revolves a master gear of the same pitch as the gear to be tested; an indicator pointer G drilled to pass down over fulcrum stud D and axle stud F; a graduated brass plate I secured to the base A; and a shaft J, the lower end of which revolves on a stud beneath the plate B. To this shaft is secured a worm-wheel, and on the part which projects above this worm-wheel the gear to be tested is rigidly secured by means of a key.

The worm L is made of machine steel, casehardened, and is driven by a ½-inch half-round belt passing over pulley M. A steel spring N is fastened to plate B and index hand G. The segment plate E is machined on its bottom face, which slides on the upper face of plate B. On the upper face of plate E rests the index hand, and on top of this is a steel washer around axle stud F. On this washer rests the master gear, which is perfect in every respect. The gear to be tested is revolved by power in the manner indicated, and any irregularity in the diameter is shown on the graduated plate.

Fixture for Testing Concentricity and Thickness of Teeth of Transmission Gears

A gear testing fixture designed especially for handling transmission gears and capable of adjustment so that it can handle various sizes is shown in Fig. 14. The gear to be tested is held on a bushing provided with a squared shank, which is inserted in the holder A; this holder is provided with a corresponding square hole and held down in the fixture by means of plate B. An ejecting mechanism comprising a handle, as shown, is provided for raising the spindle of the arbor out of the bushing when it is desired to remove the latter. The testing device consists primarily of a slide C carrying two teeth of a rack D. The latter is held to the slide by means of screws, as shown, so that it can be removed and rack teeth of the desired pitch and shape substituted to suit the work to be handled. The testing is done by means of a Lowe test indicator which is held on bracket E. This indicator is constructed somewhat differently from that ordinarily supplied, the shank being cut off short, as shown, and the multiplying lever F bearing against pin G, which is driven into movable slide C. A handwheel H attached to a shaft which carries a pinion I meshing in a rack in the lower surface of the slide is used for adjusting it back and forth to suit the size of gear being tested. It will be understood, of

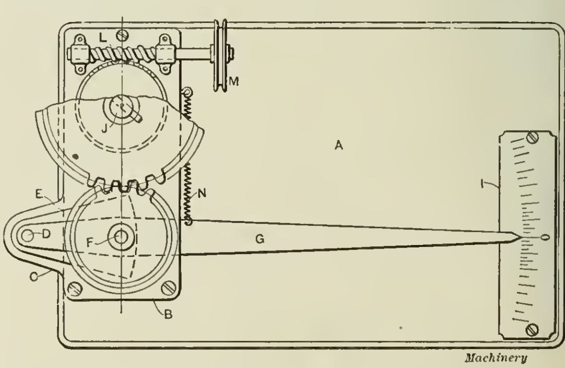

Fig. 13. Fixture for testing Truth of Cut Gears by revolving with a Master Gear and noting Change in Center to Center Distances

course, when testing the gear that after the latter has been placed on the arbor and the arbor inserted in the hole in the bushing A, handwheel H is operated to bring the rack teeth D up in contact with the gear. The gear is then rotated by hand and the movement of the indicator K noticed, and if the gear runs out more than $\pm$ 0.0015 inch it is rejected. This indicator, of course, is set by means of a master ground gear.

Fixture for Testing Concentricity of Pinion Shafts

An interesting fixture for testing the concentricity of pinion shafts is shown in Fig. 16. This comprises a base A carrying a tailstock and headstock B and C, respectively; in tailstock B is a rigid male center, and in headstock C an indicating center. The pinion shaft E to be tested is mounted on these two centers. Located in a plane at right angles to the slide of the main body of the fixture is a slide F, which carries the master gear G and a dial indicator H. The teeth in the pinion are kept in mesh with the master gear by means of a spring behind slide F. A bracket on the rear side of the fixture carries a second dial indicator I, the spindle of which is brought in contact with the ground bearing of the pinion shaft. The third indicator shown projecting from the headstock at J, and shown in detail in Fig. 15, is of the multiplying lever indicating type.

As shown in Fig. 15, this indicator comprises a sleeve A, which is made a good fit for the hole in the headstock C, Fig. 16. It carries a cone-pointed bushing B, which projects from the headstock, the pinion shaft being tested having a hole so that the cone bushing supports it on the opposite end from the rigid center. It should be mentioned that the cone-center in the hole has been ground by locating the pinion shaft from the bearing at the rear of the pinion. Sleeve A, Fig. 15, is slabbed down on the front end and machined to carry the indicating needle C. This, as shown, carries an indicator point D, which can be adjusted to suit the diameter of the hole in the work and is locked by the nut shown. The rear end of needle C is pointed and moves over an index plate E, which is provided with graduations spaced 0.069 inch apart. The multiplying lever has a ratio of 1/8 to 8 5/8 inches, or 69 to 1, so that each graduation on the scale represents 0.001 inch error in the work. The tolerances on this part are: concentricity of pitch circle of teeth, $\pm$ 0.0015 inch; tolerance for eccentricity of bearing, $\pm$ 0.0005 inch; tolerance for eccentricity of hole, $\pm$ 0.0005 inch.

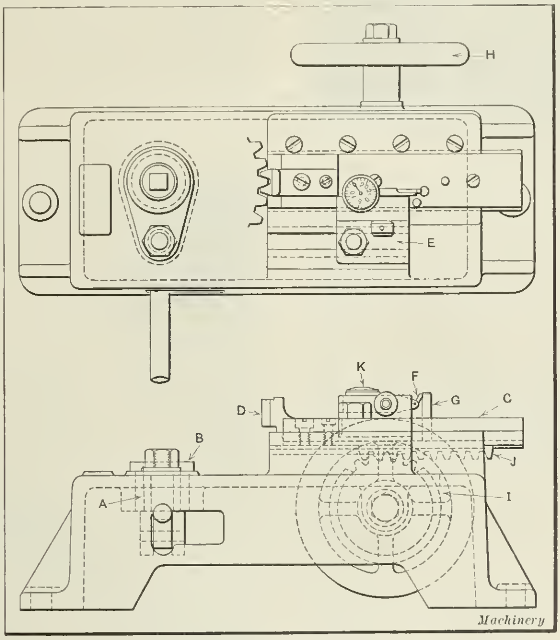

Fig. 14. Fixture for testing Concentricity and Thickness of Teeth of Transmission Gears

In operation, the pinion E, Fig. 16, is located between the centers, screw K being adjusted to eliminate end play between

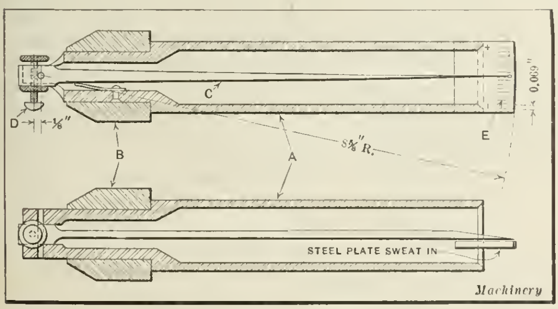

Fig. 15. Details of Multiplying Lever Indicator J, Fig. 16

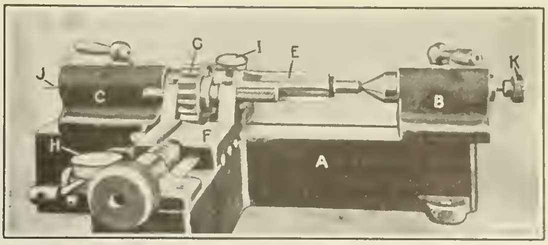

Fig. 16. Fixture for testing Concentricity of Pinion Shaft

the centers. The pinion shaft is then rotated in mesh with the master gear, and the various indicators show the following results: indicator H tests the accuracy of the pitch diameter and spacing of the teeth; I tests the concentricity of the bearing in relation to the hole; and J tests the truth of the hole in relation to the shank bearing diameter. In this way each important part of the pinion shaft can be tested and held to close limits. On gears of this type the maximum eccentricity is 0.003 inch.

Precision Spur Gear Testing Fixture

Fig. 17 shows a precision gear testing device for spur gears. It tests the following elements of the gear: pitch diameter; truth of pitch diameter with hole; thickness of teeth on the pitch line; and parallelism of teeth with axis of gear.

In this fixture revolving stud A is mounted in a fixed position and forms a basis from which the principal dimensions are checked. The removable plug B, which is mounted on the sliding block C that slides in the ways D, is located in relation to stud A by the locating pin E. Blocks C and F are connected by two bolts, only one being visible in the illustration. One end of the bolts is screwed into block C, while the other end is a free fit in block F. The blocks are normally separated by two springs on the bolts, the function of which will be explained later.

The indicating mechanism G is located in relation to plug B by the vernier H. The scale of the vernier is fastened to block C, while the vernier is fastened to part I, making it integral with the indicating mechanism. The vernier and indicating mechanism are adjusted by nuts K. The part J is secured in the T-slot by the nut directly below it, and is adjustable along the slot, which extends the full length of the fixture. The indicating mechanism and vernier are locked by nuts L; the indicating mechanism is adjusted vertically on the pillars M and secured by thumb-screws N.

In operation, a master gear is placed on driving stud A, and the gear to be tested on plug B, being free to revolve on the latter. The locating pin E is then inserted in the proper hole along the edge of gib O, thus locking block F securely and locating the two blocks in the proper relation to each other. The gear is now revolved by the master gear, which is rotated by a handle on the squared end of the stud. The indicator then shows if the teeth are concentric with the hole, and if the pitch diameter is correct. While block F is locked to gib O, block C is free to move within certain limits. This movement is indicated on dial P by the multiplying levers. If the size of the gear varies or if it is out of round, block C will slide back and forth against the tension of the springs,

thus imparting movement to the indicating lever.

The removable gage Q, for measuring the thickness of the teeth, is held against them by spring tension; any variation will then be shown upon the dial by means of the multiplying lever. For testing the parallelism of the teeth and axis, the mechanism is slid up or down along the pillars M. The indicating needles, of course, are set at zero by means of a carefully machined and checked master gear, prior to testing the gears.

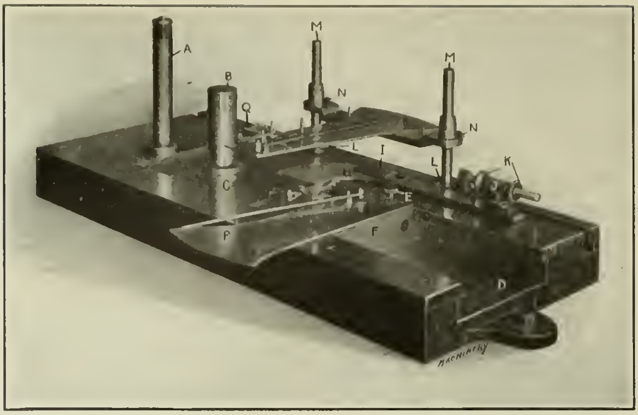

Fig. 17. Device for testing Pitch Diameter, Concentricity of Bearings, Tooth Thickness at Pitch Line and Parallelism of Teeth with Axis of Gear

Fixture for Testing Involute Curve of Spur Gear Teeth

Many interesting devices have been developed for testing spur gears, especially the shape of the involute curve on the teeth. One method consists in rolling the spur gear in contact with a master and determining whether it is correct or not by the feel. Another interesting device, which is shown in Fig. 18, determines the shape of the involute curve in such a manner that the amount of error can be read off on an indicator in thousandths inch. This device, it will be noticed, consists of a base A in which a dovetail slide B is operated by handle C. This slide has a carefully machined slot in its top face, in which a disk D rotates. Disk D is attached to a spindle E, which carries the gear to be inspected, and, in addition, two hardened, ground and lapped disks F and G. These disks run on straightedge H and are made equal in diameter to the base circle from which the involute curve on the gear teeth is laid out.

Located at right angles to slide B is a secondary slide I that carries the indicating mechanism. This slide, it will be noticed, has a rack attached to its lower surface connecting with the segment gear J that is operated by handle K. For testing the accuracy of the involute curve, the gear, together with the two disks, is rolled along the straightedges and the teeth are brought into contact with the tooth pointer L of the multiplying lever M. This lever transmits a movement to the needle of the indicator. The multiplying lever has a ratio of 10 to 1 and the indicator is graduated in thousandths inch, so that each graduation on the indicator represents 0.0001 inch variation in the shape of the curve. One objection to this device is the shape of the indicator pointer L. Instead of being rounded, this should be made to a sharp point so as to trace the involute curve without introducing any error.

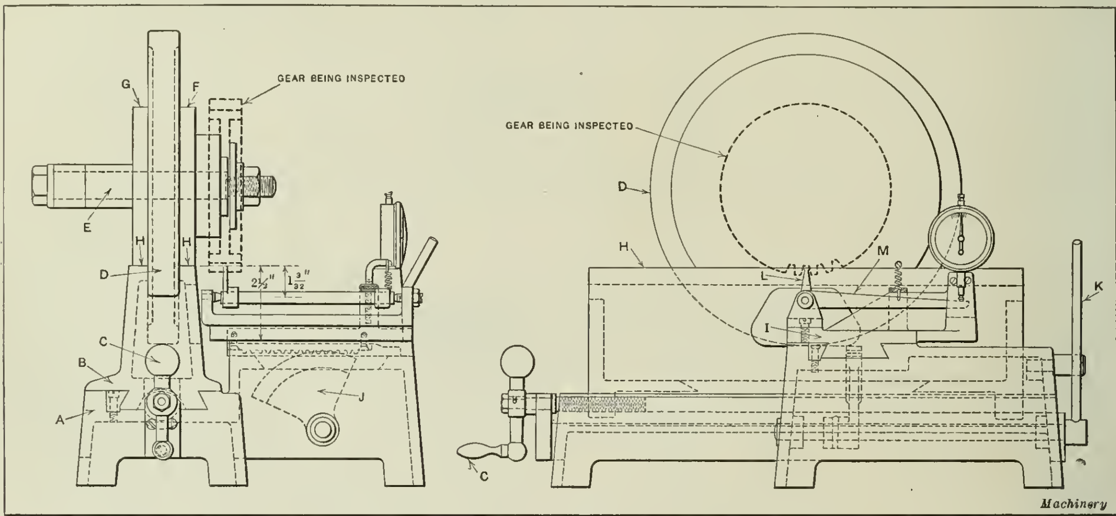

Fig. 18. Fixture for testing Involute Curve of Spur Gear Teeth

Another use of this testing fixture is to determine whether the teeth of the gear are in line with the axis or not. To make this test the gear and the member to which it is attached are held rigidly on the straightedges. Handle K is operated so that slide I is moved back and forth, passing the indicator point across the face of the tooth, and, of course, in line with the axis. In this way the straightness of the tooth surfaces in relation to the axis of the hole in the gear can be accurately tested.

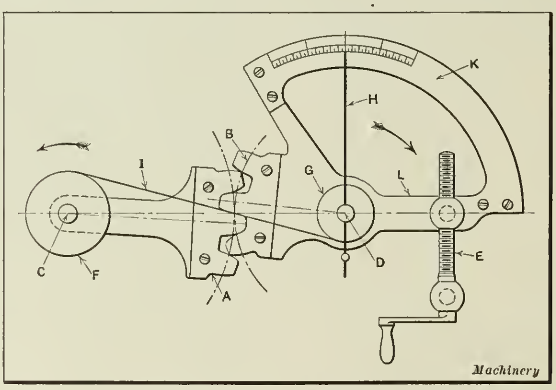

Fig. 19. MacCord Odontoscope for testing Involute Curve of Gear Teeth

MacCord Odontoscope for Testing Gear Teeth Involute Curve

Another system for testing the truth of involute curves is by means of the MacCord odontoscope, shown in the diagram Fig. 19. By this method it is possible to test the accuracy of the involute curve to a nicety. The fixture consists of two templets A and B, which are cut out

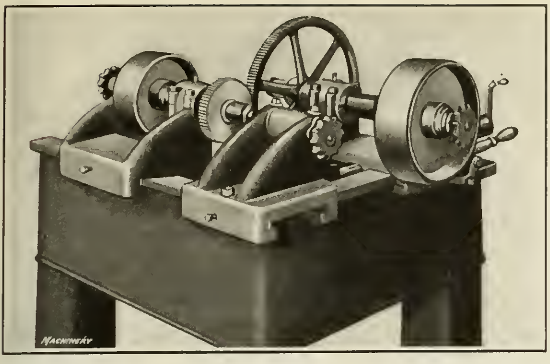

Fig. 20. Fixture for testing Spur Gears for Noise under Load

of fairly thick sheet metal and correspond to the teeth of a pair of gears. These are secured to arms turning about the axes C and D, the distance between which is adjustable. Shaft D carries a graduated segment K, which may be slowly rotated by arm L and tangent screw E or any other equivalent device. Motion is thus communicated to C, the teeth A being kept in contact with B by a light weight or spring, not shown.

Cylindrical barrels F and G are accurately turned to the same diameter as the pitch circle from which the involute curves are struck off. F is fixed on the axis C, while G carries a pointer H that turns freely on axis D and is connected by a spring, not shown. The tendency is to wind the fine flexible wire I up on G, which is secured to both barrels in the manner of a cross belt. It will thus be seen that barrels F and G turn in opposite directions with a constant velocity ratio. The velocity ratio of C and D, however, is determined by the templets A and B that will not remain in mesh unless the contour of the teeth is strictly conjugate. While turning the tangent screw in one direction or the other, it is possible to examine the action during the arc of approach or retreat of the teeth, and if the templets are correctly formed, the segment K and pointer H will move at the same rate and in the same direction, so that if the pointer is set at zero in the graduated arc it will remain at zero throughout the action, any movement indicating an inaccuracy in the shape of the involute curve. For actual work the sensitiveness of the involute is increased by introducing multiplying gears between barrels C and G, thus producing a greater deflection of needle H for a given magnitude, and causing minute errors to be indicated.

Fig. 21. Fixture used in testing Large Bevel Ring Gears for Truth after grinding Back and Front Faces

Testing Spur Gears for Noise under Load

After the gears are cut and inspected for other defects, they are generally given a noise test. In making this test it is the general practice to hold the gears to be tested in some sort of fixture in which a load can be applied while the gears are running at high speed. It is also customary to have the load either approximate or exceed that which will be carried by the gear under actual working conditions. Fig. 20 shows a gear testing fixture for spur gears which embodies the features just mentioned. This consists of a base carrying three slides. The slides at the rear, which are guided by ways on the bed, are held accurately in line with each other and are gibbed to the bed. The right-hand bracket carries a dead center and the left-hand bracket a driving center, rotated by the pulley shown. The gear to be tested is held on a mandrel and is in mesh with another gear held on a spindle that rotates in bronze bearings. The outer end of this spindle carries a disk and band brake.

Fig. 22. Running Test for Noise on Bevel Ring Gears and Pinion, accomplished by Hand

In operation, the gear to be tested is located as shown, and the gear on the spindle is brought into mesh with it by the hand-lever at the front of the machine. The power is turned on slowly at first and then gradually increased. At the same time the band is tightened on the disk to increase the power required to rotate the gear on the spindle. The operator meanwhile observes closely the noise produced. If this is in the nature of a singing hum, the gear is all right, but if it is an intermittent noise or clash, it indicates that the teeth are unevenly spaced, eccentric with the hole or incorrectly formed.

Testing Bevel Drive Ring Gears

Several methods are employed for testing bevel drive ring gears for automobile transmissions. One of the most important tests is to determine within fixed limits the relation

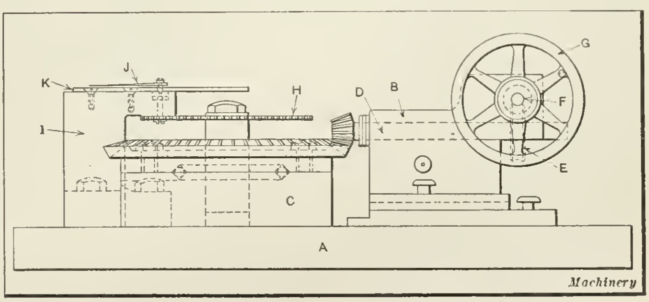

Fig. 23. Special Fixture for testing Running Action of Bevel Ring Gear and Pinion

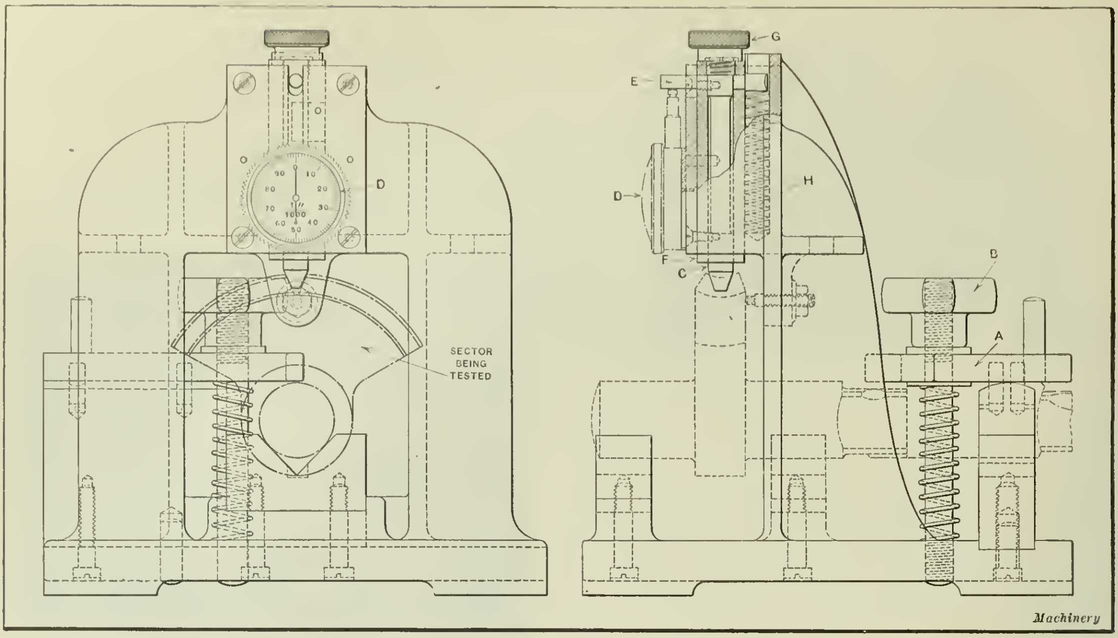

Fig. 24. Fixture for testing Eccentricity of Steering Gear Sector

of the teeth to the back face and hole. In the helical type of ring gear this is generally accomplished by what is known as a ball test. The ring gear to be tested is fastened by the bolt holes to a carefully ground ring, which forms a part of the fixture and is free to rotate. The inspecting is done by means of a dial test indicator held in an arm, in the lower or measuring end of which is a carefully ground and lapped ball that is brought in contact with the teeth being tested. The spindle carrying the ball is kept in contact with the gear teeth by means of a stiff spring, and the ball is raised up out of contact with the teeth by a lever. The spaces between the teeth are tested in this way after the gear has been hardened, and the gear is allowed to run out about 0.003 inch.

Testing Ground Faces of Bevel Ring Gears

In grinding the rear face of a bevel ring gear, it is the usual practice to locate the gear from the pitch line of the teeth by means of accurate balls. After the front and rear faces and hole have been ground, the gear is tested in the manner shown in Fig. 21. This fixture consists of a cast-iron base *A* to which a hardened and ground steel ring *B* is fastened. In the top face of this ring are carried steel balls on which the gear rests. The ring gear is located from the hole by a hardened and ground stud *C*, which is fastened to the cast-iron base.

The test for truth is accomplished with the test indicator *D* held in the bracket *E*. Bracket *E* is free to swing about the stud on which it is mounted when the clamp shown is released. The inspector, in testing for truth, rotates the gear on the balls as shown in the illustration, and at the same time watches the movement of the indicator needle to see if any inaccuracy has been caused by the grinding operation. As extreme accuracy in this part is necessary, a duplicate fixture is used in the grinding department by the operator (the one who grinds the inside face of the gear) to determine if the final grinding operation is correct before the gears leave the grinding department.

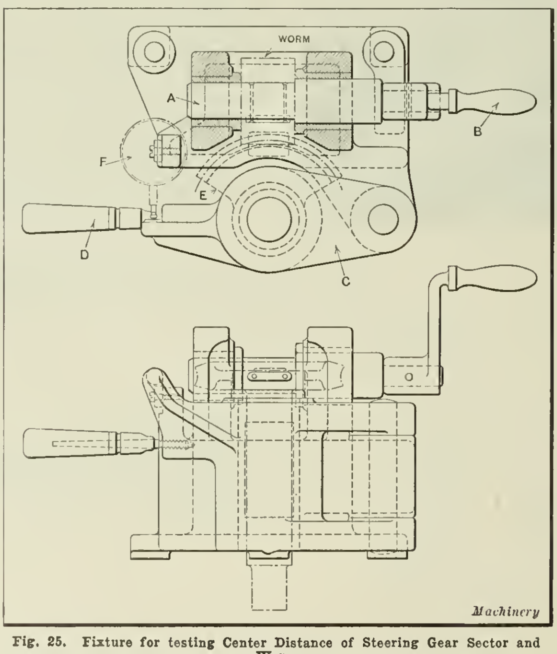

Fig. 25. Fixture for testing Center Distance of Steering Gear Sector and Worm

Testing Bevel Drive Gears for Noise under Load

Bevel drive gears are given a noise test in a similar manner to that described in connection with transmission gears. Several devices have been developed for the purpose, one of which is shown in Fig. 22. This is made out of a discarded Lincoln type milling machine. The testing fixture comprises two brackets held on the table, and a special holder on the spindle for the ring gear. The brackets *A* and *B* which carry centers for supporting the pinion arbor are held to the special table *C* by T-bolts and nuts. The bracket *A* is provided with a wing-nut, so that it can be easily removed to insert and remove the work.

The ring gear is held in a similar manner to that employed in the Gleason bevel gear generator, being located from the front inside face by a shoulder plate *D* to which the gear is bolted. Spring pins located in the special faceplate *E* are also used to support the rim of the gear. The machine is provided with a special hardened and ground spindle on which the ring gear fixture is retained. The spindle is hollow and a pull-rod passing through it is used to clamp the gear and shoulder plate *D* up against the fixture. To the rear end of the spindle is attached the handle *F*, which is used to rotate the ring gear that meshes with the pinion held on the arbor. In use, the operator brings the ring gear

and its mating pinion into mesh, and then rotates the handle *F* slowly, listening carefully to find out at which points of the rotation noise is produced or where the teeth bear hard. In addition to this, the ring gear and mating pinion are given a noise test under load, while being rotated at a high speed.

Testing Running Action of Bevel Drive Gears

A bevel ring gear and pinion must be accurately mounted to give satisfactory results, and in order to determine whether the gear will run correctly or not when mounted, it is advisable in most cases to test the gear under actual working conditions in a special fixture that has been designed for the purpose, and so arranged that any errors in the ring gear are magnified. A simple testing device which gives satisfactory results is shown in Fig. 23, and consists of a base *A* upon which is mounted an adjustable bracket *B* that carries the bevel pinion, and a bracket *C* that carries the ring gear. The pinion shaft *D* is driven by a worm-wheel *E*, which, in turn, receives power from a worm held on shaft *F*, the latter being rotated by handwheel *G*. Mounted upon fixture *C* is the bevel ring gear, which is mounted so that it is free to be rotated by the pinion. Located on the spindle to which the ring gear is attached is a fine-pitch spur gear *H* which meshes with a pinion held in a bracket *I*. The ratio between this spur gear and pinion is 10 to 1. Located on the pinion shaft is a pointer *J* which rotates around the graduated dial *K*, the latter being attached directly to the bracket *I*.

In operation, the pinion and bevel ring gear are carefully mounted and then handwheel *G* is rotated at a uniform speed. If the bevel pinion and ring gear are properly cut and in correct mesh, the indicator *J* will travel over the dial *K* with a steady, uniform motion. On the other hand, if the meshing is incorrect, corresponding with incorrect mounting in use, the pointer will move over the dial with a jerky, irregular motion. The block *B* carrying the horizontal pinion shaft is adjustable so that the gears can be made to mesh incorrectly in order to study the effect of this action. The fixture is so designed, however, that there is one correct position that cannot be varied more than 0.001 inch.

Testing Fixture for Steering Worm Sectors

Fig. 24 shows a testing fixture which is used for determining the amount of eccentricity of a steering worm sector, as used on the Cadillac motor car. This particular steering worm sector is made eccentric so that by adjusting an eccentric bushing any wobble can be taken up in the steering sector until it has been worn down to an "equal radius." The teeth on this sector are not concentric with the shank, and as they wear more in the center than at either end, this allowance for adjustment is necessary. In order to check up the amount of eccentricity on this sector, a special testing fixture has been devised as shown in Fig. 24. Here the steering worm sector is shown, by heavy dotted lines, mounted in two V-blocks and held down just tight enough to prevent any loose motion by means of a toe-clamp *A* and nut *B*. The sector is then swung around past the rack tooth *C*, which, of course, contacts with the teeth in the sector. The amount that the center of the worm is eccentric with the two extreme ends of the sector is then determined accurately by means of the dial test indicator *D*, which is acted upon by the pin *E* held in the slide *F*. This slide is moved up against the tension of spring *H* by pulling on button *G*.

Fixture for Testing Center Distance of Steering Sector and Worm

After the amount of eccentricity of the worm sector has been tested in the fixture shown in Fig. 24, the next step is to test the center distance of the worm in connection with the sector, working the latter on the high point, as indicated in Fig. 25. Here it will be noticed that the worm is held on a shaft *A* provided with a key for driving it, this shaft, in turn, being rotated by handle *B*. The sector is held in a swinging member or arm *C* operated by handle *D*. The worm is placed on shaft *A*, sector *E* is then placed in swinging arm *C*, and the latter is swung in until the sector meshes properly with the worm. From time to time this fixture is tested and set by a master sector and worm and then a reading is taken on the dial test indicator *F*. When the work being tested is put in this fixture, the needle must indicate within ± 0.001 inch of the zero point registered by the master. In order to see that the worm is not eccentric, it is rotated by means of handle *B*, and as the swinging arm *C* is only held in by means of the hand, the eccentric movement of the sector is easily taken care of as the arm is forced back by the rotation of the worm. This, of course, gives an indicating reading on the dial test indicator, and the amount of eccentricity can also be determined in the same fixture.

* * *

SOME CAUSES OF INEFFICIENCY

BY CLARENCE F. GETZLAFF [1]

All machine shops are endeavoring to attain 100 per cent efficiency, but from the writer's point of view—which is that of a machinist—a wrong starting point is usually taken. Most managements seem to think that feeds and speeds are the sole factors of efficiency and production. Although the writer believes that a machine should produce all there is in it, the minute a machine is crowded to its utmost capacity it is being forced beyond the laws of tolerance. Furthermore, burning up tool steel never resulted in efficient production.

More time is wasted on setting up a job than on almost all other operations combined, for the simple reason that a foreman cannot watch a man as closely on the preparatory work as he can on the actual running. But it is not only the machinists that keep down efficiency; the foremen are also at fault. Some of them are so impatient that the minute a casting for which they happened to be waiting comes into the shop, they compel a machinist to break up a job to get out the rush. This means setting up the first job twice, which is likely to cost thousands of dollars a year.

Much time is also lost in the tool-room waiting for tools that are stored on the shelves without a number or other means of identifying them, so that they must be looked for until found. Tools are also often brought back to the tool-room in a broken or burned condition, but are accepted by the tool-room "jack" on account of his lack of knowledge of these things. And, strange to say, drill-press tables are still used as anvils and lathe beds as tool and file racks.

In a good many shops there is a lack of judgment in regard to lubricating and cleaning the machines. In one shop, where the power was supplied by a five-horsepower gasoline engine, the writer called the attention of the owner to the fact that the engine was badly in need of repair. But the owner simply said, "Oh, she is getting weak in the joints, but she is still doing business." How long is a machine allowed to do business after its bearings are worn, and how does it run after it comes out of the repair shop?

* * *

WIDE-FACE GRINDING WHEELS

A comparatively short time ago a grinding wheel with a 1½-inch or 2-inch face was considered a wide-faced wheel, but the demand for greater production and lower manufacturing costs has brought wider and wider wheels into use, and now wheels ranging from 3 to 12 inches face are common. Their introduction has brought about a change in machine design and construction; more power and greater weight and rigidity are essential. The spindles must be of the best material, with ample bearing surfaces and large, well made boxes. Greater economy in the production of special shapes (form grinding) has resulted from the wide wheel practice. Production has been increased and the field of cylindrical grinding has been widened. Work up to 10 inches long is now ground with a wheel of 10-inch face without traversing. The non-traversing method is correct for all work that does not have an exceedingly close limit, or which is not so delicate and frail that it is not practicable to take the extra heavy cut. Longer work than 10 inches is traversed with advantage, but even then production is increased by the use of wide wheels, provided the traverse of the work is practically equal to the width of the wheel for each revolution of the work.—*Howard W. Dunbar in "Grits and Grinds."*

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MOLYBDENUM AND ITS USE IN STEEL[1]

Molybdenum is said to impart remarkable drawing qualities to nickel steel, and to make armor plate, when annealed, more readily planed, at the same time increasing the strength of the hardened steel. Its effect on steel is similar to that of tungsten, but it is much more active. While molybdenum is as abundant as tungsten and costs only one-third as much, its use in steel manufacture has been greatly retarded by the poor results obtained by the first experimenters; but these results were due to impurities in the molybdenum and to the heat-treatment given to the steels.

Pure molybdenum is a malleable white metal that will not scratch glass and is sufficiently soft to be filed and polished. Its exact melting point is not known. The Bureau of Standards has placed it at about 2500 degrees C. Osmium, tantalum, and tungsten are the only metals with higher melting points. Its specific gravity increases appreciably with the amount of mechanical working to which it is subjected. The General Electric Co. has found that the specific gravity of ductile molybdenum before drawing is 10.02; and after drawing, 10.04 for a wire 3.75 millimeters in diameter, and 10.36 for a wire 0.038 millimeter in diameter. The tensile strength of molybdenum wire 0.0028 inch in diameter is from 230,000 to 270,000 pounds per square inch; of tungsten wire of the same size, 480,000 to 530,000 pounds; and of hard-drawn piano wire 0.003 inch in diameter, 507,000 pounds.

Molybdenum produced by the reduction of molybdic oxide with carbon in an electric furnace does not possess the same physical properties as pure molybdenum, owing to its absorption of carbon. It is gray, brittle, very hard, scratches steel and quartz, and has a much lower melting point and specific gravity than the pure metal. When pure molybdenum is surrounded with carbon and heated to about 1500 degrees C., it absorbs carbon and becomes hard; when carbon-bearing molybdenum is melted with molybdenum dioxide, the product takes on the physical properties of the pure metal.

Molybdenum increases the tendency of steel to harden on cold-working and the effects of oil quenching followed by tempering, but the effect produced depends to a large degree on the treatment of the steel. Molybdenum considerably increases the tensile strength of normalized steel with only a slight reduction of ductility; this influence is most marked in high-carbon steel. Hardened and tempered steel containing 1 to 2 per cent of molybdenum shows very high tenacity values accompanied by high ductility, but higher percentages of molybdenum, when hardened and tempered, make the steel inferior.

Molybdenum steel is generally made by the crucible process though the electric furnace and the open-hearth processes are used. The molybdenum is added in the form of molybdenum powder or ferro-molybdenum. The latter contains about 80 per cent of molybdenum and has a melting point several hundred degrees C. lower than that of the ordinary commercial brands of powdered molybdenum. Besides, the powdered metal seems to be more prone to oxidation than the ferro-alloy, but it generally contains 4 or 5 per cent of various oxides of molybdenum that may aid in removing excess carbon. Molybdenum is also added in the form of alloys of chromium, tungsten, nickel, vanadium, etc. Standard alloys of this type are chrome-molybdenum, which contains 50 per cent of each element; molybdenum-nickel, which contains 75 per cent molybdenum and 25 per cent nickel; and ferro-molybdenum-tungsten, which contains molybdenum and tungsten in the proportion of 3 to 1. From 1 to 7 per cent vanadium is sometimes added to the last-named alloy.

In the presence of chromium and manganese, molybdenum acts similarly to tungsten and in combination with either of these elements and carbon it produces a self-hardening steel that is said to be a little tougher than the corresponding tungsten steel. A typical steel of this kind contains 4 to 6 per cent molybdenum, 1 to 2 per cent chromium, and 1.85 per cent carbon. The addition of molybdenum also enables a steel to retain its temper and hardness at a red heat. These qualities are developed by cooling the steel moderately fast from a high temperature—treatment that prevents the usual critical changes and keeps the steel in the austenitic condition. Many think that high-speed steels produced with molybdenum are superior to the corresponding tungsten steels both as regards toughness and durability; they also take a fine cutting edge. The superior toughness of these steels is attributed to the fact that they contain more iron, as less molybdenum than tungsten is used to obtain the same result. Besides, a lower heat is required in their tempering. If a temperature of 1000 or 1100 degrees C. is exceeded, the life of the tools may be shortened.

Some users claim, however, that molybdenum tool steels are likely to crack in quenching and that they do not hold their cutting edge after retreatment as well as before. This deterioration in the steel upon repeated heating for dressing and treatment has been ascribed to the disappearance of molybdenum from the outer skin of the steel through volatilization. Others have found that this steel is likely to be seamy and to contain physical imperfections; also, that it is likely to fire-crack under treatment. In a few instances, service tests with these steels have shown irregular cutting speeds and have indicated the tendency of the molybdenum to render the tools brittle and weak in their bodies.

Molybdenum tool steels of high carbon content require great skill in their preparation, owing to the difficulty of judging by color the definite temperature required for hardening. Further, great care is necessary in annealing, after it has been worked into bars and before it is cut into shapes for tools, previous to hardening. Most of these objectionable features are probably due to the use of impure ingredients in the manufacture of steels or to improper heat-treatment. Most American manufacturers use molybdenum in conjunction with tungsten, cobalt, chromium, manganese, nickel, and vanadium, for many of the difficulties are thus avoided. Characteristic steel of this type contains 16 to 18 per cent tungsten, 1.5 to 2 per cent molybdenum, 4 to 4.5 per cent chromium, and 0.6 per cent carbon. This steel is said to be superior in cutting efficiency to the corresponding tungsten-chromium steel and to have a finer texture. A high-speed steel in which cobalt is used in conjunction with tungsten, contains 16 to 18 per cent tungsten, 4 to 5.5 per cent cobalt, and 0.25 to 1.5 per cent molybdenum. The addition of small percentages of vanadium is said to increase the strength and cutting efficiency.

The molybdenum steels used in making permanent magnets are similar in composition to the high-speed molybdenum steels. They generally contain from 2 to 3 per cent molybdenum, 0.5 to 0.7 per cent carbon, and sometimes about 0.5 per cent chromium. Some of these steels, however, contain as much as 6 per cent molybdenum. After hardening, these steels retain their magnetism longer than hardened carbon steel and are said to be superior to tungsten magnet steels. An alloy containing 2 to 5 per cent molybdenum, about 10 per cent chromium, and little or no carbon is said to be practically acid-proof. Molybdenum-tungsten-chromium-iron alloys have also been made that are insoluble in hydrochloric, sulphuric, or nitric acid, and an alloy containing 60 per cent chromium, 35 per cent iron, and 2 or 3 per cent molybdenum is said to resist even the action of boiling aqua regia. Differences in the heat-treatment of these alloys have a great effect on their acid-resisting qualities. The addition of molybdenum gives a wider heat-treatment range and greater tensile strength to chrome-nickel steel. The high tensile strength and elastic limit of steel containing 1 per cent chromium, 2 to 3 per cent nickel, and 0.25 to 0.5 per cent molybdenum make them of special value for crankshafts, propeller shafts, and other machine parts that are subjected to alternating and repeated stresses. These steels are also employed in the manufacture of guns of large bore and rifle barrels as they are highly resistant to the erosive action of the gases generated by the explosives.

Small percentages of molybdenum are used in certain patented non-ferrous alloys consisting essentially of chromium and cobalt. These alloys are known under the trade name of stellite and possess remarkable high-speed qualities when used for machine tools. They are also employed for cold chisels, woodworking tools, cutlery, etc. Their use in cutlery is of particular interest, as they do not tarnish under atmospheric influences and are unaffected by fruit acids.

[1] Extract from the bulletin, "Molybdenum; its Ores and their Concentration," issued by the United States Bureau of Mines.

Manufacture of Steel Balls-2

by Edward K. Hammond[1]

A visitor who is conducted through the plant of the Hoover Steel Ball Co. of Ann Arbor, Mich., finds it exceptionally easy to become acquainted with what is going on in each shop, because, although the plant is large, it is engaged in making a single product, manufacturing operations on different sizes of balls being conducted in essentially the same way throughout. This condition stands out in marked contrast to that found in plants engaged in the production of a variety of different parts, as the manufacturing operations necessarily vary, making it more difficult to see just what is being done.

Fig. 18 shows the condition of the product at each step in the process of manufacture, and it will be of interest to study this illustration carefully, as it shows just what is done to the balls by each operation through which they pass before completion. At *A* is shown a string of hot-forged ball blanks before they have been sheared apart, and at *B* are illustrated two ball blanks made by the cold-heading process. Blanks produced by either of these methods are first subjected to a rough dry-grinding operation which reduces them to an approximately spherical form, as shown at *C*, although the surface is covered with a multitude of small flats and scratches left by the grinding wheel. At *D* are shown two rough-ground blanks after they have been subjected to the process of heat-treatment, and it will be noticed that their appearance is essentially the same as that of the rough-ground blanks shown at *C* except that the surface is darkened as a result of the heat-treatment. Two blanks are shown at *E*, which have received the finish dry-grinding after being hardened, and it will be noticed that the appearance of these blanks is the same as that of the rough-ground blanks *C* except that the flats and scratches are not so pronounced. At *F* and *G* are shown two blanks that have gone through a process known as "oil-rolling" and two blanks that have been through the oil-grinding process. The appearance of both these balls is practically the same except that the oil-ground balls have been reduced to exactly the desired size. At *H* are shown two finished balls after being polished, ready to be sent on to the inspection department, where they will be subjected to a series of rigid tests.

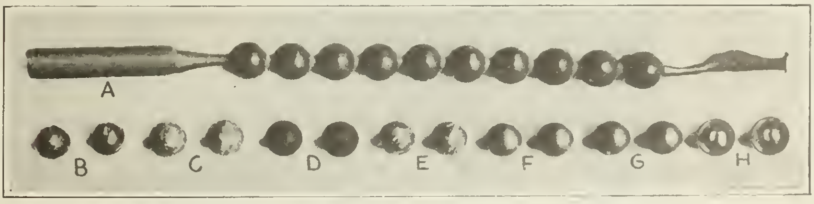

Fig. 18. (A) String of Hot-forged Ball Blanks. (B) Ball Blanks made by Cold-heading Process. (C) Rough Dry-ground Balls. (D) Rough Dry-ground Balls after hardening. (E) Finish Dry-ground Balls. (F) Oil-rolled Balls. (G) Oil-ground Balls. (H) Polished Balls ready for Inspection

Oil-rolling Balls in Tumbling Barrels

After receiving the finish dry-grinding, the balls are of approximately spherical form, but the surface is covered with flat spots and scratches left by the grinding wheel and there is still a considerable amount of excess metal on the balls to be removed. The first step is to subject them to a process known as oil-rolling, which consists of tumbling a charge of balls in an iron barrel containing oil and abrasive. This oil and abrasive is refuse from machines on which a subsequent operation known as "oil-grinding" is performed; this operation will be described in detail later, and the nature of the abrasive will be explained at that time. Most of the tumbling barrels used in this department have capacity for a charge of 1500 pounds of balls, and these were built especially for the Hoover Steel Ball Co.; but some 800-pound barrels made by the Baird Machine Co. of Bridgeport, Conn., are also employed. Some of these barrels are shown in operation in Fig. 19. The purpose of oil-rolling is to smooth off the flats and scratches left by the dry-grinders and to remove excess stock, about 0.004 inch being allowed for removal in the oil-grinding operation. Balls up to 1½ inch in diameter are given this oil-rolling treatment.

It is necessary to leave the balls in these tumbling barrels from twenty to thirty-six hours, according to the amount of stock that must be removed, and as each ball rotates in such a way that its entire surface is uniformly exposed to the action of the abrasive and of the balls adjacent to it, this treatment results in the production of perfect spheres. Experience enables the foreman of the oil-rolling department to judge with considerable accuracy the length of time that it is necessary to leave balls in the tumbling barrels in order to reduce them to the proper size for oil-grinding. When this time has almost expired, a number of balls, selected at random from the contents of each barrel, are taken out and measured with a micrometer in order to see how closely they approach the required size. The oil-rolling is then continued with successive gagings until the balls have been reduced to the required dimension plus 0.004 inch, after which they are removed from the barrels, cleaned, and then taken to the oil-grinding department. In reducing balls by the process of oil-rolling, it occasionally becomes necessary to add more abrasive to the supply of oil and abrasive obtained from the oil-grinders. When this is done, No. 36 carborundum is used, as this coarse-grain abrasive increases the speed at which the balls are reduced to the required size.

How the Process of Oil-grinding is Conducted

There are two grades of balls made in the Hoover factory, known as "Micro-chrome" and "A grade" balls, the former

[1] Associate Editor of MACHINERY.

being the better quality. Both grades are reduced to the final size by the process known as "oil-grinding" that is conducted on machines of the form shown in Figs. 20 and 22. The construction and operation of the oil-grinding machines will be best understood from Fig. 22, which shows details of its construction. These machines are provided with two iron rings A and B, each of which has an annular groove cut in it of a suitable size to accommodate the balls C to be ground. It will be noted that there is a small groove at the bottom of the annular groove in the lower ring A, which provides for holding a supply of oil and abrasive. Ring A has the annular groove for the balls cut at the bottom of a larger groove, and ring B has a flange in which the ball groove is cut that drops into this large groove in ring A; the arrangement will be readily understood from the illustration. It will, of course, be understood that the grinding ring is filled with balls, the number that constitutes a complete charge varying according to the size of balls that are being ground.

Fig. 19. View in Oil-rolling Department, showing Special Tumbling Barrels of Large Capacity

To provide for loading and unloading the machine, lower ring A is drawn out onto a table D which is provided for that purpose, and after a fresh charge of balls has been put in place, this ring is pushed back into position under the upper ring B that is secured to the spindle of the machine. A sheet metal shield is then pushed into place in front of the rings in order to prevent splashing of the oil. Ring A is located in approximately the desired position by means of a hole in the machine bed into which an extension on the under side of ring A drops, but the extension on this ring is a loose fit in the hole to allow ring A to align itself properly with ring B.

The upper ring is secured to the spindle, and in order to start the grinding operation it must be lowered into contact with the balls carried in the annular groove of ring A. This is accomplished by a rack on the spindle sleeve that meshes with pinion E secured to lever F.

In order to raise ring B out of contact with the work so that ring A may be drawn out onto turntable D, lever F is pulled down into the horizontal position shown in the illustration. In this position spring latch G drops into a notch on ring H that is secured to the frame of the machine, thus holding ring B in the suspended position. After the machine has been reloaded and it is desired to drop ring B into contact with the work preparatory to starting the grinding operation, spring latch G is withdrawn from the notch in ring H by pulling back grip I that is connected to the end of the rod on which latch G is carried. Then the wheel is lowered by gravity, care being taken to hold tight to the crank at the end of lever F so that it is slowly raised to a vertical position instead of flying up and allowing ring B to drop heavily onto the balls carried in the lower ring. It will be seen that there are three grinding heads provided on each machine, and these are furnished with independent tight and loose pulley drives, so that any head may be stopped without interfering with the operation of the other two. This is done by throwing the belt from the tight to the loose pulley by means of lever J, which actuates the belt shifter. The oil-grinders are provided with a dial similar to that of a clock, so that the time for grinding can be observed; the grinding operation usually takes from twenty to forty-five minutes, according to the size of the balls and the amount of stock that must be removed. When the machine is set up ready to start the grinding operation, this dial is set to the approximate time at which the grinding operation will be completed, and a little while before this time is reached several balls are selected at random from different points around the ring, and are measured with an indicator to see how near they come to the required size. The dials on the machine and the test indicator are shown in Fig. 20.

Cleaning and Polishing Oil-ground Balls

As soon as the balls have been ground down to the desired diameter, they are removed from the machine and taken to tumbling barrels containing hardwood sawdust, in which they are rolled for a sufficient length of time to clean off all oil and abrasive. The charge in each tumbling barrel is then taken out and put into riddles through which the sawdust is sifted, as shown in Fig. 21, to separate it from the balls; the balls next go to the tumbling barrels containing a mixture of oil and Vienna lime. They are rolled in this mixture for a sufficient length of time to give them a preliminary polish, after which they are removed and again cleaned in tumbling barrels filled with hardwood sawdust. The sawdust is sifted from the balls in riddles, after which they are rolled for from twenty to twenty-five minutes in kegs containing strips of kid similar to that from which gloves are made, the arrangement of this polishing equipment be-

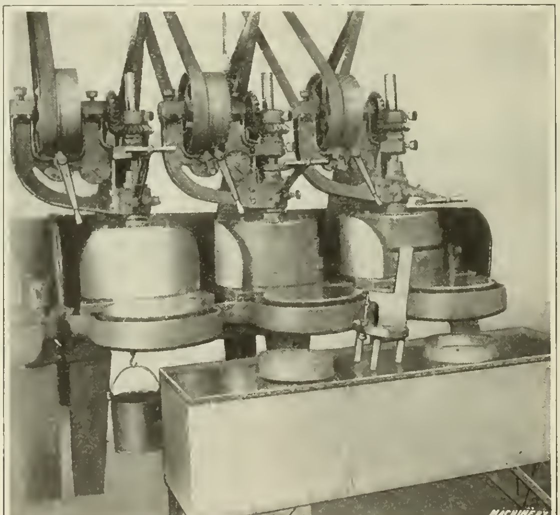

Fig. 20. Oil-grinding Machine on which Final Grinding Operation is performed — Attention is called to Dials showing Approximate Time when Grinding will be finished, and Indicator for testing Size of Balls

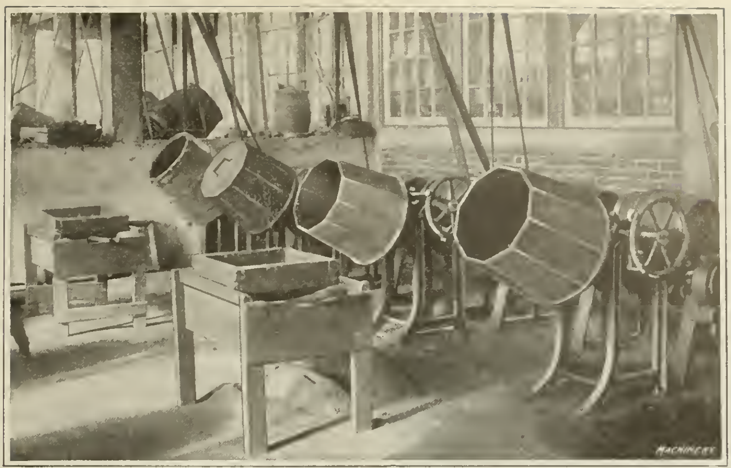
Fig. 21. Small Tumbling Barrels for cleaning Balls in Sawdust, and Riddles for separating Sawdust from Balls

ing shown in Fig. 23. Rolling the balls in this way gives them a high polish, which is the final step in the process; and the finished balls are then ready to be taken to the inspection department.

The following data concerning conditions under which oil-grinders are operated and abrasives and oils used on these machines will prove of interest. It has been mentioned that two grades of balls are made, which are known as "Micro-chrome" and "A grade," the former being the better quality. On the "Micro-chrome" balls the grinders are run at 195 revolutions per minute and the abrasive used is a mixture of No. 3-F carborundum and "Atlantic Red" machine oil made by the Standard Oil Co. On "A grade" balls, the grinders are run at a speed of 325 revolutions per minute and the abrasive is an equal mixture of Nos. 180 and 150 carborundum to which No. 4 "Road Oil" is added, this oil also being the product of the Standard Oil Co. Used oil and abrasive from the grinding machines is collected and used in the tumbling barrels.

Special Treatment for Large Balls

Certain variations from the practice described in the preceding paragraphs are necessary in the case of large sized balls which would be too heavy to handle in tumbling barrels. For instance, "A grade" balls over 1½ inch in diameter and "Micro-chrome" balls over ⅝ inch in diameter are burnished on oil-grinders running at high speed and in which very fine abrasive and light oil are used instead of being subjected to a tumbling operation in barrels containing a mixture of oil and lime, as previously described. If large balls of this kind were put in a tumbling barrel, there would be too much shock from the balls striking one another; hence the variation in practice.

Production of Oil-rolled Balls

It has been explained that in the regular process of manufacture the balls go from the tumbling barrels to the oil-grinders on which they are reduced to the required size ready for polishing. There are some poorer grades of balls, however, that do not go to the oil-grinders; these balls are reduced to size by oil-rolling in the tumbling barrels, after which they are polished and sent to the inspection department. The method of polishing is the same as that to which the better grades are subjected, which was previously described. In oil-rolling the balls, a mixture of No. 36 carborundum and No. 4 "Road Oil" is used in the tumbling barrels.

Manufacture of Brass and Copper Balls

In addition to its regular product, the Hoover Steel Ball Co. does quite an extensive business in the manufacture of brass and copper balls of various sizes. One important use of these balls is for various forms of valves, although they find a number of other applications. The general features of the methods used in producing these balls are the same as those employed in making steel balls, but there are certain modifications which will prove of interest. Brass and copper ball blanks up to 1¼ inch in diameter are produced on Manville cold-headers, and blanks for balls exceeding this size are cast. In the case of very large balls the practice is often adopted of making the blanks hollow, which is done by casting them

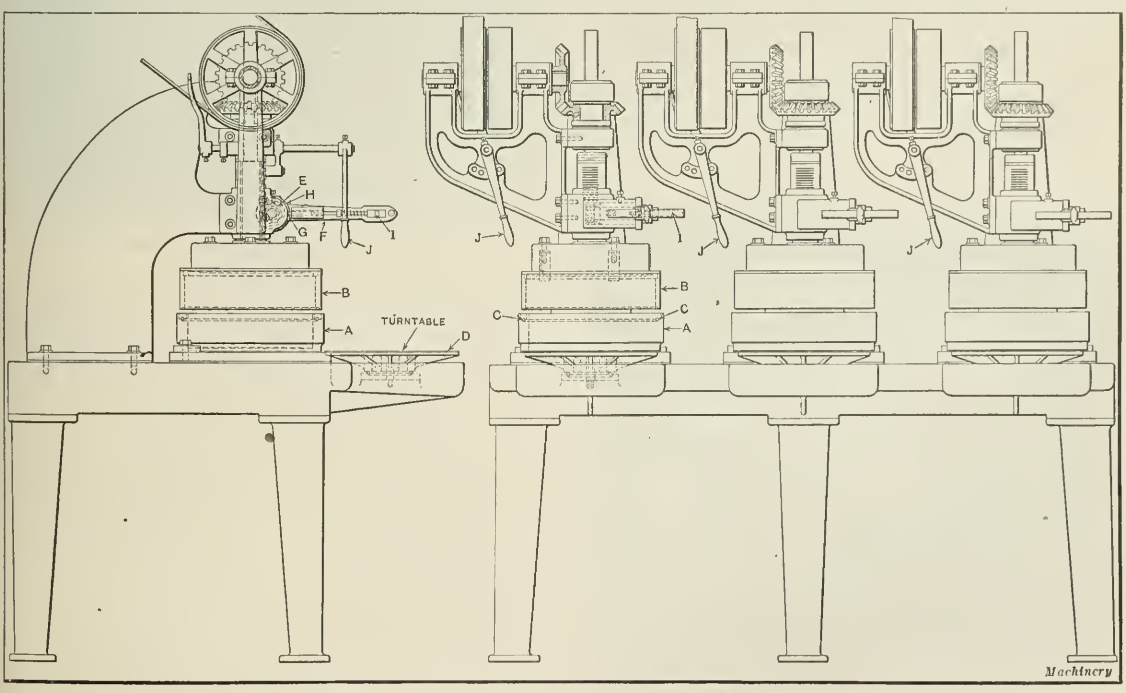

Fig. 22. Side and Front Views of Oil-grinding Machine, illustrating Method of Operation

Fig. 23. Kegs in which Balls are polished by rolling in Leather — Attention is called to Small Pile of Leather on Floor in Foreground

with a sand core that is subsequently removed. Then in order to prepare the blank for finishing, the holes left by the core prints are drilled, reamed and tapped so that threaded plugs may be screwed in. These hollow ball blanks are then subjected to the regular process of manufacture, and it is a difficult matter to detect the place where the plugs have been screwed in.

As in the case of steel balls, these blanks are first subjected to a process of dry-grinding to make them approximately spherical. Brass and copper balls are too soft to stand treatment in tumbling barrels, as they would be covered with bruises from impact with each other. After being dry-ground, they receive the regular process of oil-grinding and are then polished in machines of the same design as those used for oil-grinding; but in polishing, the balls are rolled in oil without any abrasive, which results in giving them quite a high polish, although the surface produced is not as highly finished as in the case of steel balls which are subjected to burnishing and polishing operations after being oil-ground. In treating brass and copper balls in the oil-grinding machine, care must be taken not to subject them to too great pressure, and in order to guard against this the rings on the machine are filled with brass and steel balls arranged alternately; the steel balls support the pressure of the upper ring and the head on which it is carried, and allow the balls to be ground and polished without being subjected to sufficient pressure to flatten them.

Fig. 24. Type of Glass Plate on which Preliminary Inspection is conducted

Inspection of Finished Balls

After each step in the process of manufacture, the balls receive a general inspection to make sure that nothing is wrong with the adjustment of the machines or with the material from which the balls are made that will prevent the production of balls that come up to the standard. After receiving their final polish, the finished balls go to the inspection department, where they are subjected to a number of searching tests in order that all defective balls may be eliminated and that those balls which pass inspection may be divided into various grades according to the accuracy of their dimensions.

The first step is to clean the balls thoroughly, which is done by placing them in metal baskets provided with long handles so that the load of balls may be dipped into gasoline to remove grease and particles of leather carried over from the polishing department. After this washing, the balls are put into canvas bags and rolled on a table so that the bags will absorb the gasoline and wipe off the dirt. The balls are given a preliminary wiping in one of these bags, after which they are placed in a second bag that is cleaner and insures the removal of the last traces of gasoline and dirt.

Fig. 25. Close View of Battery of Automatic Gaging Machines with Inclined Blades

Making Plate Inspection

After cleaning, the first actual examination is conducted on what are known as "inspection plates," one of which is shown in Fig. 24. These plates are used on benches that run all the way around the two inspection rooms, so that advantage may be taken of the liberal amount of daylight provided by the windows which extend from below the bench up to the ceiling. The plates are made of glass and painted black. A reflector is set up at the back of each inspection plate which throws light on the balls; and a strip of thin flexible cardboard is drawn back and forth beneath the balls to rotate them and bring all surfaces into view. Several times while making this inspection, all the balls on the plate are rubbed with a cloth

to change their axes of rotation and insure exposing the whole surface. The first step is to pick out balls having fire cracks, flats, etc., and these are sold to novelty manufacturers for use in the familiar form of toys that return to a standing position after being tipped over, due to a ball which rolls down to the lowest point at the cavity in the center.

During the next step in the process of inspection, attention is paid to a white spot on each ball that is thrown from the reflector at the back of the inspection plate. As previously mentioned, a card is drawn back and forth under the plates to make them revolve, and the inspectors first pick out what are known as "wigglers," which is the name given to balls that are out of round and go through a series of contortions while being rolled. After this has been done, the balls on the plate are gone over carefully and all those that show any defect are picked out. During this process of inspection, the balls are sorted into eight grades, as follows: (1) "Fire cracked," balls that have been cracked during the process of heat-treatment; (2) "Junk", balls which have flats, holes, etc.;

Fig. 26. Close View of Battery of Automatic Gaging Machines with Horizontal Blades

(3) "Rubbish," same defects as (2) but not so bad; (4) "Dead soft," balls that are covered with small pits caused by impact with hard balls during the process of tumbling; (5) "Out of round," balls known as "wigglers" by the inspectors; (6) "Fifth grade," balls with small cuts and scratches on them; (7) "Fourth grade," balls showing same defects as "Fifth grade," but not of so serious a character; (8) Balls having no defects sufficiently serious to be visible to the eye. The inspectors engaged in making the plate inspection are provided with small magnets somewhat the shape of a pencil with which they handle the balls with amazing dexterity.

A large majority of the balls come under the eighth classification, which includes those that show no visible defects while going through the plate inspection. Disposal of the defective balls varies somewhat according to their size. Many of the small balls with defects of the kind referred to are sold to various manufacturers, according to the class of service required of them. For instance, very poor balls are sold to novelty makers for uses already referred to. Other balls that

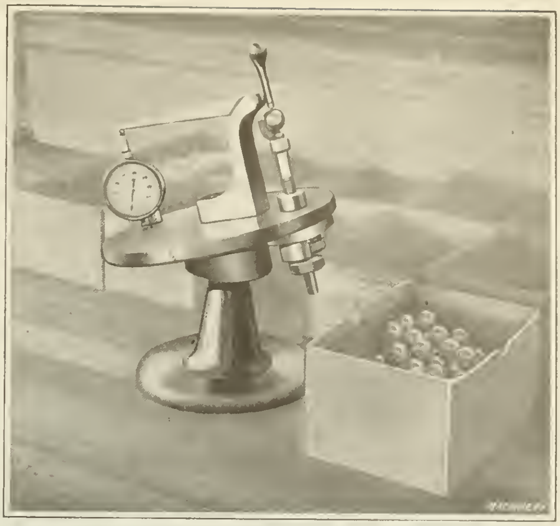

Fig. 27. Dial Indicator with 10 to 1 Leverage Ratio, for testing Accuracy of Balls to 0.0001 Inch

are not good enough for use in high-grade ball bearings are plenty good enough for the use of certain manufacturers of hardware specialties, such as roller bearing castors for furniture, roller bearing roller skates, etc. Large balls that are found defective are returned to the manufacturing department, where they are ground down to a smaller size in order to remove the defects from the surface of the metal; and these balls are then carried through the regular process of manufacture, which has already been fully described.

Gaging Balls for Size

Balls that are used in annular bearings must be of absolutely the same size in order to give satisfactory results. If this is not the case, the large balls will support all the load, and the undue amount of service to which they will be subjected will cause them to be destroyed more rapidly than would otherwise be the case. In order to fit properly in the races, it is desirable for the balls to be of exactly the specified size, but provided all the balls are of the same size, they are capable of giving very satisfactory results even though they are either slightly over or under the specified size. In the final process of inspection, the balls are gaged and sorted out into different grades, according to whether they are of exactly the specified size or somewhat under or over this size. Attention is called to the fact that this variation in high-grade steel balls does not exceed a few ten-thousandths inch. As balls of the different grades are all of the same size, they are capable of giving perfectly satisfactory results. Some users of balls gage them at their own plants and make this subdivision, while others buy gaged balls ready for assembly.

Fig. 28. Methods used for counting Balls preparatory to packing

In gaging those balls which show no defects in conducting the plate inspection, practice varies according to the size of the balls, but in all cases the object is the same, namely, to sort the balls out into those which are of absolutely the desired size and those which vary by different degrees either above or below the standard. Balls up to and including 5/8 inch in diameter are gaged on automatic machines which sort them into seven different grades, as follows: balls exceeding 0.0002 inch over size; balls 0.0002 inch over size; balls 0.0001 inch over size; balls of the specified size; balls 0.0001 inch under size; balls, 0.0002 inch under size; and balls more than 0.0002 inch under size. Automatic gaging machines are used for this grading, two batteries of such machines being shown in Figs. 25 and 26. The balls are placed in hoppers *A*, at the bottom of each of which there is a plate in which a number of holes are drilled in a ring, these holes being of slightly larger size than the balls to be gaged. The plates are revolved, and as each hole comes into line with the delivery tube, the ball carried in this hole drops into the tube and runs down over gage blades *B* which are set at a slight angle to each other so that balls of the different sizes referred to will drop between the gage blades and enter tubes that carry them to the proper drawers in the cabinets beneath.

It will be seen that two types of machines are shown in Figs. 25 and 26. In Fig. 25 the gage blades are placed on an incline so that the balls run over them by gravity, and as the balls are always in contact with the gage blades, the tubes leading to the drawers of the cabinet can be placed much closer together than on the type of machine shown in Fig. 26, where the gaging blades are in a horizontal position. On the latter type of machine an agitator is necessary to keep the balls moving over the gage blades. This agitator consists of a crank *C* and connecting-rod *D* that actuates a link mechanism which causes a horizontal bar to rise in the space between the gaging blades. This bar rises slightly and then moves forward, carrying the balls with it, after which the agitator bar slowly drops and leaves the balls once more supported on the gaging blades. In this way the balls are moved along over successive tubes and finally drop through between the gaging blades—the position being determined by the size of the balls—so that different sizes of balls are sorted out as previously described. A stop checks the progress of the ball as it passes onto the gaging blades, and prevents it from rolling too fast. The gaging blades are set by master balls, in order to have the desired angle between them; and before the balls are packed, the accuracy of the blade setting is tested.

Special Indicator for Testing Balls

For gaging balls larger than 5/8 inch in diameter use is made of an instrument of the form shown in Fig. 27. This will be seen to consist of an ordinary Brown & Sharpe dial test indicator accurate to 0.0001 inch, that is set up on the table on which is also carried a holder for the ball to be tested. Connection between the ball and the dial test indicator is made by a lever, the fulcrum of which is so placed as to give a ratio of 1 to 10, and in this way readings obtained are accurate to 0.0001 inch. The girls who conduct this inspection handle the balls very rapidly and sort them out into different sizes according to the amount of deviation from the normal size.

Counting and Packing Balls

It is necessary to use great care in handling finished balls to prevent them from becoming rusty. On this account it would not do to have the balls touched by hand; but even if this were possible, to attempt to count the product of the Hoover Steel Ball Co. by hand would involve a prohibitive amount of time. For these reasons, several methods of mechanical counting have been developed which give extremely satisfactory results. The apparatus used for this mechanical counting is shown in Fig. 28. The balls are placed in hopper *A* and dropped down in holes in sliding plate *B*, which is pushed forward so that the holes are under the hopper during the "loading" period. The plate is then drawn forward to allow the balls to drop out into a box placed to receive them. Each stroke of the plate counts out one hundred balls, and plates for counting balls of various sizes are made interchangeable so that all of them may be used on a given machine. Balls up to 1/2 inch in diameter are counted by the machine, and balls from 9/16 to 7/8 inch in diameter are counted mechanically by means of board *C*, into the grooves of which the balls are loaded up to an index line. Plates of this kind are made for various sizes of balls, and each plate holds 500 balls. Large balls are counted by hand, care being taken not to touch the balls with the bare fingers. After counting, the balls are packed in cartons lined with waxed paper, and these are packed in substantial wooden boxes for shipment to the consumer.

Fig. 29. General View of Room in Inspection Department, showing Different Forms of Equipment used for testing, counting and packing Balls

INTERNAL WORM-GEARING[1]

ADVANTAGES AND PECULIARITIES OF CONSTRUCTION—PROPORTIONS OF WORM THREADS AND GEAR TEETH—METHODS OF MAKING INTERNAL WORM-GEAR

BY REGINALD TRAUTSCHOLD[2]

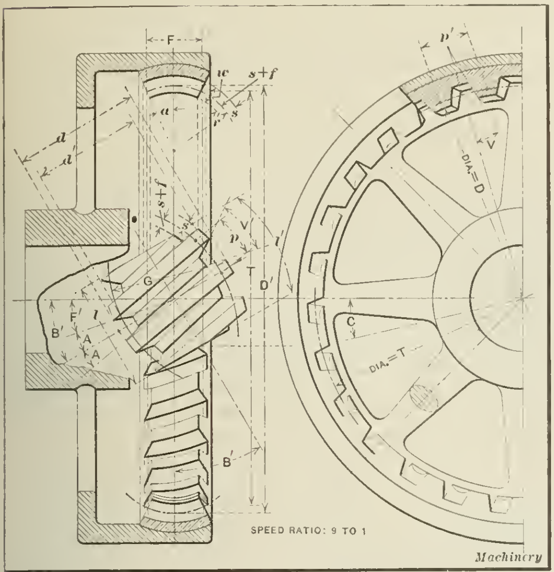

Fig. 1. Lay-out of Internal Worm-gearing

NOTWITHSTANDING the comparatively wide use of externally meshing worm-gearing with its possibilities for high speed ratios and its relatively high efficiency when properly designed and mounted—in spite of the popular belief that such gearing is inefficient—little or nothing has been done to develop and put to practical use worm-gearing of the internally meshing type. As the same advantages can be secured with internal worm-gearing (in fact, the advantages are somewhat greater, as internal worm-gearing is necessarily a modification of the efficient Lanchester worm construction) failure to use the internal worm can only be due to lack of knowledge as to its design and proper machining.

Fig. 1 shows a typical lay-out of worm-gearing and illustrates the two principal peculiarities of the construction: First, the worm and gear shafts, viewed from the back of the worm, must always lie in intersecting planes, that include an angle of greater than 90 and less than 180 degrees; and second, the worm is of the globoid form. The angularity of the shafts, most conveniently expressed in terms of the complement of the angle actually included between them (angle B') and termed the "shaft angle," cannot be 90 degrees ($B' = 0$ degrees), as is the common construction for externally meshing gears, on account of the impossibility of directly driving a worm so located. It should, however, be less than 180 degrees ($B' = 90$ degrees), for at such shaft angularity the worm would develop into an ordinary spiral pinion and require a driven gear with spiral teeth.

Derivation of Worm Formula

The globoid form of the worm depends on the angularity of the shafts, the diameter of the gear, and the face of the gear. Fig. 2 diagrammatically depicts the derivation of the formula for ascertaining the radius of longitudinal curvature to the pitch line profile of the worm, and also the "lay-out method" for arriving at the value of this dimension. The pitch outline of the worm is shown superimposed on the sectional pitch outline of the gear, the diagrams of the two members being their actual positions when viewed from above the parallel shaft planes. The length of the worm is arbitrarily fixed by the projections of the points u and v at which the axis of the worm would intersect the outer pitch lines of the gear. The line contact between the worm and the gear in any plane that includes the axis of the gear is evidently not the curve of the large pitch diameter d' of the worm, but the curve straddling the minor axis of an ellipse. This ellipse has a minor axis equal to the large pitch diameter of the worm and a major axis equal to the pitch diameter of the worm (large) divided by the cosine of the shaft angle B'; it is shown in dotted outlines, centered about the worm. The curve bounding the flattened sides of this ellipse, in the vicinity of its minor axis, is virtually an arc of a radius equal to the major axis of the ellipse minus one-half the large pitch diameter of the worm. This radius r' is that of the pitch surface of the gear in the radiating axis planes.

The pitch diameter on the edge of the gear T is then equal to the pitch diameter D' minus twice the difference between the gear face radius r' and the product of this radius by the cosine of half the angle a included by the slopes of the ends of the gear teeth. Points u, v, and w—the last the projection of the central contact point between the gear and pinion—lie on the contact curve between the gear pitch surface and the longitudinal pitch profile of the worm. An arc passing through these three points will closely approximate this contact curve. The radius of such an arc and the radius of the longitudinal pitch profile of the worm (see calculations in Fig. 2) is designated G and is equal to the length l of the worm divided by four times the product of the sine and cosine of the angle E included between the axis of the arc and its semi-chord. The sine of the contact angle of the worm C is equal to the product of the length of the worm and the cosine of the shaft angle divided by the pitch diameter of the gear at the ends of the teeth T.

Obliquity of Gear Teeth

Unless the angular pitch of the worm (the angular lead of the worm thread measured on the projection of the spiral

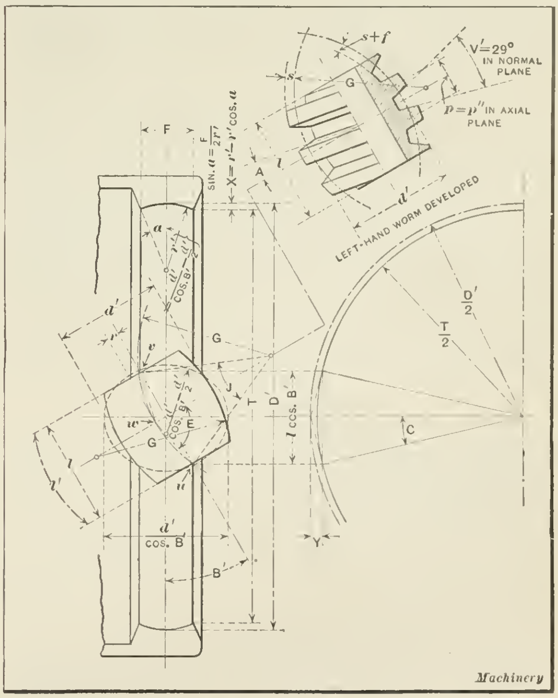

Fig. 2. Diagram showing Derivation of Worm Formula

[1] For articles on other types of internal gearing, previously published in MACHINERY, see "Internal Bevel Gearing," March, 1917, and articles there referred to.
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pitch line) that is, the angle A included between the projected pitch line and the central plane normal to the axis of the worm, and the shaft angle B' are the same, the gear teeth must cross the gear face obliquely. The angle of this gear-tooth obliquity depends on the shaft angle, the angular lead of the worm, the hand of the worm, and the hand of the drive. The hand of the drive is designated right or left as the shaft angle B' when viewed from the back of the worm, lies to the right or the left of the plane of the gear. The angular lead of the worm may be measured by an angle which is either less or greater than the shaft angle; that is, angle A may be less or greater than angle B'. With the possibility of the worm being either of the right-hand or left-hand variety, the drive right-hand or left-hand, and the angular lead of the worm either greater or less than the shaft angle, there are eight different arrangements of gear tooth obliquity, for each of which a simple relation exists between the various angles. These are shown in Figs. 3 to 10. The accompanying table gives convenient formulas for arriving at the value of either

GEAR-TOOTH OBLIQUITY

Arrangement	Angular Lead (Worm) A	Tooth Obliquity (Gear) F'
Fig. 3	$A = B' - F'$ (+)	$F' = B' - A$ (+)
Fig. 4	$A = F' - B'$ (—)	$F' = B' + A$ (+)
Fig. 5	$A = B' - F'$ (—)	$F' = B' - A$ (—)
Fig. 6	$A = F' - B'$ (+)	$F' = A + B'$ (—)
Fig. 7	$A = B' + F'$ (+)	$F' = A - B'$ (+)
Fig. 8	$A = F' - B'$ (—)	$F' = A + B'$ (+)
Fig. 9	$A = B' + F'$ (—)	$F' = A - B'$ (—)
Fig. 10	$A \quad F' - B'$ (+)	$F' = A + B'$ (—)

Machinery

the angular lead of the worm or the obliquity of the gear teeth for these eight arrangements. The hand of obliquity is designated as plus (+) for right hand and minus (—) for left hand.

Worm-thread Proportions

The normal cross-section of the worm thread establishes the shape and proportions of the gear teeth and is, of course, the conjugate of the gear tooth spaces. It is quite similar to an Acme female screw thread cut upon a pitch curve with a radius equal to twice the longitudinal pitch profile radius of the worm divided by the cosine of the angular worm thread pitch, minus the longitudinal pitch profile radius of the worm. Fig. 12 depicts the same pitch curve for the hob used in cutting the gear teeth.

The teeth, disregarding their position about a curved surface, are quite similar in shape and proportions to standard 29-degree involute rack teeth in normal section. The main difference is in the increased dedendum of the worm thread and in the proportions being based on the normal circular pitch. In the longitudinal plane of the worm, the effective section is heavier than the normal section and the obliquity of the sides of the threads is greater, the distortion depending on the angular lead of the worm. The longitudinal pitch of the worm, corresponding to the circular pitch of the gear but measured on an arc of smaller radius, is equal to the normal distance between threads, measured on the pitch surface of the worm, divided by the cosine of the angular lead of the worm.

Gear-tooth Proportions

As the teeth of internal worm-gears, like those of the ordinary type of externally meshing worm-gears, are most efficiently and expeditiously cut with a hob, the tooth spaces are proportioned to conform to the shape of the worm thread. That is, the gear teeth themselves are proportioned by the elimination of the tooth spaces. These tooth spaces are proportioned, proper allowance being made for clearance, etc., as are the worm threads. The gear-tooth section on the center plane of the gear (see Fig. 11) differs from the normal section of both the worm thread and the gear tooth and also from the longitudinal worm-thread section, the obliquity of the gear teeth and the angularity of the worm threads not being the same, as a rule. The pitch circle of the gear is measured by its pitch diameter, and the circular pitch is equal to the pitch circumference divided by the number of gear teeth. The width of the tooth space on the pitch circle is equal, of course, to one-half the circular pitch. The pressure angle of the gear teeth meshing with a worm with a standard 29-degree thread is measured by an angle having a tangent equal to the tangent of an angle of 14 degrees, 30 minutes divided by the cosine of the angle of gear-tooth obliquity.

In normal cross-section, the proportions of the tooth space more nearly conform to the normal section of the worm thread but differ in that the gashing of the tooth spaces is about a surface of lesser curvature than the curved profile surface of the worm. The normal pitch of the gear is equivalent to its circular pitch multiplied by the cosine of the angle of gear-tooth obliquity. The width of the tooth space on the pitch curve, which for each pair of adjacent teeth is approximately equal to an arc of a radius equal to the pitch diameter of the gear divided by the cosine of the angle of gear-tooth obliquity minus one-half the pitch diameter of the gear, is equal to half the normal pitch. The pressure angles of adjacent gear teeth include an angle of 29 degrees. The addendum of internal worm-gear teeth is the same as that of 14½-degree standard involute teeth of similar pitch and diameter; the other tooth proportions, the dedendum, clearance, etc., are also similar but for the slight increase in clearance that is provided to allow for wear.

Notation for Internal Worm-gearing

Speed ratio	R
Shaft angle	B'
Obliquity of gear teeth	F'
Angular lead of worm	A
Number of teeth in gear	N
Number of threads to worm	n
Circular pitch	p'
Normal circular pitch	p''
Longitudinal worm pitch	p
Angularity of sides of gear	a
Face of gear	F
Pitch radius of gear throat	r'
Pitch diameter of gear	D'
Pitch diameter at ends of gear teeth	T
Pitch diameter of worm (large)	d'
Effective pressure angle of gear teeth	V
Addendum	s
Clearance	f
Depth of teeth and worm threads	W
Inside diameter of gear	D
Outside diameter of worm (large)	d
Length of worm	l
Length of contact arc	l'
Longitudinal contact arc (gear)	C
Height of contact arc	Y
Contact angle (worm)	E
Longitudinal pitch profile radius of worm	G
Angular worm contact	J
Axial thread space angle of worm	V'

Formulas for Internal Worm-gearing

$A = B' + F'$ or $F' - B'$; $F' = B' + A$ or $A - B'$ (See table)

$$p' = \frac{3.1416\,D'}{N} \quad (1) \qquad p' = \frac{p''}{\cos F'} = p'' \sec F' \quad (1a)$$

$$p'' = p' \cos F' \quad (2) \qquad \sin a = \frac{F}{2r'} \quad (\text{Usually } a = 30 \text{ degrees}) \quad (3)$$

$$r' = d' \sec B' - 0.5d' \qquad r' = F \quad (\text{When } a = 30 \text{ degrees}) \quad (4)$$

$$D' = Np'\,0.3183 \quad (5)$$

$$T = D' - 2(r' - r' \cos a)$$

$$T = D' - 0.2679F \quad (\text{When } a = 30 \text{ degrees}) \quad (6)$$

$$\text{Tan } V = \frac{\tan 14 \text{ deg., } 30 \text{ min.}}{\cos F'} = 0.2586 \sec F' \quad (7)$$

$$s = p''0.3183 \quad (8) \qquad f = p''0.0650 \quad (9)$$

$$s + f = p''0.3833 \quad (10) \qquad W = p''0.7016 \quad (11) \qquad D = D' - 2s \quad (12)$$

$$d' = \frac{\sin a}{2r'(\sec B' - 0.5)}$$

$$d' = \frac{F}{\sec B' - 0.5} \quad (\text{When } a = 30 \text{ degrees}) \quad (13)$$

$$n = \frac{N}{R} \quad (14) \qquad d = d' + 2s \quad (15)$$

$$l = \frac{F}{\sin B'} \quad (16) \qquad \sin C = \frac{l \cos B'}{T} \quad (17)$$

$$Y = 0.5(D' - T \cos C) \quad (18) \qquad \operatorname{Cot} E = \frac{2Y}{l} \quad (19)$$

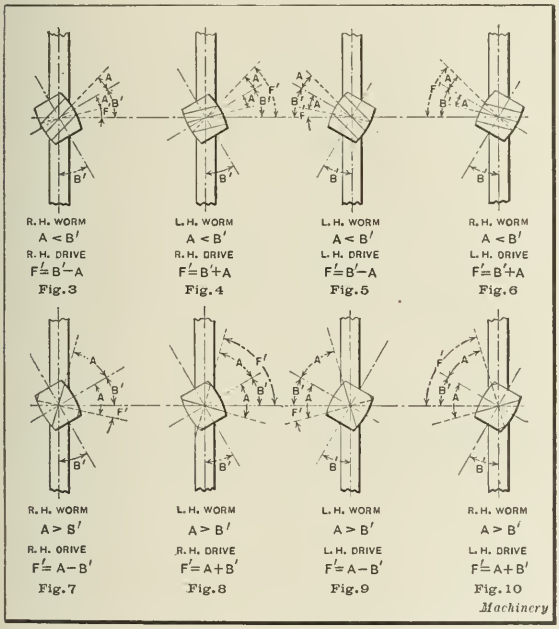
$$G = \frac{l}{4 \sin E \cos E} \quad (20) \qquad J = 360 - 4E \quad (21)$$

$$l' = \frac{3.1416GJ}{180} = 0.01745GJ \quad (22)$$

$$p = \frac{l'}{n} = \frac{p'D'}{2G \cos B'} \quad (23) \qquad R = \frac{N}{n} \quad (24)$$

Discussion of Formulas

The circular pitch is the quotient of the pitch circumference of the worm-gear divided by the number of teeth in the gear, or is equal to the normal circular pitch multiplied by the secant of the angle of obliquity of the gear teeth. It governs the diameters of the gear but it is in no way indicative of the strength of the teeth. The normal circular pitch, which is the criterion of the strength and wearing qualities of the gear teeth, and governs the proportions of the worm thread in effective section, is less than the circular pitch. It is the



Figs. 3 to 10. Diagram depicting Gear-tooth Obliquity

product of the circular pitch and the cosine of the angle of gear-tooth obliquity.

The angularity of the sides of the gear (the ends of the teeth) is controlled by the pitch diameter (large) of the worm and the shaft angle; it is usually 30 degrees. A larger angle increases the face of the gear and aggravates wear through increased friction, and a smaller angle gives insufficient contact surface for efficient transmission of power. The arbitrary fixing of the angularity of the sides at 30 degrees enables a number of the design formulas to be greatly simplified and made more adaptable for accurate computations.

The pitch radius of the gear throat is dependent on the pitch diameter of the worm and the shaft angularity, being the contact line, in the plane of the gear's axis, between the inclined worm and gear. This radius, when the angularity of the sides of the gear is 30 degrees, equals the face of the gear, a dimension that is customarily chosen arbitrarily or is fixed by the amount of power to be transmitted by the gearing.

As the gear teeth cross the gear face obliquely, the pressure angle of the teeth in the plane of the gear is obtained from its tangent. This tangent is equal to the tangent of the normal

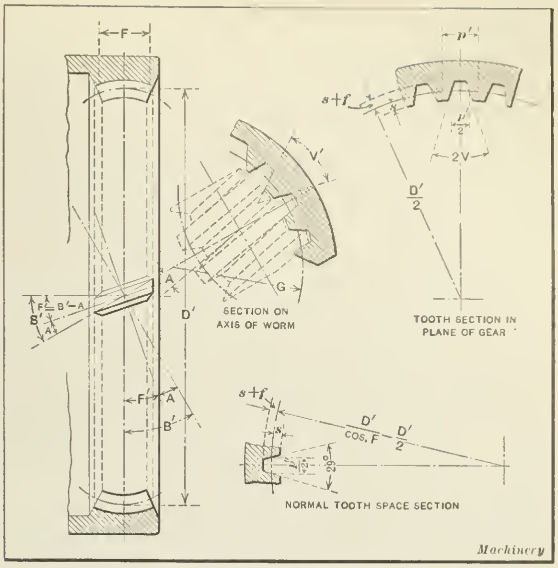


Fig. 11. Gear-tooth Proportions

pressure angle (which is usually 14 degrees, 30 minutes) divided by the cosine of the angle of obliquity of the gear teeth.

The clearance allowed in worm-gearing is customarily greater than is allowed in gearing operated through rolling contact. This increase is arbitrarily taken as equal to p'' 0.015. The addendum and dedendum are calculated from the normal circular pitch, not from the circular pitch. The increase does not affect the addendum but does enlarge the dedendum and the whole tooth depth dimensions.

Inasmuch as the angularity of the sides of the gear and the pitch radius of the gear throat are controlled by the large pitch diameter of the worm, there is a fixed relationship between the large pitch diameter of the worm and the factors that it controls. The general formula for the large pitch diameter of the worm is the sine of the angle of the sides of the gear divided by the product of twice the pitch radius of the gear throat by the secant of the shaft angle minus 0.5. By making the angularity of the sides of the gear equal to 30 degrees, the formula is simplified to the gear face divided by the secant of the shaft angle minus 0.5.

The necessary number of simple threads to the worm is most easily found by dividing the number of teeth in the gear by the required speed ratio. Preferably the number of threads should be a whole number, but this is not absolutely necessary, for any number, mixed or whole, of complete threads may be employed. A mixed number of threads, however, complicates the checking up of the worm. The length of the worm is controlled by the shaft angle and should be made equal to the face of the gear divided by the sine of the shaft angle. A shorter worm will not develop the full efficiency of the con-

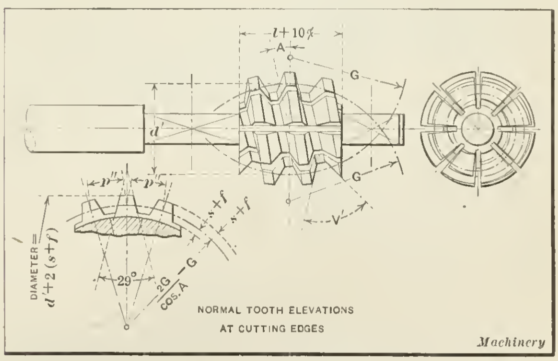


Fig. 12. Detail of Hob for Internal Worm-gear

struction and a longer worm will not be effective over the added length.

The longitudinal contact arc on the pitch circumference of the gear, measured by the sine of the angle included between the projection of the semi-chord of the arc and its center axis, is equal to the projection of the normal contact curve on the pitch circumference divided by the pitch diameter of the ends of the gear teeth. The height of this arc, also the height of the normal contact arc, is equal to one-half the difference between the pitch diameter of the gear and the product of its pitch diameter at the ends of the teeth by the cosine of the angle measuring the longitudinal contact arc of the gear. The cotangent of the contact angle E (see Fig. 2) is then equal to twice the height of the contact arc divided by the length of the worm and the radius of the arc is equal to the length of the worm divided by four times the product of the sine and cosine of the angle of the contact arc E.

The angle included by the contact arc, or the angular worm contact, is equal to 360 degrees minus four times the contact angle E, from which the length of the contact arc is readily obtained by direct proportion, the longitudinal pitch profile radius of the worm being known.

The longitudinal worm pitch, or the distance between centers of threads measured on the pitch arc, obviously equals the length of the contact arc divided by the number of threads to the worm. It is also equal to the product of the circular pitch of the gear and its pitch diameter divided by twice the product of the longitudinal pitch profile radius of the worm by the cosine of the shaft angle.

Example in Design of Internal Worm-gearing

Example:—Required, an internal worm-gear combination; 48 teeth in gear; speed ratio, 12 to 1; right-hand worm; right-hand drive; 1 inch circular pitch; angle of sides of gear teeth, 30 degrees; shaft angle, 30 degrees; angular lead of worm, + 15 degrees; and face of gear, 3 inches. That is, $B' = 30$ degrees, $A = 15$ degrees, $a = 30$ degrees, $N = 48$, $F = 3$ inches, $p' = 1$ inch, $R = 12:1$.

$F'' = 30 - 15 = +15$ degrees (arrangement Fig. 3, from table)

$$p'' = 1 \times 0.96593 = 0.966 \text{ inch} \qquad (2)$$

$$r' = 3 \text{ inches} \qquad (4)$$

$$D' = 48 \times 1 \times 0.3183 = 15.2784 \text{ inches} \qquad (5)$$

$$T = 15.2784 - 0.2679 \times 3 = 14.4747 \text{ inches} \qquad (6)$$

$$\text{Tan } V = 0.2586 \times 1.0353 = 0.26773 \qquad (7)$$

$$V = 14 \text{ degrees, } 59 \text{ minutes}$$

$$s = 0.966 \times 0.3183 = 0.3075 \text{ inch} \qquad (8)$$

$$f = 0.966 \times 0.0650 = 0.0628 \text{ inch} \qquad (9)$$

$$s + f = 0.966 \times 0.3833 = 0.3703 \text{ inch} \qquad (10)$$

$$W = 0.966 \times 0.7016 = 0.6777 \text{ inch} \qquad (11)$$

$$D = 15.2784 - 2 \times 0.3075 = 14.6634 \text{ inches} \qquad (12)$$

$$d' = \frac{3}{1.1547 - 0.5} = 4.582 \text{ inches} \qquad (13)$$

$$n = \frac{48}{12} = 4 \qquad (14)$$

$$d = 4.582 + 2 \times 0.3075 = 5.197 \text{ inches} \qquad (15)$$

$$l = \frac{3}{0.5} = 6 \text{ inches} \qquad (16)$$

$$\text{Sin } C = \frac{6 \times 0.86603}{14.4747} = 0.3589 \qquad (17)$$

$$C = 21 \text{ degrees, } 2 \text{ minutes}$$

$$Y = 0.5\,(15.2784 - 14.4747 \times 0.93337) = 0.88407 \text{ inch} \qquad (18)$$

$$\text{Cot } E = \frac{2 \times 0.88407}{6} = 0.29469 \qquad (19)$$

$$E = 73 \text{ degrees, } 35 \text{ minutes}$$

$$G = \frac{6}{4 \times 0.95923 \times 0.28262} = 5.533 \text{ inches} \qquad (20)$$

$$J = 360 - 4\ (73 \text{ degrees, } 35 \text{ minutes}) = 65 \text{ degrees, } 40 \text{ minutes} \qquad (21)$$

$$l' = 0.01745 \times 5.533 \times 65.666 = 6.340 \text{ inches} \qquad (22)$$

$$p = \frac{6.340}{4} = 1.585 \text{ inch} \qquad (23)$$

The Hob

The outside diameter of the hob for cutting the gear teeth must be equal to the outside diameter of the worm plus twice the clearance; the increase in diameter usually provided for the hobs of ordinary externally meshing worm-wheels to allow for wear should also be provided. That is, the addendum and dedendum dimensions of the hob should be made the same, the increase in diameter being the same as the increase in the clearance allowed for the gear and worm. The length of the hob should be about 10 per cent greater than that of the worm employed in driving the gear to be cut, in order to insure a gradual bite into the metal of the worm-wheel without danger of marring the edges of the completed gear teeth, the cutting teeth of the hob engaging the edges of the gear face before the mid-tooth section.

The proportions of the hob teeth on the normal cutting planes (see Fig. 12), with the exception of the elongated addendum and the corresponding increase in their length, are similar in every respect to those of the worm thread and require no explanation. The draft and clearance of the hob teeth, however, are of the utmost importance. The normal pitch curve radius for each individual tooth of the hob, like the corresponding radius for the worm, equals twice the longitudinal pitch profile radius divided by the cosine of the angle of the angular thread (tooth) pitch minus the longitudinal pitch profile radius. This pitch curve radius, common to the hob and the worm, is that of the curve of the flattened sides of an ellipse with a minor axis equal to twice the pitch profile radius and a major axis equal to the minor axis divided by the cosine of angular worm lead.

Machining Internal Worm and Hob

The worm and hob are machined in the same manner, the same, or similar cutting tools being employed. No special equipment is ordinarily required for the lathe, other than a

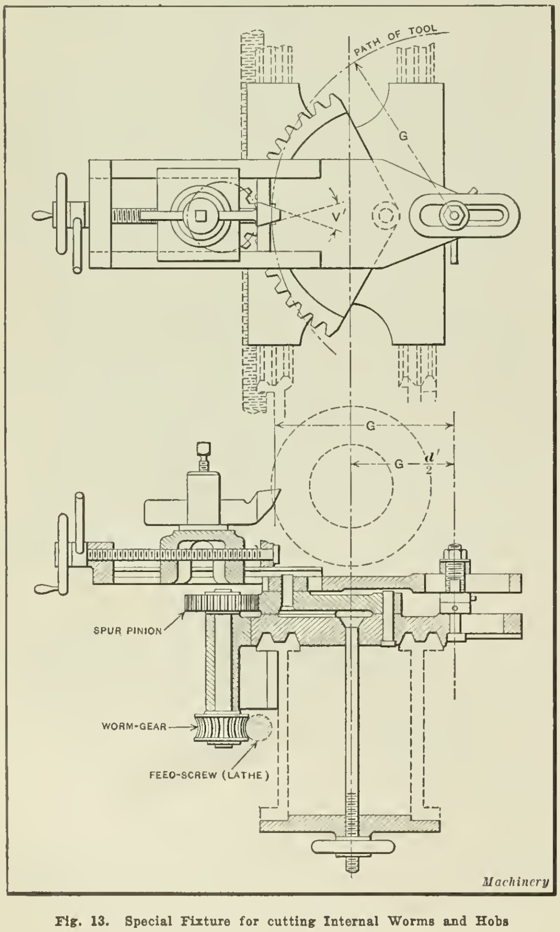


Fig. 13. Special Fixture for cutting Internal Worms and Hobs

radius link—conforming in length to the longitudinal pitch profile radius of the worm or hob—for guiding the cutting tool about the face of the worm. The pivot end of the link is fixed, in relation to the lathe bed, in the normal central plane of the worm, while its swinging end carries the toolpost, etc., the cross-feed being located on the link. The cutting tool is ground to conform not to the normal thread space but to the thread space in an axial plane, that is, angle V', and extreme care should be exercised to see that the angle between the sides of such space is the same for the worm as for the hob used in cutting the mating gear. As in all cases where a cutting tool is made to conform to an axial space that differs in form from the normal section of the gash cut, adequate clearance for the cutting tool must be provided.

A slight variation in the angularity (obliquity) of the threads cut at the center of the worm or hob and that of those cut toward the ends of the worm cannot be avoided in this method of guiding the cutting tool about the face of the worm, for the carriage travel along the lathe bed—actuated by the feed-screw of the lathe—must necessarily be at a constant speed. With the path of the cutting tool the arc of a circle, the cutting tool must travel farther than the distance along the lathe bed covered by the carriage in its journey from end to end of the worm. The travel of the cutting tool is measured by the arc of the longitudinal profile curve of the worm, while the travel of the carriage is only the axial length of the worm; the relationship of the paths is as l' to l. Hence, the circumferential feed of the tool must be gradually increased as it passes the normal center plane of the worm and must be retarded as it approaches the center of the worm. The increased circumferential feed of the cutting tool toward the ends of the worm increases the obliquity of the end threads, the increase in obliquity being gradual toward either end. This slight increase in the angularity of the threads at the ends of the worm and hob proves somewhat of an advantage when the gearing is first put into operation.

Should the worm be unusually long, however, some special fixture is necessary, for the difference between the circumferential and axial lengths of the worm will otherwise cause considerable variation in the obliquity of the worm thread, particularly if the radius of profile curvature is comparatively short, as would probably be the case. However, this method can be used for almost any length of worm, the difference in length of the operating arcs of the two swinging segments being much less than the difference in the lengths of the operating paths of the carriage and of the cutting tool in the "radius-arm method."

The special fixture shown in Fig. 13 can be used with any lathe of suitable swing. It is automatically actuated by the regular feed-screw of the lathe and consists essentially of two swinging segments pivoted to a supporting base clamped firmly to the lathe bed. The feed-screw engages the operating worm-gear of the fixture, which, in turn, drives a spur pinion meshing with the toothed edge of the lower of the two swinging segments. This toothed segment, which is a sector of a gear of the same pitch as the driving pinion and a pitch radius closely approximating the average longitudinal pitch profile radius of the worms and hobs suitably proportioned for the fixture, carries a driving pin that fits into a sliding wearing block in the upper swinging segment and causes the latter to swing about its pivot center as the toothed segment is shifted by the screw of the lathe. The upper segment carries the tool carriage and, with the distance of the cutting end of the tool from the pivot center of the upper segment set to correspond with the longitudinal pitch profile radius of the worm or hob, the path of the cutting tool follows the profile curve of the blank, being carried from end to end of the work at such a speed that the obliquity of the groove cut conforms to the angular lead of the worm thread.

A slight variation in the angularity of the threads cut at the center of the worm or hob and that of those cut toward the ends of the worm cannot be avoided with this type of guiding fixture, unless the pivot radius centers of the two segmental parts of the fixture are the same. A fixture designed on such lines would have a very limited capacity. A special fixture would be required for cutting each worm or hob of differ-

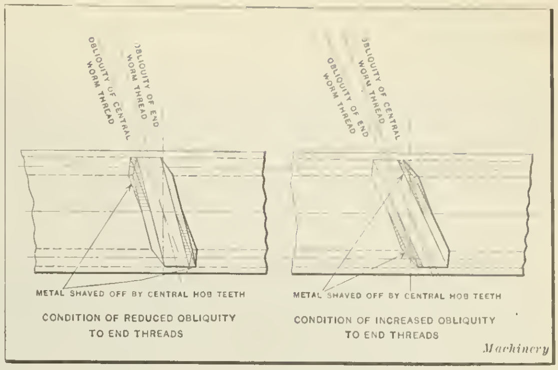


Fig. 14. Correction of Gear-tooth Obliquity by Central Hob Teeth

ing longitudinal pitch profile radius, pitch diameter or variation in ratio of longitudinal pitch profile radius to pitch diameter. A particular fixture for each worm cut would materially complicate the question of necessary equipment for manufacturing internal worm-gearing, though simplifying the type of fixture that could be used. By making the toothed segment pivot radius slightly different from the average longitudinal pitch profile radius of the worms for which the fixture is proportioned, an appreciable amount of adjustment can be made so that worms of varying size, etc., can be cut with the same fixture, and at the same time the variation in the rate of feed of the cutting tool, due to the non-concentricity of the two swinging segments, remains very slight. The variation in the rate of feed of the cutting tool would be almost negligible and might be a slight acceleration at the ends of the worm or hob or a gradual retardation in feed.

Machining Internal Worm-gear

Cutting the gear teeth with the globoid form of hob presents even less difficulty than hobbing the ordinary externally meshing type of worm-wheel, when the gear blank has once been correctly located in reference to the hob, and the shaft angle is accurately set. The worm-gear must be driven at the proper lead by an independent set of gears and at a speed commensurate with the speed at which the hob is driven; that is, the relationship between the speeds of the hob and the gear blank must be the same as that between the worm and the gear when in operation. With the gear blank and hob properly mounted, etc., a light cut is first taken to locate the spacing of the gear teeth correctly. The locating gashes are made along the face edges of the gear with the end teeth of the hob, as the outside radius of the hob is greater than the inside radius of the gear face in the plane of contact. The obliquity of the gashes differs slightly from that of the mid-tooth section later cut by the central teeth of the hob, on account of the method employed in cutting the hob. As the depth of the cut is increased and the central cutting teeth come into play, however, the obliquity of the teeth is correctly cut at mid-section and the obliquity at the ends gashed out by the end teeth of the hob corrected on one side of the tooth space. The side of the teeth corrected for obliquity depends upon the relationship of the radius of the toothed segment of the special fixture used in cutting the hob to the pivot radius of the cutting tool used—the longitudinal pitch profile radius of the worm.

When the radius of the toothed segment is slightly longer than the effective tool-carriage pivot radius, the obliquity of the end hob teeth is very slightly less than that of the central cutting teeth; this results in a trivial retardation of the feed of the cutting tool as it approaches the ends of the worm and hob. Should the longitudinal pitch profile radius—the effective tool-carriage pivot radius—be the longer, on the other hand, there will be a slight increase in the obliquity of the end threads and a corresponding increase in the feed of the cutting tool at the ends of the worm. The obliquity correction by the central hob teeth is to shave off one side of each tooth, the amount of metal removed increasing from the center of each tooth to the end, the removal of metal alternating from

end to end of tooth as graphically depicted, on an exaggerated scale, in Fig. 14.

Effect of Shaving Teeth on Tooth Action

The effect of thus removing a slight amount of metal from alternate semi-lengths of the sides of each gear tooth is to provide a very slight clearance for the initially engaging worm thread. This clearance, either in advance of or behind the worm thread, is negligible when the central threads of the worm come into action, and is effectively concentrated on the sections of the gear teeth in intimate contact with the end worm threads. These end worm threads actually transmit but a very small proportion of the power delivered and are more valuable as pilots for the proper engagement of the central worm threads than for the small amount of power they may transmit. The heavy pressure of the worm is thus gradually shifted from end to end of the gear teeth, resulting in a much smoother operation of the gearing while new. The tooth action is improved for new gearing, without in any way detracting from the smooth action of older gears that have become slightly worn. This is particularly so if the wear has been equal on both the worm threads and the gear teeth, a requisite for the satisfactory operation of any type of worm-gearing.

* * *

LOYALTY

BY J. P. BROPHY [1]

The editorial in the February number of MACHINERY entitled "Building Up an Organization" is interesting, but I do not altogether agree with the ideas expressed. The editorial says:

> The manufacturing concerns that have achieved a reputation for square dealing and general reliability are those which by years of effort and training have built up an organization of efficient and loyal employes.

The last two words, "loyal employes," I am sorry to say, do not mean very much to me. Loyalty is supposed to mean a generous amount of good feeling nearly approaching love for those to whom you are loyal. It might be supposed that any man in your employ from five to twenty years, who has been well treated in every respect, must be satisfied with his job or he would not remain so long, and should be considered loyal. If, as an employer, you have always considered the employe's comfort to the best of your ability, treating him with due consideration to the extent of having the surroundings as comfortable as possible and guarding against any unjust treatment by those in power, you certainly would expect some returns in fair treatment when the opportunity presented itself; not that you would expect more work from the old employe than from the man who has been employed, say, for a few months, but when trouble arises in the factory, you would think that the old-time employe would do the fair thing and not be carried away by the arguments of men who are here today and somewhere else tomorrow. From my experience during the last few years, I have become convinced that loyalty is rarely ever found in those in whom you would naturally expect it. In my estimation, if you have 5 per cent of actually loyal employes, you are lucky, regardless of whether you employ 50 or 5000.

Building up an organization is all right, and can be done as far as efficiency is concerned, because this is controlled by good management, but loyalty cannot be considered to go hand in hand with efficiency. The foregoing extract is nicely worded and will be read by many who will be much interested in it. However, I have never found loyal employes in abundance. They usually keep under cover and certainly do not act when the time arrives to defend the company that has employed them for a number of years. Of course, in any line of business, large or small, there are generally some loyal men. But, if you will consider what loyalty really means, I think you will agree that the human element crops out in most employes and results in actions that are detrimental to the employer.

Loyalty to country is certainly expected and should be demanded, but loyalty in the work-shop is a different proposition. The word loyalty looks good in print and it is a fine thing when lived up to. When two men can speak freely to each other on almost any subject, feeling safe in so doing, the ideal condition exists and one to be cherished through life. As already stated, we, and thousands of others, have tested the matter of loyalty many times, in our business troubles, and have found it a farce. It is well to be cautious to whom you speak confidentially in trying times. The risk is great and the damage irreparable in many instances. When it is too late, you will ponder and try to solve the problem. Old employes should consider their company's welfare, but many men lack the courage. There is a sneaky attitude noticeable, especially if it means the gain or loss of a few dollars; and when money is involved many employes are not dependable. It is regrettable for me to have to speak so plainly on this subject; it would be a gratification to take the opposite point of view.

If you, Mr. Editor, have not had these experiences, you are lucky. You will probably not escape this unpreventable shock that hardens every tender feeling you ever entertained for your men. If your nature is of the forgiving type, you may pass through life making excuses for those who prove treacherous rather than loyal. I am not trying to destroy the belief that loyalty exists in this world of ours; sometimes it is found where least expected. It does seem impossible that a vast number of old employes with whom you come in contact constantly could be anything but loyal.

Another paragraph in the editorial says that we should educate a certain percentage of our employes each year in the elements of the trades, as that practice is necessary to insure against strikes and labor troubles. I emphatically and without hesitation make the statement that if those who have had labor troubles were not afraid to speak their minds, they would testify that such practice will not be an insurance against strikes. No matter what you do or how you do it, can you for one moment feel safe when you have labor troubles. Even your old employes who should be considered old friends will desert you. It is exceptionally distasteful for me to have to express myself so forcibly on a subject of such great importance, but in all the strikes and labor troubles I have ever had to contend with, I have discovered, in many instances through being on the alert, that there were few men in the employ of the company I represented that showed the slightest inclination, regardless of how long they had been employed, to say one word in favor of the company. A great number of men whom I thought the most trustworthy have proved the reverse. It made no difference whether there was any justification in these labor troubles or not, the majority of the men proved to be the opposite of what should be expected, considering the length of time they were with the company and the manner in which they were treated for many years. Loyalty is like radium, extremely difficult to find and almost priceless when discovered.

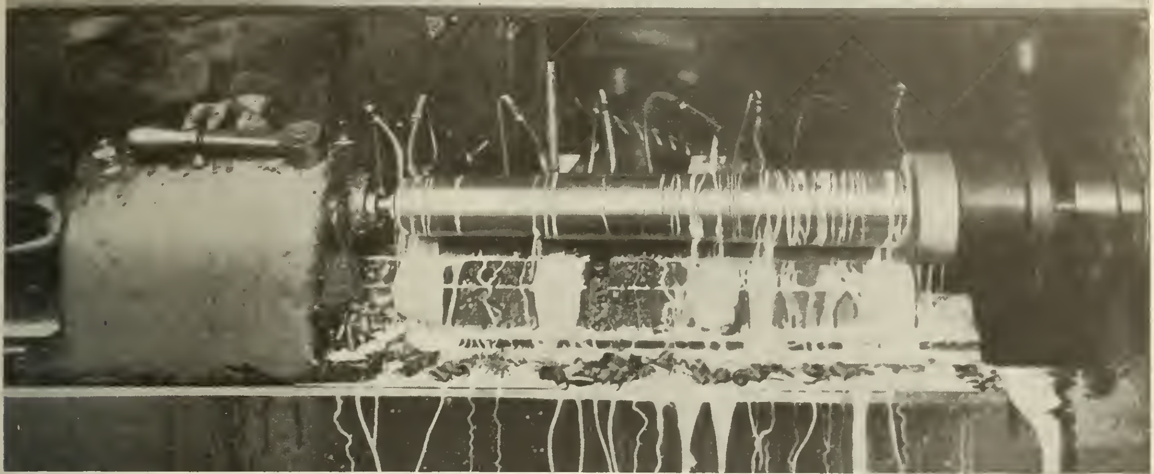
[1] Vice-president and General Manager, Cleveland Automatic Machine Co., Cleveland, Ohio.

* * *

The New York Connecting R. R.—Hell Gate Bridge Route—for through passenger service between New England and the West and South, was dedicated to the service of the public by Samuel Rea, president of the Pennsylvania R. R. Co. March 9. The special train which conveyed the inspection party and which was the first train operated over the new link, left the Pennsylvania Station, New York City, passed through the East River tubes to the Sunnyside Yards, Long Island, then traversed the line of the New York Connecting R. R. to the northern end of Hell Gate Bridge, and thence proceeded to the junction of the New York, New Haven & Hartford R. R. in the Bronx. Gustav Lindenthal, designer of the Hell Gate Bridge and chief engineer of the East River Bridge Division, stated in his address at the dedication, that the project has cost over $27,000,000. It completes the car rail connection *via* New York City, between the Pennsylvania and New Haven systems, and consists of a four-track elevated line about six miles in length built of concrete and steel, which joins the New York, New Haven & Hartford R. R. with the lines of the Pennsylvania R. R. system, by way of the East River tubes, the Pennsylvania Station in New York City, and the Hudson River tubes. It makes possible through train service from all points in New England to Philadelphia, the West and the South. The Hell Gate Bridge is a single 1000-foot span supported by a double arch of steel across the East River.

Lubrication of Cutting Tools-4

by Edward K. Hammond[1]



REFERENCE has been made in a previous installment to the diversity of practice which exists in the lubrication and cooling of metal cutting tools, and it was pointed out that this is largely due to numerous variable factors entering into the action of an oil or cutting compound which make it difficult to determine exactly the nature of the service performed by the fluid. When one manufacturer is using a soluble cutting compound costing, say, two cents a gallon, and another manufacturer uses petroleum oil costing twenty-four cents a gallon for the same purpose, it would appear that the latter practice involves unnecessary expense, and possibly this is the case. But the difference may not be as marked as a mere comparison of cost makes it appear, owing to the fact that the oil may wear longer and may enable the cutting tools to be operated for a greater length of time before they require grinding; or the work may be improved in quality and the wear of machine-tool equipment decreased.

A careful investigation of practice in representative American manufacturing plants goes to show that there are particular classes of work in which each of the commonly used cutting lubricants gives exceptionally good service, and a discussion of this subject will be presented to supplement the tabulated data in Table IV. Briefly, this information may be summarized as follows: Pure lard oil is one of the most efficient lubricants available, but owing to its high price, which is slightly in excess of $1 per gallon under present market conditions, the use of this lubricant undiluted is not generally recommended except for such machining operations as tapping, reaming, and similar classes of work where a high finish and great accuracy are required. In many such cases it has been found impossible to find a satisfactory substitute.

For automatic screw machine work some manufacturers still use pure lard oil, but here the need of a large volume of oil causes the question of economy to play an important part; as the so-called "mineral lard oil" mixtures, ranging from 30 per cent of lard oil and 70 per cent of medium petroleum oil up to equal parts of lard oil and petroleum oil, have been found to give practically as good results as pure lard oil, it seems desirable to use these mixtures. Furthermore, mineral lard oil has an advantage over pure lard oil in that it is more fluid and thus runs more freely to the tool and work; also, this mixed oil is not so likely to give trouble from gumming. Lard oil possesses a peculiar unctuous property that is not found in other oils, and it is a matter of common experience that trouble is likely to develop on automatic screw machine work—particularly in cases where forming, threading and tapping operations have to be performed—unless the lubricant used contains lard oil as one of its constituents.

Mineral lard oil mixtures are used for automatic screw machine work and for numerous other machining operations, and the following mixtures have been found highly satisfactory: (1) Equal parts of lard oil and petroleum machine oil. (2) Lard oil, 30 per cent, and mineral oil, 70 per cent. (3) On Cleveland automatic screw machines for cutting steel of different grades, from 10 to 12 per cent pure lard oil and 88 to 90 per cent neutral mineral oil of about 32 degrees Bé. gravity. The fluidity of this mixture permits it to reach the extreme cutting point of the tool and it possesses sufficient viscosity to form the required film on the work. (4) One part lard oil and three parts Pennsylvania petroleum oil. (5) Mineral lard oil reduced with from 33 1/3 to 66 2/3 per cent kerosene or paraffin. (6) Ten gallons lard oil to one gallon kerosene. (7) For drilling, reaming and gear planing, 30 per cent lard oil and 70 per cent petroleum.

With the view of reducing the cost of lubricants, some manufacturers have resorted to the use of pure petroleum oil on such machining operations as milling and turning, which seems to be a step in the direction of economy that is justified, because the mineral oil is giving satisfactory service. A further step in reducing the cost was made through the introduction of the so-called soluble oils and compounds used with water to form the well-known white cutting emulsions which are available at prices ranging from about 1½ to 15 cents a gallon, according to the degree of dilution. Opinion is divided in regard to the advisability of using these water emulsions,

[1] Associate Editor of MACHINERY.

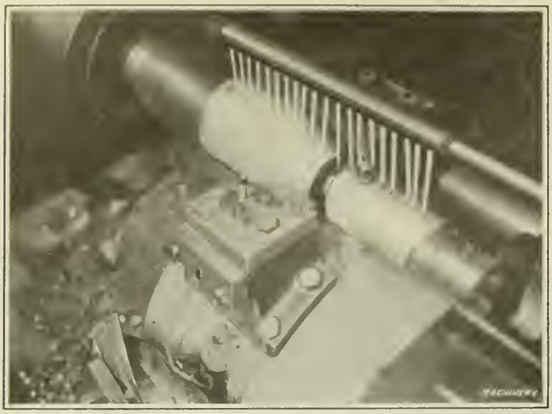


Fig. 78. Pipe with Series of Holes to distribute Coolant to Tools on Shell Turning Lathe

but the following seems to be representative of experience in shops where the question has received most careful consideration. For milling, drilling, grinding and other operations where short chips are produced, making cooling the most important service performed by the fluid, these water emulsions give very satisfactory results. They flow freely, and as water has a higher specific heat than any of the oils, these emulsions are more efficient than oil for cooling. In cases where lubrication of the tool is also important, it is good practice to add more of the soluble oil or paste compound in mixing the emulsion than where cooling only is necessary; but under the most favorable conditions these emulsions have but a slight lubricating action, so that they are unsuitable for use where long chips are produced. In such cases, some kind of oil will give more satisfactory results.

It has been a matter of fairly general experience that the soluble oil compounds are unsuitable for use on automatic screw machines, turret lathes and other machines having slides and bearings into which the emulsion can easily find its way. When fluids containing water are used on machines of this kind, the detergent action is a source of trouble because the oil is washed out of the bearings, and serious wear results.

The preceding is a brief summary of experience with the use of pure lard oil, mineral lard oil, pure mineral oil and soluble cutting compounds, which are the four classes of lubricants used on the majority of the cutting tools in American factories. Detailed information is given in the following paragraphs concerning the lubricants used for typical machining operations on different kinds of metal. In each case the recommendations are presented in the order in which these different lubricants are generally used. To supplement this information, Table IV gives lubricants that are more commonly employed for various machining operations on different classes of metal; and Table V gives a list of soluble oil compounds and their manufacturers, together with the degree of dilution recommended by these manufacturers for different classes of machining operations. In addition to the soluble compounds there are a number of commercial oil mixtures on the market; some of these are used "straight" while others are diluted with kerosene, fuel oil, etc. Table VI gives recommendations in regard to the classes of work for which these are adapted and the degree of dilution recommended for different classes of work.

General Lubricants for Different Machining Operations

In attempting to make recommendations for lubricants for various machining operations on different classes of metals, letters were sent out to a list of representative builders and users of different types of machine tools, asking them to furnish information concerning the lubricants and coolants they had found most satisfactory. Information obtained from these sources was supplemented by the observation of MACHINERY's editors while visiting manufacturing plants engaged in a great variety of work. When these data were analyzed it

TABLE IV. CUTTING LUBRICANTS FOR MACHINING OPERATIONS ON DIFFERENT CLASSES OF MATERIAL[1]

Operation	High-carbon and Alloy Steel	Low-carbon Steel	Cast Iron	Wrought Iron	Malleable Iron	Brass	Bronze	Copper	Aluminum	Monel Metal
Turning	Mineral lard Compound	Compound Dry	Dry	Dry Compound	Dry Compound	Dry	Dry	Dry	Kerosene	Dry Compound
Forming	Mineral lard Paraffin oil 28° Bé.	Mineral lard Compound	Dry	Dry Compound	Dry Compound	Dry	Dry	Dry	Kerosene	
Boring	Mineral lard Paraffin oil 28° Bé.	Mineral lard Compound	Dry	Compound	Dry Compound	Dry	Dry	Dry	Kerosene	
Milling	Mineral lard Compound	Compound Mineral lard	Dry Comp. air	Compound Water	Compound	Dry Compound	Dry or comp. Kerosene	Mineral lard	Kerosene	Compound
Drilling	Mineral lard (Hard) Turpentine	Mineral lard Compound	Dry Comp. air	Compound Mineral lard	Compound	Dry	Compound Dry	Mineral lard	Kerosene Beeswax or tallow	Compound
Reaming	Lard oil Sperm oil	Lard oil Mineral lard	Dry Mineral lard	Lard oil Mineral lard	Compound	Dry	Dry	Mineral lard	Kerosene	
Tapping	Lard oil Cottonseed	Lard oil Cottonseed	Lard oil Compound	Lard oil Compound	Lard oil Compound	Lard oil Compound	Lard oil Lard oil and white lead	Lard oil	Lard oil Kerosene	
Tapping nuts		Mineral lard Compound		Mineral lard Compound		Mineral lard Compound				
Broaching	Neatsfoot oil Compound	Neatsfoot oil Compound	Dry	Neatsfoot oil Compound	Neatsfoot oil Compound	Dry	Neatsfoot oil Compound		Kerosene	
Gear cutting	Lard oil	Mineral lard Compound	Dry Compound		Compound		Mineral lard Compound			
Gear planing	Mineral lard	Mineral lard	Dry		Compound Mineral lard	Dry	Dry			
Gear hobbing	Lard oil Mineral lard	Mineral lard	Dry Compound		Compound	Dry	Lard oil Mineral lard			
Gear shaper	Lard oil Mineral lard	Lard oil Compound	Compound			Compound	Compound			
Auto. screw machine work	Lard oil Mineral lard	Mineral lard Paraf. and mineral lard		Mineral lard Paraffin and mineral lard		Mineral lard Paraffin oil	Mineral lard	Mineral lard	Mineral lard Compound	
Thread cutting	Lard oil Cottonseed	Mineral lard Cottonseed	Dry	Mineral lard Cottonseed	Dry Compound	Dry	Dry Mineral lard	Dry	Kerosene	Lard oil and white lead
Thread milling	Mineral lard Paraffin oil 28° Bé.	Mineral lard Paraffin oil 28° Bé.	Dry		Dry Compound	Mineral lard Compound				
Threading dies	Lard oil Sperm oil	Mineral lard Compound		Lard oil Mineral lard	Dry Compound	Mineral lard Compound				
Cold-saws	Mineral lard	Mineral lard Compound	Dry Compound	Mineral lard Compound	Compound	Dry	Compound Dry	Compound Dry		Compound
Grinding	Compound	Compound	Compound	Compound	Compound	Compound	Compound	Soda water		

Machinery

[1] Babbitt, hard rubber and fiber are machined dry with few exceptions. Lard oil or soap may be used when tapping babbitt; water when turning hard rubber, and soap compound when tapping, boring, milling, drilling and reaming; turpentine or kerosene is used when drilling and reaming glass.

at once became evident that there are no accepted standards of practice; different manufacturers use different lubricants for the same work, and as previously explained, each may obtain the same amount of service for his money, owing to variations in the life of different oils and of tools lubricated with these oils, regardless of the fact that oils used for the same purpose may be of widely different price. In Table IV information is given concerning lubricants for the different machining operations on materials commonly worked in machine shops. It will be noticed that in most cases two lubricants are named, these being given in the order in which they are most generally used. It was impracticable to tabulate all the information available concerning lubricants for different machining operations and metals, but the following paragraphs supplement the table by giving additional cutting lubricants that have been found to give good service. As in the case of Table IV, these are named in the order in which experience has shown they are most generally used. Where the use of "compound" is recommended, it means any of the emulsions made by mixing soluble oil or paste with water. Attention is called to the fact that no recommendations are made in the case of such materials as cast iron, etc., where it is good practice to conduct the machining operation dry.

Automatic Screw Machine Work—High-carbon and alloy steel: lard oil, mineral lard oil consisting of ten parts mineral lard oil and one part kerosene. Low-carbon steel: mineral lard oil, asphaltic base petroleum oil, paraffin oil and mineral lard oil in equal proportions. Wrought iron: mineral lard oil, asphaltic base petroleum oil. Brass: mineral lard oil, light paraffin oil. Bronze: mineral lard oil, asphaltic base petroleum oil. Copper: mineral lard oil. Aluminum: mineral lard oil, compound. Hard rubber: dry, compressed air. Fiber: dry. In all cases the mineral lard oil mixture may run anywhere from equal parts of mineral oil and lard oil down to 70 per cent mineral oil and 30 per cent lard oil.

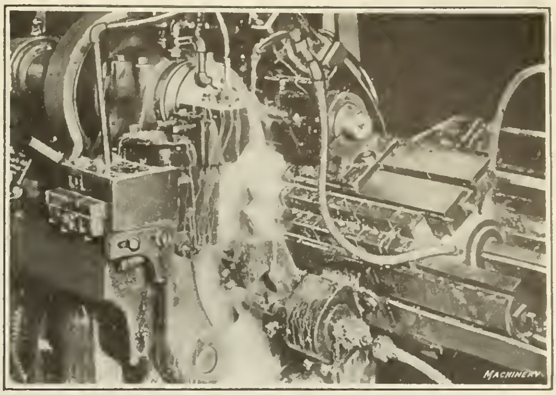


Fig. 79. Application of Lubricant to Tools on Automatic Screw Machine

Boring—High-carbon and alloy steel: mineral lard oil, lard oil, paraffin oil. Low-carbon steel: mineral lard oil, petroleum oil, compound. Brass: compound. Bronze: compound. Copper: lard oil or kerosene. Aluminum: kerosene.

Broaching—High-carbon steel: neatsfoot oil, compound. Low-carbon steel: neatsfoot oil, compound. Wrought iron: neatsfoot oil, compound. Malleable iron: neatsfoot oil, compound. Bronze: neatsfoot oil, compound.

Cutting off with Cold-saws—High-carbon and alloy steel: mineral lard oil, mixture of two parts kerosene and one part signal oil, petroleum oil. Low-carbon steel: mineral lard oil, petroleum oil, compound, mixture of two parts kerosene and one part signal oil. Wrought iron: mineral lard oil, petroleum oil, compound. Bronze: compound.

Cutting off with Hacksaw Machines—On all metals use soda-water mixture of two pounds soda to three gallons water.

TABLE V. APPROXIMATE DEGREES OF DILUTION (PARTS OF WATER PER PART OF OIL OR PASTE) FOR CUTTING COMPOUNDS ON DIFFERENT MACHINING OPERATIONS

Name of Company	Compounds and Oils	Cost per Gallon	Turning and Boring	Milling	Drilling	Cold-saws	Grinding	Threading	Gear Cutting	Gear Hobbing	Nut Tapping	Broaching
A.L.A. Mfg. & Sup. Co.	A. L. A. Compound	0.06½[1]	16	32	32	...	...	16	...			
	A. L. A. Hydrosol	60	20	30	30	...	...	20	...			
American Oil Corp. ...	Am. Cutting Comp.	...	16	16	16		16	...	...			
	Oleosity	...	16	16	16	...	50	...	...		...	
American Oil Prod. Co.	Opco-lardo	0.60	25 to 30	25 to 30	40 to 50	25 to 30	25 to 30	25 to 40	10 to 15	10 to 15	30 to 40	
Baum's Castorine Co..	Baum's Compound	0.11[1]	20	20	30	20	20	16	16	16	20	16
Bayerson Oil Works...	Emulso	0.52	6 to 11	20 to 30	20 to 30	20 to 30	20 to 30	6 to 11	6 to 11	...	6 to 11	...
Climax Refining Co......	Climax Perfection	0.10[1]	16	16	16	12	...	8	8	8	16	8
Crescent Oil Co........	Aqualene	0.85	30	30	30	30	50	20	15	15	20	10
	Duocene	0.50	25	25	50	25	50	Straight	Straight	Straight	20	Straight
	Solucene	0.55	20	20	20	20	25	15	10	10	10	8
J. L. Fannon & Co.......	Lardoleum	0.48	16	12	16	16	20	8	12	12	8	Straight
Garnet Co..................	Triprocess	0.98	8 to 12	8 to 12	8 to 12	3 to 10	20	Straight 10	12	Straight 5	Straight 10	10
Hawkeye Oil Co..........	Faultless	0.08[1]	16	12	16	12	12	12	8	10	16	16
George A. Haws, Inc..	Marnile	...	20 to 35	10 to 25	10 to 40	10 to 35	40 to 50	5 to 10	20 to 30	20 to 30	15	18
Interstate Chemical Co.	Key brand	0.06½[1]	20	20	40	40	40	13 to 16	16 to 20	16 to 20	20	27
	Key sol	0.40	25	25	25 to 50	25 to 50	25	16	16	16	16	25
Lucent Oil Co.....	Tul-lub	0.45	6 to 24	16 to 24	6 to 48	6 to 24	...	3 to 24	Straight	Straight	6 to 24	
Magie Bros.................	Challenge	0.07¼[1]	...	...	48	...	...	...	...	...	...	
	Rock brand	0.06[1]	10	10	...	10	...	...	10	...	...	...
Moore Oil Co...............	Buckeye	0.08[1]	25	35	25	20	30	8	25	10	10	10
	Solubo	0.50	20	30	20	18	25	7	22	9	10	8
Oil City Oil & Grease Co.	Germania Lubro	0.60	12	20	30	50	50	12	12	12	12	12
Paragon Refining Co.	Emulsol	0.60	25	25	25	15	25	10	6	15	8	10
Pennsylvania Lubricating Co......................	Palubco	0.05[1]	20	20	20	50	50	16	20	20	16	24
	Kutwell	0.45	20	25	35	40	50	12	25	25	20	25
	Kut-o-lene	0.06[1]	24	28	28	32	50	16	24	24	20	28
B. G. Pratt Co............	Hydroil	1.00	32	60	60	20	40 to 60	20	30	45	20	...
	New Departure	0.60	32	60	60	15	40 to 60	12 to 15	30	45	12 to 15	
Racine Tool & Mach. Co.	Peerless compound	0.11	50	50	50	50	50	50	50	50	50	...
	Peerless soluble oil	0.60	50	50	50	50	50	50	50	50	50	
W. C. Robinson & Son Co....................	Aquasol	0.38	10 to 13	30 to 35	30 to 35	15 to 18	40 to 45	12 to 15	25 to 30	25 to 30	25 to 30	25 to 35
	Soluble cutol	0.45	12 to 16	35 to 40	35 to 40	20	40 to 50	15 to 18	30 to 40	30 to 40	25 to 40	30 to 40
	Oriole	0.08[1]	...	...	...	...	...	...	...	...	...	
L. Sonneborn Sons, Inc.	Amalie C	...	25	25 to 34	25 to 34	50	50	25	10 to 25	10 to 25	25	..
	Amalie D	...	25	25 to 34	25 to 34	50	50	25	10 to 25	10 to 25	25	
D. A. Stuart & Co., Inc.	Kleen-kut	...	7 to 10	15 to 25	15 to 25	15	25	15 to 25	10	10 to 15	10 to 25	...
	A	0.60	15	15	30	25	60	15	10	10	15	5
	AA	0.70	18	18	35	30	60	18	15	15	20	10
Ulco Oil Co.................	Nagle soluble oil	0.65	30 to 50	30 to 50	30 to 50	10 to 25	50 to 100	8 to 25	5 to 25	8 to 25	5 to 15	3 to 20
Union Petroleum Co...	Exanol	0.50	10 to 16[2]	25 to 50	50	50	200	10 to 16	10 to 16	...	10 to 16	...
Vortex Mfg. Co............	Vorco soluble oil	0.51	20	20	20	20	50	30	20	20	20	...
	Alumincut	0.53	20	20	20	20	20	0	...	...	...	20
White & Bagley Co......	Eco. cutting lubricant	0.07	35	16	35	35	...	13	13	13	13	6
	Eco. grinding lubricant	0.10	...	...	...	...	32	...	...	...	...	...
White Star Refining Co.	White Star	0.45	20	17	36	36	20	7½	17	17	7½	17

Machinery

[1]Cost of paste per pound. [2]Add one quart of kerosene to each fifty gallons.

TABLE VI. COMMERCIAL OIL MIXTURES RECOMMENDED FOR VARIOUS MACHINING OPERATIONS

Name of Company	Compounds and Oils	Cost per Gallon	Turning and Boring	Milling	Drilling	Cold-saws	Grinding	Threading	Gear Cutting	Gear Hobbing	Nut Tapping	Broaching
American Oil Products Co.	Opco Lardo	$0.60	40 to 50% fuel oil 20 to 30% ker.	40 to 50% fuel oil 20 to 30% ker.	40 to 50% fuel oil 20 to 30% fuel oil	40 to 50% fuel oil 20 to 30% ker.	20% fuel oil	40 to 50% fuel oil	20% fuel oil	20% fuel oil	20 to 30% fuel oil	....
Franklin Oil & Gas Co.	Extra special cutting oil	......	50% ker.	50% ker.	50% ker.	50% ker.	....	15% ker.	15% ker.	15% ker.	15% ker.	15% ker.
	No. 650 cutting oil	......	Straight	15% ker.	15% ker.	25% ker.	....	Straight	Straight	Straight	Straight	Straight
	Perfection cutting oil	......	15% ker.	25% ker.	25% ker.	25% ker.	....	Straight	Straight	Straight	Straight	15% ker.
	No. 660 cutting oil	......	25% ker.	25% ker.	40% ker.	50% ker.	....	Straight	Straight or 15% ker.	Straight or 15% ker.	Straight	25% ker.
Penn. Lubricating Co.	Pen-o-lard[1]	0.50	50%	70%	70%	20 to 1	....	30 to 50%	20 to 40%	30%	20 to 40%	30 to 50%
G. Whitfield Richards	Near-a-lard[1]	0.50	30%	50%	50%	....	....	30%	30%	40%	50%	50%
D. A. Stuart & Co., Inc.	Dascolene	0.60	30% ker.	30% ker.	30% ker.	50% ker.	16 to 1 of soda water	Straight or 40% paraf.	Straight or 40% paraf.	Straight or 50% paraf.	30% ker.	Straight
	Dasco mineralized lard oil	0.45	20% paraf.	20% ker.	20% ker.	50% ker.	16 to 1 of soda water	Straight	Straight	Straight	50% paraf.	Straight
	Dasco gear cutting oil	0.65	....	....	....	....	....	....	Straight	Straight	....	....
	Dasco auto. cutting oil	0.50	30% paraf.	30% paraf.	30% paraf.	....	....	30% paraf.	....	....	....	....
	Dasco screw cutting oil	0.40	Straight	Straight	Straight	Straight	....	Straight	Straight	Straight	Straight	Straight
Union Petroleum Co.	Mineral lard oil	0.55	40% 28° paraf.[2] 30% fuel oil[3]	....	....	....	....	40% 28° paraf.[2] Straight[4]	40% 28° paraf.[2] 30% 28° paraf.	30% ker. 40% 28° paraf.[2]	30% ker. 40% 28° paraf.[2]	Straight 30% 28° paraf.

Machinery

[1] Dilute with kerosene, fuel oil, light gravity neutral or paraffin oil. [2] Dilute mixture with 30 per cent 300-degree burning oil. [3] For machining 3½ per cent nickel high-carbon steel. [4] For use on cast iron.

Drilling—High-carbon and alloy steel: mineral lard oil, lard oil. Low-carbon steel: mineral lard oil, petroleum oil, compound. Very hard steel: turpentine or mixture of turpentine and spirits of camphor, kerosene. Cast iron: compressed air. Wrought iron: mineral lard oil, petroleum oil, compound. Malleable iron: compound, petroleum oil. Brass: compound. Bronze: compound. Copper: lard oil, mineral lard oil, kerosene. Aluminum: kerosene, beeswax or tallow (rubbed on rotating drill after cutting two or three holes. Monel metal: compound. Glass: turpentine, turpentine and spirits of camphor, kerosene.

Forming—High-carbon and alloy steel: mineral lard oil, lard oil, paraffin oil, mixture of two parts kerosene and one part signal oil. Low-carbon steel: mineral lard oil, petroleum oil, compound, mixture of two parts kerosene and one part signal oil. Wrought iron: petroleum oil, compound. Brass: compound. Copper: lard oil or kerosene. Aluminum: kerosene.

Gear Cutting—High-carbon and alloy steel: lard oil, mineral lard oil. Low-carbon steel: mineral lard oil, petroleum oil, compound. Bronze: lard oil, mineral lard oil, compound.

Gear Hobbing—High-carbon and alloy steel: lard oil, mineral lard oil. Low-carbon steel: mineral lard oil. Cast iron: compound. Brass: compound. Bronze: mineral lard oil, compound.

Gear Planing—High-carbon and alloy steel: mineral lard oil. Low-carbon steel: mineral lard oil. Bronze: mineral lard oil.

Gear Shaping—High-carbon and alloy steel: lard oil, mineral lard oil, turpentine, kerosene. Low-carbon steel: mineral lard oil, compound, turpentine, kerosene (on steel where trouble is experienced from tearing the metal, add a small amount of powdered sulphur to the lard oil or mineral lard oil). Cast iron: compound. Brass and bronze: compound.

Grinding—High-carbon and alloy steel: compound. Low-carbon steel: compound. Cast iron: compound. Wrought iron: compound. Brass: compound. Bronze: compound.

Milling—High-carbon and alloy steel: mineral lard oil, compound, petroleum oil, paraffin oil, lard oil. Low-carbon steel: compound, mineral lard oil, petroleum oil. Cast iron: compressed air. Wrought iron: mineral lard oil, compound, petroleum oil, soda water. Brass: compound. Bronze: compound, kerosene. Copper: mineral lard oil, lard oil, kerosene. Aluminum: kerosene.

Reaming—High-carbon and alloy steel: lard oil, mineral lard oil, sperm oil, mixture of lard oil and white lead of about consistency of glue. Low-carbon steel: lard oil, mineral lard oil, compound, lard oil and white lead. Wrought iron: lard oil, mineral lard oil. Brass: compound. Copper: mineral lard oil, lard oil, kerosene. Aluminum: lard oil, kerosene.

Tapping—High-carbon and alloy steel: lard oil, mineral lard oil, mixture of 90 per cent tallow and 10 per cent graphite, cottonseed oil. Low-carbon steel: lard oil, mineral lard oil, tallow and graphite, lard oil and white lead mixed to consistency of glue, cottonseed oil. Cast iron: lard oil, compound, white lead. Wrought iron: lard oil, compound. Malleable iron: lard oil, compound. Brass: lard oil, lard oil and white lead mixed to consistency of glue. Copper: lard oil. Aluminum: lard oil, kerosene, beeswax or tallow (rubbed on rotating tap after each operation). Babbitt: lard oil, soap (packed into hole before tapping). Nuts: mineral lard oil compound.

Thread Cutting—High-carbon and alloy steel: lard oil, mineral lard oil, cottonseed oil, grapeseed oil. Low-carbon steel: mineral lard oil, mixture of mineral lard oil and 25 to 50 per cent kerosene, turpentine and white lead, lard oil, cottonseed oil, grapeseed oil. Very hard steel: turpentine. Wrought iron: mineral lard oil, compound. Brass: compound. Bronze: mineral lard oil. Copper: mineral lard oil. Aluminum: kerosene. Monel metal: mixture of lard oil and white lead reduced to consistency of glue.

Thread Milling—High-carbon and alloy steel: mineral lard oil, paraffin oil. Low-carbon steel: mineral lard oil, paraffin oil of 28 degrees Bé. gravity.

Threading with Dies—High-carbon and alloy steel: lard oil, sperm oil. Low-carbon steel: lard oil, mineral lard oil, compound. Wrought iron: lard oil, mineral lard oil. Brass: mineral lard oil, compound. Copper: lard oil, mineral lard oil.

Turning—High-carbon and alloy steel: mineral lard oil, lard oil, compound, paraffin oil of 28 degrees Bé. gravity, signal oil. Low-carbon steel: mineral lard oil, signal oil, petroleum oil, compound. Wrought iron: petroleum oil, compound. Brass: compound. Bronze: compound. Copper: lard oil or kerosene. Aluminum: kerosene. Monel metal: compound. Hard rubber: cold water.

Importance of Complete Stability of Cutting Emulsions

When cutting emulsions are made by mixing paste or soluble oil with water it is important for the oil or paste to be uniformly mixed in the water and for the emulsion to be stable at all temperatures under which it is likely to be used. When this is not the case, there is danger of certain constituents of the oil settling out in layers, resulting in lack of uniformity of the emulsion, which will prevent it from having the maximum lubricating effect, and may cause rusting of machines and product. The user of cutting compounds will do well to place in tall glass bottles test samples mixed with water in the proportions recommended for the class of work on which the emulsion is to be applied and observe whether there is any tendency for the constituents to settle out. Any compounds which show this tendency should not be used.

Mixing Cutting Oils and Emulsions

In order to secure the best results with mixtures of oil or cutting emulsions which the consumer mixes in his own shop, great care should be taken to follow the instructions given by the firm from which oils are purchased, as even slight deviations from the recommended practice will often seriously reduce the efficiency in cooling or lubricating. It is good practice to standardize cutting lubricants as far as possible, and in every case a competent person should have charge of their handling and mixing. Satisfactory results cannot be expected

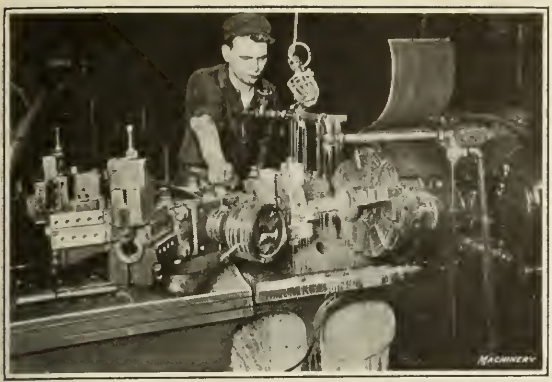


Fig. 80. Arrangement of Piping for delivering Oil to Tools on Turret Lathe

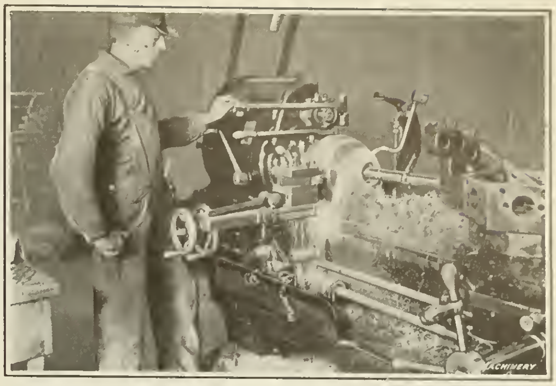


Fig. 81. Jointed Delivery Pipe which makes it Possible to direct Fluid exactly to Desired Position

where the practice is followed of allowing each operator to make up his own mixture, as this tends to destroy uniformity and there will be many cases in which unsuitable mixtures will be used. It is a good plan to have a printed schedule of lubricating practice placed in the hands of each shop superintendent and department foreman, showing the kind of lubricants to use for all classes of work. Such schedules will show the formulas used by the man who has charge of making up oil mixtures, and in cases of trouble they will assist in determining whether the proper lubricant has been supplied for handling a given job. This practice will also be the means of reducing the consumption of lubricants and of obtaining lubricants that will give satisfactory results.

In mixing cutting emulsions and oils—particularly in cases where there is a lot of mixing to be done—equipment should be provided that will enable this work to be conducted with the least possible delay, and that will also guard against the loss of material that is bound to occur when buckets and other slipshod methods are used for handling various metals. Fig. 77, which appears in the third installment of this article, published in the March number, shows an excellent arrangement of equipment for conducting mixing operations. This consits of a barrel located on the floor above the main storage tank from which lubricant is pumped to the gravity tank that supplies the various machines in the factory. Leading into this barrel there are a steam pipe and a water pipe, either of which may be opened to provide for boiling the ingredients of cutting emulsions or diluting them as required. Below the barrel is a valve connecting with a pipe leading to the storage tank; after the mixture has been made up this valve is opened to allow the lubricant to run into the tank.

Formulas for Homemade Cutting Emulsions

The following are formulas for cutting emulsions which well-known manufacturers have found to give very satisfactory results. It will be noted that some of these are recommended for general application on those classes of work on which compounds give satisfactory results, while in certain other cases compounds are especially recommended for specific machining operations. In this connection, the reader's attention is called to the formulas for making emulsions that are given out by many oil manufacturers. Naturally these have especial reference to trademarked oils sold by these firms, and as they call for the use of these special ingredients, no mention is made of them in the following section of this article.

Soda-water mixtures are still used to a considerable extent, but while they possess an advantage over plain water in that there is no tendency to rust the tools or work, soda water has no greater lubricating effect than pure water. The following gives the formula for a soda-water mixture containing lard oil, which has a lubricating effect in addition to the usual properties of pure soda water: Mix 1/4 pound sal soda, 1/2 pint lard oil and 1/2 pint soft soap with enough water to make ten quarts. This mixture is boiled for one-half hour and is ready for use after cooling to normal temperature. This will give very satisfactory results for all classes of work on which cutting compounds can be used, except for drilling, and in this case the stock soda-water solution should be thinned down considerably to prevent foaming.

For general use in drilling, milling and other operations for which a cutting compound may be used, the following formula produces a coolant that will be found to give very satisfactory results: Take two galvanized iron buckets and fill one two-thirds full with No. 1 lard oil and the other two-thirds full with No. 1 screw cutting oil. To one pail add a pint measure of Proctor & Gamble's white soap chips and to the other pail add one-half pound of powdered soda. The contents of these two pails are then poured into a wooden barrel and thoroughly boiled with live steam which results in dissolving the soap and soda and thoroughly mixing it with the oil. After this has been done, the barrel is filled with cold water and thoroughly stirred to secure a uniform mixture, after which the contents are run into the storage tank of the central distributing station, from which pumps deliver it to circulating pipes leading to the machines in the factory.

For drilling and milling operations, the following formula gives a good cutting compound: Dissolve 2 1/2 pounds soda ash in water and mix with 2 or 3 gallons lubricating oil. These constituents are thoroughly stirred to secure a uniform mixture and are then added to 40 gallons water.

For all milling, turning and drilling operations, the following formula produces a good compound: Dissolve 1 3/4 pound sal soda in 10 gallons water and boil the solution with a steam jet, then add 1 gallon lard oil.

For reaming and tapping holes for staybolts, one of the largest locomotive shops in the country uses a compound made up according to the following formula: Mix 18 gallons good-grade lard oil, 60 pounds tallow and 100 pounds white lead.

To make a grinding compound, the following formula is highly recommended: Dissolve 75 pounds soft soap and 30 pounds sal soda in 15 gallons boiling water. Keep the mixture boiling and stir in 10 gallons lard oil. To this mixture add 1 ounce creosote oil as a disinfectant. When cool, mix 1 gallon of this stock solution with 3 gallons water to make the compound delivered to the wheel and work.

To make a lubricant for gear-cutting with rotary cutters or hobs, the following formula produces an emulsion that gives excellent results: Stir together 3 1/2 gallons mineral lard oil and 2 3/4 pounds sal soda, and when thoroughly mixed add to one barrel of soft water. This compound does not thicken or leave a gummy residue.

Effect of Oil or Cutting Compound on Power Required to Drive Machine Tools

There is considerable diversity of opinion concerning the effect of oil or cutting compound on the amount of power required to drive the machine. Some investigators in this field have been unable to secure results that show any reduction of power consumption through the use of oil or cutting compound as compared with operating tools dry. Others have found a marked difference in favor of the lubricated cutting tools, and it seems reasonable to assume in cases where no improvement has been found that the tool was probably work-

ing on those classes of metal where fairly satisfactory results might be obtained without the use of a lubricant. The following gives the experience of one or two investigators who have found cutting lubricant to be a valuable factor in reducing the amount of power required by the machine.

At the plant of the Bullard Machine Tool Co., Bridgeport, Conn., a machine was working on a steel casting which had about ¾ inch left on the diameter for machining. The surface to be finished was about 16 inches wide, and two large streams of cutting compound were delivered to the tools which were taking two cuts, one at the top and one at the side. The cutting compound was delivered at the rate of about thirty-six quarts per minute directly to the tools, but even under these conditions the chips turned blue when they came out from the cutting compound. With a view to determining the effect of the compound upon the machine's power factor, the experiment was tried of shutting off the flow while the machine was in operation under the conditions mentioned. When this was done the machine made one-half revolution and then the belt went off. It was expected that the tools were either broken or burned, but an investigation showed that they were still in perfectly good condition because the machine had not run far enough to cause damage in this way.

After putting on the belt, the machine was started and continued to run satisfactorily until the flow of lubricant was again shut off; then the machine went less than one-half revolution before the belt was again thrown off. This experiment was tried a sufficient number of times to show conclusively that there was a direct relation between the power factor and the lubricant. With the view of obtaining definite information on this subject, the machine was provided with a motor attached to a recording watt meter, and with this equipment it was found that on heavy cutting there was a difference of as much as 43 per cent in the power required to machine a piece with and without the application of cutting lubricant to the tools. With machines working on smaller work and taking lighter cuts, less difference was found.

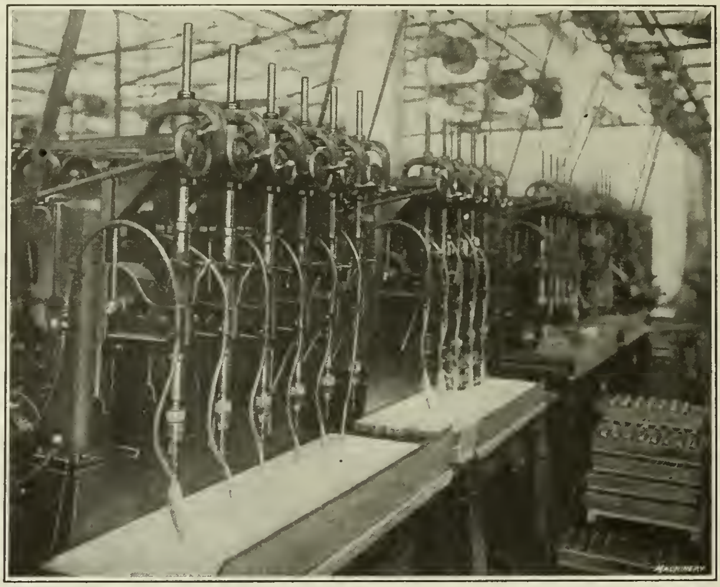


Fig. 82. Multiple-spindle Drill Presses with Flexible Tubes for delivering Cutting Compound to Tools

Further experiments conducted along the same lines showed that pieces machined without the use of cutting lubricant became so badly heated that they were difficult to handle, and the expansion and subsequent contraction had seriously affected the accuracy of the dimensions. For instance, a hole 15 inches in diameter when a piece was cold became 15.009 inches when a light facing cut was taken across the top of the casting, so that measurements made while the piece was hot had to be corrected for expansion, which was often a difficult matter. The elimination of such inaccuracies and the saving of power are of sufficient advantage to warrant the use of cutting lubricants in turning such materials as cast iron, where the use of lubricant is not an absolute necessity.

Experiments conducted in England by Dempster Smith showed that where lubricants were used in drilling with twist drills, using a feed of 0.040 inch per revolution, the torque was 72 per cent, and with a feed of 0.030 inch per revolution the torque was increased to 92 per cent of the value obtained when operating the drill dry. When machining soft, medium and hard steel, the respective thrusts were 26, 37 and 12 per cent less when a lubricant was used than when the drill was operated dry, but no marked difference was found for different rates of feed, as in the case of the torque. Experiments conducted with boring-bars and trepanning tools showed the following relation of power consumption for different conditions of operation: Tool operated dry, relative power consumption, 1; pure water delivered to tool, relative power consumption, 0.91; soap and water delivered to tool, relative power consumption, 0.94; emulsion of oil and water delivered to tool, relative power consumption, 0.87.

Another investigator found that thorough lubrication of twist drills reduces end thrust by 35 per cent and torque by 20 per cent of the values secured when operating the tool dry, thus effecting a large saving of power as well as increasing the working efficiency and duration of sharp cutting edges for the drill.

On March 12, 1912, Harry E. Harris, who at that time was engineer of tests for Wells Bros. Co., Greenfield, Mass., read a paper before the American Society of Mechanical Engineers in New York City entitled "Data on Taps and Tapping," in which was given the following information on the lubrication of taps and the effect of cutting lubricant upon the power consumed by the machine. Table VII, which was presented in connection with that paper, shows the effect of varying the tap drill sizes and using different lubricants for performing the tapping operation. The data presented in this table show that the power required to break a properly made ½-inch, 13-thread per inch U. S. standard tap is approximately 1000 inch-pounds. For comparative purposes this breaking strain is taken as 100, and the lesser strains required for tapping holes under different conditions are expressed as percentages of this breaking strain. Multiplying the percentage given in the table by 10 gives the actual average power in inch-pounds. The test pieces were common hexagon cold-punched nuts, accurately reamed to respective sizes, and the taps were regular ½-inch U. S. standard taps. This series of tests shows the following points: (1) Up to a certain point, lubricants have the same effect on the driving power required as would be exerted by the presence of more or less metal to be removed. For instance, a tap in a ½-inch nut with a 0.425-inch tap hole, using machine oil instead of sperm oil, would have practically the same effect on the power required as reducing the diameter of the tap hole 25 per cent of the total depth of the thread. Referring to Table VII, it will be seen that the power is approximately doubled in both cases; 16.5 per cent to 34.2 per cent in changing from sperm oil to machine oil for a tap hole 0.425 inch in diameter; and 16.5 for sperm oil with a 0.425-inch tap hole changes to 35.5 for the same cutting lubricant with a 0.400-inch tap hole. (2) Animal lard oil, sperm oil, and graphite and tallow mixture are the best lubricants of those tested. (3) A good soap compound is better than mineral lard oil for tapping. (4) Machine oil is a detriment instead of a help, as taps are cut better dry than with this lubricant. (5) Breakage of taps can be greatly reduced by the use of a proper lubricant, and taps should never be run dry when machining steel.

Fire Hazard in Use of Cutting Oil

The use of water for cutting purposes, while quite desirable from a fire standpoint, was soon found to produce inferior results as compared to oil, owing to the fact that for certain classes of work a greater measure of lubrication was desirable, and the water caused trouble by rusting the machines. The use of oil has therefore increased rapidly in the last fifteen years, owing to the great development of high-speed tools, until at present the modern machine shop frequently contains large quantities of cutting oil pretty well exposed and distributed throughout the shop. This oil is used over and over again in circulating systems which may involve an individual pan or reservoir for the oil and a pump for each machine or a system of pipes through which the oil is carried back to a main storage tank, and then forced by one large pump back into the system, feeding several machines.

The fire hazard which these large quantities of oil may present was strongly emphasized during the past year, when a large machine shop was completely destroyed by fire. The building was not equipped with sprinklers and the construction was not of the best, but the rapidity with which the fire spread brought up the question as to whether the large quantities of cutting oil, which in that case contained a considerable proportion of kerosene, had not been an important factor in the rapid spread of the fire.

It was therefore decided to have the Inspection Department of the Associated Factory Mutual Fire Insurance Cos., 31 Milk St., Boston, Mass., conduct an investigation of the matter of cutting oil hazard, and the following information is taken from its report. This investigation has been conducted along three lines; first, a study by means of reports prepared by the regular inspectors of conditions in risks, covering the amount and character of the oils used, the general conditions with respect to oil-soaking of the floors, use of sawdust, etc.; second, a laboratory investigation covering flash and fire points, spontaneous combustion tests and viscosity measurements of samples obtained from risks, and also of mixtures prepared in the laboratory; third, a series of fire tests to determine the hazard of oil-soaked wood, the readiness of ignition and spread of fires in oil-soaked sawdust and steel chips, the ignition of oil in pans, methods of extinguishing oil fires, etc.

The amount of oil used varies considerably with the kind of machine, some using not more than four or five gallons, while a few of the large automatics use thirty to fifty gallons. Ten gallons per machine, however, may be considered a fair average.

The majority of factories use the individual pumping system, in which a pump is provided for each machine. A few, however, have large systems in which one pump may supply fifty or more machines. In some mills both systems are used. Paradoxical as it may seem at first, it is believed that the multiple feed system, where it can be properly arranged, is the safer. With this system it is possible to reduce materially the amount of oil in important buildings, as the storage tank and pump can be located outside. This arrangement, of course, requires more or less piping carrying oil, but this is believed to be less of a hazard than the presence of a large number of open oil pans.

Splashing and Oil-soaking of Floors

From a study of the conditions in several plants, it became evident that there is a wide difference in the amount of oil which gets on the floor. Some shops have made a special study of guards for catching oil and preventing it from reaching the floor, while others have apparently paid no attention whatever to this matter. One shop did a piece of investigation work that showed unusual interest in solving this problem. A machine was set up in an open space where it could be easily observed, and blotting paper was placed all around it on the floor. The foremen of the different departments were then assembled, and the machine was started. Each man was instructed to watch a certain part of the floor, and whenever a drop of oil struck, it was traced back to the point from which it came, and a guard was constructed to catch this oil. By this means the machine was completely guarded, so that it threw no oil whatever on the floor. This process was repeated with the different types of machines in the plant, resulting in a clean shop with practically no oil on the floor, greater economy and much safer conditions as respects fire hazard.

The manufacturers of machine tools make guards to be used with their machines, but these are sold separately and are ordered in only a few cases by the purchasers of the machines. It is undoubtedly true that it is impossible to guard some machines completely without interfering with the operation, but this is not true in the majority of cases, and there is certainly room for a great deal of improvement over present conditions in many risks.

A frequent offender in the splashing of oil on the floor is the pump, where the individual feed is used. The pumps are sometimes placed at one side of the oil pan of the machine, and as the stuffing-boxes frequently leak, they throw large

TABLE VII. EFFECTS OF VARIOUS LUBRICANTS AND DIFFERENT TAP DRILL DIAMETERS ON CUTTING ACTION AND BREAKING OF TAPS[1]

Lubricant	Animal Lard Oil	Sperm Oil	Graphite, 10 Per Cent; Tallow, 90 Per Cent	Cataract Soap Compound	Mineral Lard Oil	Tapping Dry	Machine Oil
0.425 Inch Diameter of Tap Hole. 75 Per Cent Thread							
Per cent of breaking strain	15.9	16.5	16.9	18.9	19.9	29.9	34.2
Breakages in tests	None	None	None	None	None	14 per cent	15 per cent
Quality of thread cut	Smooth	Smooth	Smooth	Smooth	Smooth	Rough	Torn
0.410 Inch Diameter of Tap Hole. 90 Per Cent Thread							
Per cent of breaking strain	......	23	......	25.1	36.5	60.2	68.5
Breakages in tests	......	None	......	None	None	50 per cent	71.5 per cent
Quality of thread cut	......	Smooth	......	Smooth	Smooth	Rough	Torn badly
0.400 Inch Diameter of Tap Hole. 100 Per Cent Thread							
Per cent of breaking strain	......	35.5	......	41	57.5	71.8	100
Breakages in tests	......	None	......	None	None	66 per cent	100 per cent
Quality of thread cut	......	Smooth, but with tops torn	......	Slightly rough, tops torn	Smooth, but with tops torn	Torn and partly stripped	Torn and wedged, so as to prevent tap cutting through

Machinery

[1] By multiplying the above percentages by 10, the actual average power required in inch-pounds may be obtained.

Fig. 83. Means of distributing Lubricant on Espen-Lucas Planer Type Milling Machine

quantities of oil on the floor. The pump should always be placed over the pan of the machine, and properly guarded to prevent splashing. Another frequent source of trouble is the carelessness of the workmen in handling finished pieces dripping with oil.

Probably little can be done in the way of improvement that would require much cooperation on the part of the workmen, but it is possible to improve conditions, at least in some plants, with respect to the receptacles in which the finished pieces are placed, both as regards their character and location, so as to reduce the amount of dripping to a minimum. The receptacle should be oil-tight, and should be placed as close to the machine as practicable. A sheet-iron drain or trough should also be provided between the machine and the box, so that the finished pieces would normally be conveyed over this drain from the machine to the box. These precautions are only necessary in cases where the finished work comes in contact with large quantities of oil, and has no opportunity to drain in the machine before being removed.

Use of Kerosene in Cutting Oils

The practice of adding kerosene to cutting oils, which has developed in the last few years, has been resorted to for one or more of the following reasons: first, to obtain a cutting oil which will cool the work and tool rapidly, and carry the chips away quickly, but which will still possess considerable lubricating value; second, to cheapen the cost of the cutting medium; third, to prevent gumming or thickening of the cutting oil.

It is clear that the addition of kerosene at 10 to 12 cents a gallon results in a material reduction in the cost per gallon of the cutting oil. The actual reduction in price, however, is less than would appear at first thought, as kerosene evaporates appreciably at room temperatures, and it is generally necessary to add more kerosene from time to time, while with the straight cutting oils, or cutting oils thinned with light mineral oils, this evaporation is practically negligible. The amount of kerosene added varies widely, ranging from 3 to 75 per cent.

In a few special operations, such as cutting aluminum, there appears to be a firmly fixed idea on the part of some manufacturers that nothing but straight kerosene can be used. There is no doubt but that the cutting of aluminum presents difficulties not found with steel, but one large manufacturer of machine tools has found it possible to use an emulsion for cutting aluminum with entirely satisfactory results.

From a careful investigation of the matter, both by means of laboratory tests and a study of conditions in different risks, the conclusion has been reached that the use of kerosene is not necessary in any case for cutting metal with the possible exception of aluminum. The kerosene has but slight lubricating value, and acts merely as a diluent to thin down the oil. This reduction in viscosity is undoubtedly necessary for some purposes, but can be effected by using light mineral oils of high flash point. Thus a shop, which has been using 25 per cent kerosene and 75 per cent lard oil, can prepare a satisfactory substitute by mixing about 40 per cent extra light spindle or transil oil with 60 per cent lard or mineral lard oil. This mixture will have a much higher flash point than that containing kerosene, and will have approximately the same viscosity and lubricating efficiency.

In extreme cases where it is absolutely necessary to have a very thin oil the kerosene may be replaced with 300-degree fire test oil. By using this product it is possible to obtain mixtures with practically as low viscosities as the kerosene mixtures having up to 50 per cent kerosene, but which have materially higher flash and fire points. It is believed, however, that it is necessary to resort to 300-degree oil only in a few cases.

In cutting aluminum some manufacturers have claimed that straight kerosene or a mixture containing a large proportion of kerosene is necessary. On the other hand, one large manufacturer of machine tools and measuring instruments has used an emulsion for cutting aluminum with entirely satisfactory results. Even though emulsions do not prove generally satisfactory for this purpose, there is little doubt but that the 300-degree fire test oil could be used in place of kerosene.

Tests were made on oil-soaked mixtures of sawdust and bicarbonate of soda containing varying proportions in order to determine the effect of the bicarbonate of soda on the combustibility of the sawdust and oil. The following mixtures were prepared, the proportions being by weight.

No.	Sawdust, Parts	Bicarbonate of Soda, Parts	Lard Oil, Parts
1	100	20	100
2	100	100	100
3	100	100	200
4	100	200	200

In sample No. 1 the bicarbonate of soda produced no visible effect on the combustibility of the mixture. In No. 2 the combustibility of the mixture was considerably retarded, but the amount of oil in this combination was considerably less than is generally found in sawdust before it is considered sufficiently saturated to warrant removal. No. 3, where the quantity of oil was doubled, and which still contained less than is frequently found in oil-soaked sawdust in mills, burned freely; the same was true of No. 4. It is evident from these tests that no amount of bicarbonate of soda, which could be used at a reasonable cost, would have any important effect on the combustibility of oil-soaked sawdust.

Conclusions

The development of high-speed tools has resulted in conditions which require the application of a cooling and lubricating medium, on the tool and work. Water and soda solutions were at first used for this purpose, but these do not furnish sufficient lubrication, and are somewhat objectionable on account of rusting the machines. Oil has therefore largely replaced water for this purpose, and its use has produced much better results from a manufacturing standpoint, making a considerable increase in the speed of the cutting tools possible. In the modern machine shop large quantities of oil, sometimes containing a high percentage of kerosene, are used in open pans as a part of circulating systems in which the oil is applied continuously to the work.

The character of the oils in use varies widely in different plants, but mineral lard oils, which are simply mixtures of lard oil and mineral oil, sometimes with other animal oils or

fats, are most commonly used. Kerosene mixed with the cutting oil has been used considerably in the last few years. In the majority of cases the chief reason for the use of the kerosene is to cheapen the cutting oil.

Type of System

The multiple feed system for supplying cutting oil to machines when properly arranged is preferable to the individual feed. With the multiple feed it is possible to locate the main storage tank outside of important buildings and therefore greatly reduce the amount of oil inside the buildings. This advantage, it is believed, more than offsets the objection to the introduction of oil-filled pipes in buildings.

Prevention of Oil Splashing

A great deal of improvement is possible in the matter of preventing oil from getting on the floor by the provision of proper oil guards. In some classes of automatic machines it is not possible to keep all the splash from reaching the floor, but in many cases this can be done, and in all cases the greater part of the splash can be caught. Oil-tight receptacles for the finished pieces should be provided, and these should be located as near the machine as practicable. Drains or troughs should also be arranged to catch the drip when the pieces are being conveyed from the machine to the box. The pumps on individual feed systems should be given attention by locating them over the oil pans, and keeping the stuffing-boxes in good condition, or providing adequate guards.

Starting of Fires

The hazard resulting from the use of large quantities of cutting oils depends to a considerable extent on the character of the oil and the condition of the floor. If a straight cutting oil is used, a fire cannot be readily started with a match or a small quantity of burning waste. Where straight cutting oil has leaked through from the floor above onto the ceiling, a fire can be started from a comparatively small source, whereas without oil no fire would result from the same cause. Fires could not be started from a match or small quantity of oily waste on floors, even where the floors were covered with as much as 50 per cent of kerosene mixed with cutting oil. In ceiling tests the oily wood ignited much more easily when kerosene was used than when it was absent, the ease of ignition being proportional to the percentage of kerosene present.

Spread of Fires

The tests showed clearly with what difficulty a small fire spreads in a horizontal direction on the top of a floor, even though the wood is oil-soaked with a mixture containing a considerable proportion of kerosene. This is purely a result of unfavorable draft conditions. The draft from such a fire is inward and upward so that the heat does not reach the wood or oil to raise it to the flash point. If, however, as the result of the presence of other readily combustible material a fire of any size is started, the presence of oil-soaked floors is undoubtedly an important factor in increasing the rate of spread and producing a hot fire. Where the oil-soaked wood is in a vertical partition, a fire does not develop very rapidly from a small source unless there is an open space under the partition to furnish a good draft. The effect of the kerosene on the partition, however, is very definite and marked, the height of the flames being dependent on the percentage of kerosene used. Fires on the under side of a ceiling spread without difficulty. This is due to the fact that the heat from the fire comes in contact with the wood immediately adjacent to the flame and heats it up to the flash point. Here again the spread of the fire is in proportion to the percentage of kerosene.

Fire in Open Pans

In open pans where straight cutting oils of a high flash point were used, the oil could not be ignited from a fire of small size such as fifty grams (approximately two ounces) of cotton waste. Where kerosene was used, however, a fire could be started with the same quantity of waste and spread rapidly. The ease of ignition of the kerosene-cutting-oil mixture depended on the percentage of kerosene.

Fire in Oily Steel Chips

The presence of steel chips on the floor or in pans aids materially in igniting the oil and spreading the fire. In pans containing steel chips and a mixture with a large percentage of kerosene, it was possible to ignite the oil with a match, whereas with smaller percentages of kerosene this could not be done.

Fire in Oil-soaked Sawdust

The use of sawdust on floors for absorbing cutting oils greatly increases the fire hazard. Where a straight cutting oil is used, a fire can be started in the oil-soaked sawdust with a match, although it does not spread rapidly. If the oil contains kerosene, however, fires can be easily started by means of a match and spread very rapidly, particularly where a large percentage of kerosene is present. When the cutting oil contains over 60 per cent of lard oil, there is a possibility of spontaneous ignition of the sawdust under favorable conditions. The use of bicarbonate of soda mixed with sawdust in any quantity, which would not be prohibitive in cost, does not materially affect the combustibility of the oil-soaked sawdust.

Extinguishers for Cutting-oil Fires

For extinguishing cutting-oil fires in pans, sawdust and bicarbonate of soda was found as efficient as any other material. In cases where large pans or several pans were involved, the sawdust and bicarbonate of soda could not, of course, be used, but such fires would have then passed outside the field of hand apparatus.

Use of Emulsions

The use of emulsions in place of cutting oils could undoubtedly be greatly extended in many plants by adopting emulsions especially compounded according to the character of the work in hand. The increased use of emulsions would result in a material reduction in the fire hazard and in the cost of lubrication.

Elimination of Kerosene

The use of kerosene cutting oils does not appear to be necessary under any conditions with one possible exception.

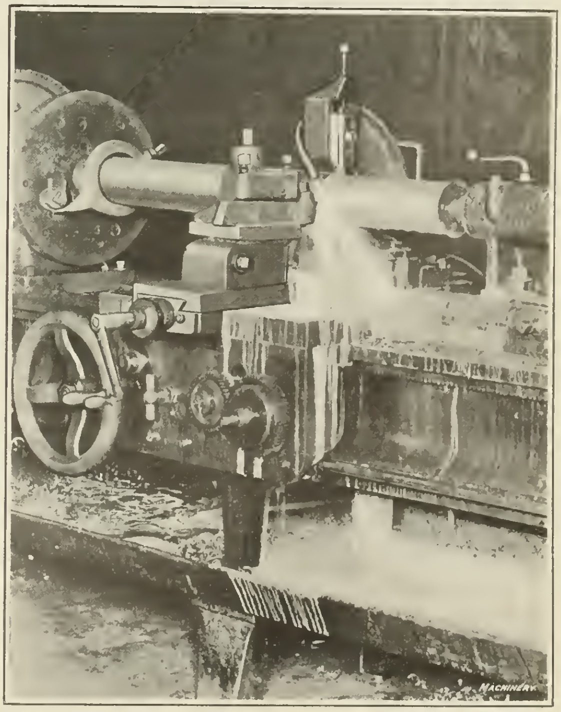


Fig. 84. Provision for delivering Copious Flow of Compound to insure Adequate Cooling of Tools and Work

This exception is in the cutting of aluminum, but even here the matter is open to question. Two or three manufacturers claim that kerosene is necessary for this purpose, but one large manufacturer of machine tools and measuring instruments uses an emulsion with entirely satisfactory results. In any event, it seems probable that even though the emulsion does not suit all requirements in cutting aluminum, 300-degree fire test oil can be generally employed in place of kerosene.

Kerosene possesses but slight lubricating properties, and its chief function is as a diluent to reduce the viscosity of the cutting oil. This object can be attained by using the proper amount of light spindle oil, or in extreme cases by adding 300-degree fire test oil. In no cases, it is believed, should oil for general cutting purposes have a fire point of less than 300 degrees F., and in the great majority of cases it can be higher. That the use of kerosene can be eliminated is shown by the fact that since this investigation was started, a number of shops have, without interfering with the efficiency of their plants, given up the use of kerosene.

* * *

COOPERATION IN SAFETY WORK

Two great safety organizations—the American Museum of Safety and the National Safety Council—have been drawn into close affiliation by the appointment of Arthur H. Young as director of the American Museum of Safety. Mr. Young is a member of the National Safety Council, and for several years was in charge of the safety work of the Illinois Steel Co. in South Chicago.

It is fitting that these two safety organizations should work in close cooperation. The one visualizes what has been accomplished by safety engineers in the matter of protecting belts, shafting, pulleys, presses, gears and other dangerous features of machinery, in promoting safety of travel and health of industrial workers by sanitary measures and appliances. The other organization deals more with the administration and promotion of safety work through the instruction of superintendents, foremen and workers in manufacturing plants. The National Safety Council has in a few years made a marked reduction in the number of accidents in the plants represented in its branch councils. These plants have shown conclusively that safety work is economic—it pays well.

The work of the two societies has defined to some extent the field of the safety engineer, a comparatively new profession likely to attract many technically educated young men as the possibilities of the work are better realized. It is difficult to estimate accurately the savings that have already resulted from safety work or to predict the savings that will be made as it is developed and as those responsible for production become familiar with its fundamental principles and the beneficent effect of human conservation.

* * *

APARTMENTS FOR WORKING MEN

Factory owners and executives in Cincinnati are particularly interested in two model tenements that have just been completed on the west side of Logan St., midway between Findlay and Elder Sts. They see in them the possible solution of housing economically industrial workers in large cities in an entirely sanitary and wholesome manner. Col. William Cooper Proctor, the man financially interested in this improvement, plans to add five more units if the present ones prove successful. The land for these has already been purchased. These seven units when completed will represent an investment of approximately half a million dollars. It is understood that while Col. Proctor has gone into the proposition more or less from a philanthropic standpoint, he plans to demonstrate that it is by no means an act of charity. In fact, he is confident that he can show it is a paying investment.

The average rental to be charged will be probably about $1.10 per room per week; this will include heat from a modern vapor system. The apartments vary in size from one to four rooms. The location is close to several crowded industrial centers and within fifteen to twenty minutes walk of the heart of the city. This location in such a crowded district, while particularly handy for the workers, necessitates as much economy as possible in the use of space. Five-story buildings were decided upon. Each of the present units contains fifty-three apartments. Besides the modern heating system in each apartment, there is a gas stove and other necessary conveniences. Screens are supplied for all windows. The children throughout each tenement have the advantage of a well-equipped playground and nursery on the roof.

A notable feature of the project, and one of prime importance, is the thoroughly fireproof construction used. The walls are of brick, and the structural columns and beams and the floors are of reinforced concrete. The partitions between the rooms are fireproof, and the doors are metal. In addition to this, the stairways serve the double purpose of stairway and fire escape, for while they are protected from the weather, they are not entirely enclosed.

The use of reinforced concrete construction for this type of building is a new departure, but it has proved entirely successful, not only from the point of the economical use of space for columns and beams, but from the point of economy, the reinforced concrete construction being considerably cheaper than structural steel columns and beams with hollow tile and concrete joist floors. William Emerson, of New York City, who has made a study of tenement construction, drew up the plans for these model tenements. The building work has been done by the Ferro Concrete Construction Co., Cincinnati, Ohio.

* * *

AMERICAN METRIC ASSOCIATION

The American Metric Association has been formed to further the use and adoption of the metric system of weights and measures, made legal for all transactions by Act of Congress in 1866. The officers are: president, George F. Kunz; vice-presidents, William J. Schieffelin, E. P. Albrecht, and O. E. Stanley; treasurer, Arthur P. Williams; and secretary, Howard Richards, Jr.

In stating the purpose of the American Metric Association, an address by Hon. William C. Redfield, secretary of commerce, before the Philadelphia Chamber of Commerce, January 10, 1917, is quoted, in part, as follows:

> The fact, of course, is that the metric system adopted by thirty-four nations is simpler, easier, more effective and more widely used than any other. It has made its way by its merits. Nobody wishes it to make its way by any other means. There is no argument for the retention of our present system of weights and measures that is not an argument against our decimal system of currency. No reason supports our decimal system of currency that does not support a decimal system of measures. This handicap we must throw off, not necessarily at once, but by adopting some reasonable method as an evolution out of darkness toward light—out of foolishness toward reason.

Membership is open to those in sympathy with the objects of the association. The annual dues, payable in advance, are $2 a year for individuals; $5 a year for firms and corporations; and $10 a year for organizations. Life membership is $50 for individuals and $100 for other classes of members. The association has headquarters at 156 Fifth Ave., New York City. Applications for membership should be sent to Howard Richards, Jr., secretary, at that address.

* * *

CONSOLIDATION OF PUBLISHING HOUSES

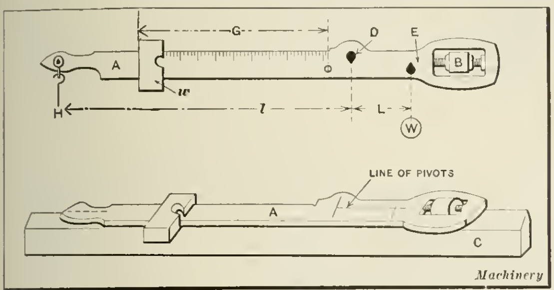
The McGraw Publishing Co., Inc., and the Hill Publishing Co., both of New York City, have consolidated as the McGraw-Hill Publishing Co., Inc. The new company acquires the *Electrical World, Electrical Merchandizing, Electrical Railway Journal, Engineering Record, Metallurgical and Chemical Engineering, The Contractor, American Machinist, Power, Engineering News, Engineering and Mining Journal* and *Coal Age*. The *Engineering News*, owned by the Hill Publishing Co., and the *Engineering Record*, belonging to the McGraw Publishing Co., Inc., will be joined in one publication known as the *Engineering News-Record*. The officers of the consolidated concern are James H. McGraw, president; Arthur J. Baldwin, vice-president and treasurer; E. J. Mehren, vice-president and general manager.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

PRESSURE ON A SCALE BAR

Referring to the inquiry by R. J. T., concerning the pressure on a scale bar, in the February number of MACHINERY, a scale maker would first attach to the short arm of the scale beam A a balance ball B heavy enough to counterbalance the long arm when the poise is at zero. Then he would balance the beam over a knife-edge C, placed lengthwise, in order to find the neutral axis. He would mark this line and set the pivots D and E with their edges on the mark. The metal will now



Diagrams illustrating Pressure on Scale Bar

be equally distributed to the right and left of pivot D and above and below the pivot line. This disposes of the troublesome factors w_1, w_2, and l_1, l_2, and LW will equal lw. The weight of the poise w may be found by either of the following formulas:

$$G : L = W : w$$

$$w = \frac{\text{Pounds per inch of marking} \times l}{X_n \text{ at } H}$$

in which G = "run," or length of graduated portion;

L = distance between pivots;

W = load on pivot E.

X_n is the "multiplication," or relation between the counterpoise weights and the load on platform: that is, if it requires ½ pound at H to balance 100 pounds on the platform, X_n is 200. If the beam is attached to a scale having multiplying levers, then W is the load on the platform divided by X_n of scale levers.

Rutland, Vt. W. H. SARGENT

SETTING UP HEAVY MACHINERY

In the installation of a new flanging press recently, the management of a metal-working plant found itself confronted with a serious problem. Though four ten-ton cranes served the floor where the new press was to be erected, their combined lifting capacity was only forty tons, if the nominal ratings were observed, and not over fifty-five tons if they were overloaded to the limit. In addition, it was practically impossible to hitch all four cranes to the load so that each would take its equal share of the strain; and even if this were feasible there still remained twenty-five tons of iron to be handled in some other way, as the main frame casting of the press weighed a little over eighty tons.

A standard gage railway spur that entered one end of the plant for handling incoming materials was continued down the shop nearly to the site for the new press, where it was divided and a line placed on each side of the press foundation. The heavy casting was then shunted in on a special car, because of its bulk and weight, and "spotted" just beyond the foundation. Two railroad wrecking cranes of sixty and eighty tons' capacity, obtained from the nearby division ends of two railroad systems, were then run into the plant—one down each switch. Hitches were taken on the casting and it was unloaded and lowered on its foundation; the actual time the hitches were on the casting was a little over forty minutes.

The cranes were charged for at the rate of $16 and $20 an hour, respectively, the charge being computed from the time the units left the railroad yards until they returned. But the cost of placing the press was so much less than would have been incurred by any of the other methods suggested that the management felt that an appreciable saving in cost—not to mention the additional working time of the press gained by the quick set-up—was obtained by this method.

Pittsburg, Pa. CHARLES C. LYNDE

PROTECTOR AGAINST BLOTTING

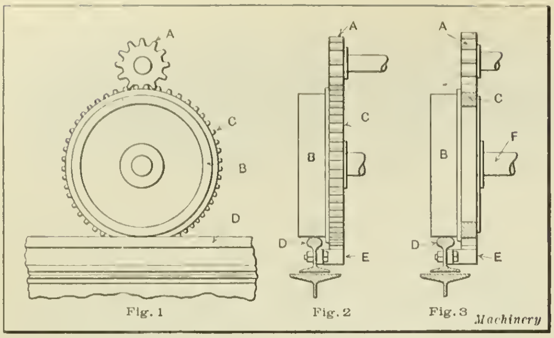
The barrel stave as an educational appliance applied to the ignoble portion of a recalcitrant youth is too little used; but as an accessory to the drawing-board to prevent blotting or smudging, as suggested by A. P. Connor in the February number of MACHINERY, the writer would prefer a T-square with two strips of cork affixed to the under side of the blade by drafting tacks, or even with two thick rubber bands, snapped around it. Anyway, no man with jiggly hands is fit to be a draftsman. R. G.

FAULTY GEAR AND RACK CONSTRUCTION

Often a mistake in design will go through the drafting-room and be incorporated in the completed machine for some time before it is noticed. The machine, on account of this, may give some unlooked-for results and attract attention, but the real seat of trouble may not be suspected. It will be known that there is something wrong and the chances are that a hundred different persons noting the trouble will advance as many theories as to the cause. These mistakes usually turn out to be such simple and foolish things that, after their discovery, we wonder how in the world they were made.

A mistake of this nature is here given. Figs. 1 and 2 show side and end elevations of a track wheel which it was found advisable to drive positively, because of the slippery condition of the track, rather than rely on the uncertain traction between track and wheel. The wheel is driven by pinion A meshing with gear C, which is integral with the flanged wheel B. Parallel to the track D runs a rack E with which gear C meshes, thus forming a positive drive for the track wheel, which merely supports the load. More than the estimated energy was required to move the machine supported by these wheels, and after this apparent oversight had been checked the power allowed was found to be ample; but it was not sufficient to run the machine properly. The first hint of the trouble came from the shearing of the key in pinion A. Investigation of the parts beyond this pinion, where the trouble was obviously located, revealed the following conditions: The outside diameter of wheel B was 15 inches. The pitch diameter of the driving gear was 15¾ inches. Therefore, during one revolution of the gear the machine was moved forward a distance equal to the pitch circumference of the gear or about 49½ inches. But as the diameter of wheel B was only 15 inches, one revolution of this wheel meant only a little more than 47⅛ inches of travel; hence, the load on each wheel was dragged about 2⅜ inches for each revolution of gear C.

This condition was remedied by making gear C revolve upon a sleeve of the wheel B, as shown in Fig. 3, where gear



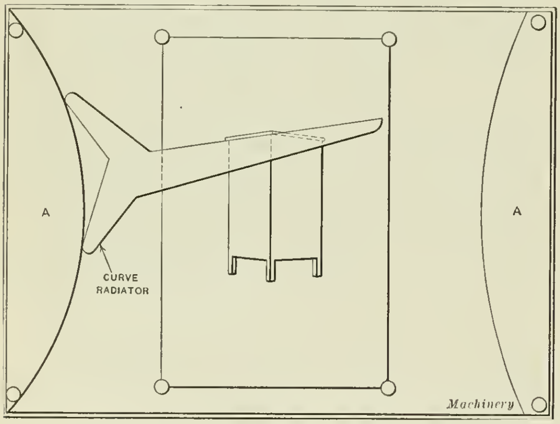
Figs. 1 to 3. Faulty and Improved Gear and Rack Construction

C is idle on wheel *B*, which is keyed to shaft *F*. A short study of this arrangement will show that it also has objectionable features, for the pressure of gear *C* against axle *F* as a fulcrum is equal to twice the force necessary to revolve the gear. Work is therefore dissipated through a part of each revolution due to this force on the gear bearing and consequent friction between the bearing surfaces at a large diameter. The best arrangement would have been to have made the wheel diameter and pitch diameter of the rack gear the same.

Otto Abdt

PERSPECTIVE DRAWINGS

The making of perspective drawings is generally termed a "deuce of a job" and often an isometric or some other distorted angular projected view is made to serve the purpose. Isometric drawings are satisfactory for working drawings, but for patent-office work and other cases where appearance is a great factor the true perspective is preferable. This, however, brings with it a nightmare of centrolineads or the expedient of putting the vanishing points within the limits



Making Perspective Drawings with Curve Radiator

of the drawing-board, which may give an unnatural viewpoint and hence a distorted picture of the article represented, especially if one is working with an 18- by 24-inch drawing-board.

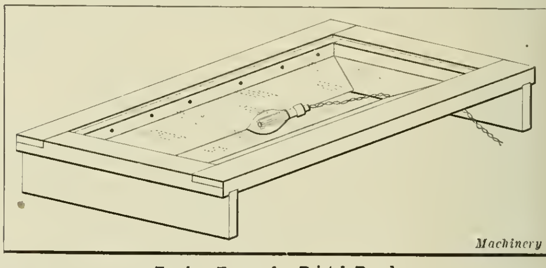
The following kink will perhaps be useful to many draftsmen, when making patent or other small drawings. First, cut a sheet of drawing paper about one-quarter inch smaller than the drawing-board. Then, from three-sheet bristol board, cut two pieces curved as shown at *A*. These should be free from irregularities, but their radii can be made to conform to each draftsman's taste in vanishing points; the centers from which the radii are drawn form the two vanishing points of the drawing. Paste these two pieces upon the sheet of drawing paper, being careful that the edges are down close; then when dry tack the paper upon the board and set true by means of the center line.

By using a curve radiator against the bristol board, the vanishing lines from each side may be obtained without the trouble of changing the arms, as when a centrolinead is used, while the thickness of the bristol board, 0.01 inch, offers no obstacle to the use of the T-square or triangle for parallel lines. For constant use, the curves may be made of stiffer and more durable material that will lie flat, and holes may be drilled in it for thumbtacks. A few moments' study of the figure will give a good idea of the manner of using this device.

East Orange, N. J. B. E. Barnes

TRACING FRAME FOR BRISTOL BOARD

The frame shown in the accompanying illustration has been found useful for tracing on bristol board. Recently the writer had to reproduce twelve Van Dyke drawings on bristol board for a patent application; by using this frame, the work was done in less than one-half the time it would have taken to lay it out. The frame is also useful for tracing the outline of a machine previously patented, on which an improvement is to be made. The construction is simple. A rabbet along the inner edges of the frame holds a pane of glass, which in this case is 8¼ by 13¼ inches, the size of a patent sheet. Tin is then tacked on both sides of the frame and inclined at an



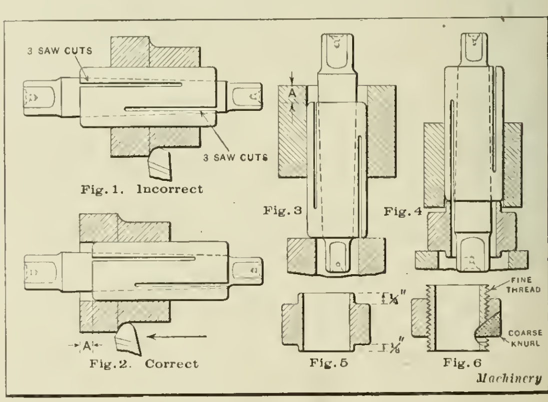
Tracing Frame for Bristol Board

angle of 45 degrees to reflect the light where it is most needed. At first the writer used a carbon lamp, but it was found that a Mazda lamp gave better light and less heat. Of course the room must be darkened when the frame is used.

Cincinnati, Ohio Harry W. Davis

USE AND ABUSE OF EXPANSION MANDRELS

In most shops where the split bushing type of expansion mandrel is used, a great number of bushings are damaged by being cut with the tool when facing the work, are broken into pieces, or are out of true. These conditions are generally brought about by inserting the bushing and arbor as shown in Fig. 1, thus leaving the bushing unsupported at the large end of the tapered hole. The correct position of the bushing and arbor is shown in Fig. 2. After the hole is bored and one end is faced in the usual way, the split bushing is inserted by hand with the large end of the tapered hole toward the un-



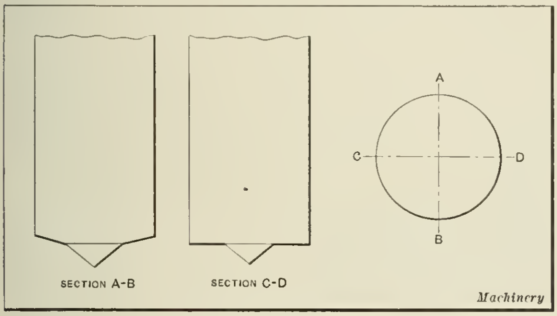
Figs. 1 to 6. Correct and Incorrect Methods of using Expansion Mandrels

faced end of the work. As the distance A, Figs. 2 and 3, is a little more than the amount to be faced off, it supports that part of the bushing where the greatest pressure occurs; it also provides clearance for the tool when facing, and eliminates the danger of cutting the bushing. The taper arbor is driven or pushed in as shown in Fig. 3.

To withdraw the arbor, special bushings are used in the manner shown in Fig. 4. The small expense incurred by making a few special packing bushings, as shown in Fig. 5, or the adjustable ones shown in Fig. 6 will soon be repaid, when once made, for they are practically indestructible. These bushings should be stored with and handed out with the arbors and split bushings. The two dimensions given in Fig. 5 have proved convenient for most sizes of work, though other dimensions may be made as required. The travel of the tool, when turning diameters, should always be in the direction of the arrow shown in Fig. 2. F. H. C.

HEAVY-DUTY PUNCH

The heavy-duty punch with a 90-degree teat, shown in MACHINERY for January, would be improved by grinding off the face from two opposite sides toward the teat, forming two



Heavy-duty Punch

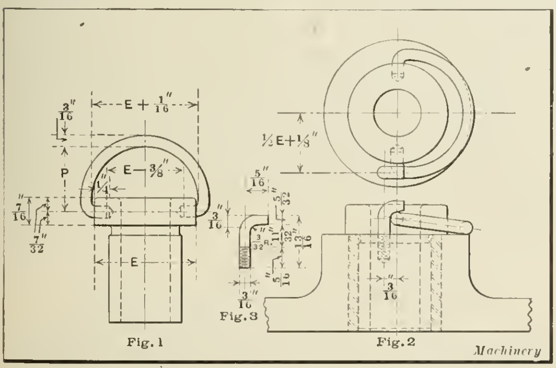
slanting surfaces, as shown in the accompanying illustration. The punch will grip the plate nicely and start easily, instead of requiring all the power at once. Where the two oblique planes meet, the line should be eased off a bit.

New York City ROBERT GRIMSHAW

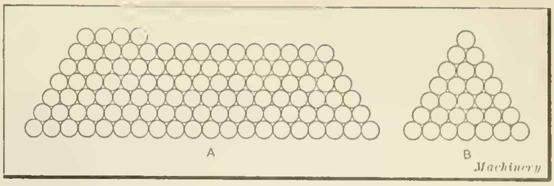
SLIP BUSHING

There is a type of slip bushing in fairly common use that the writer has not seen illustrated or mentioned in any books on jigs that he has read, and yet it is cheaply made and a great deal more easily handled and clamped than the knurled-head type. Fig. 1 shows the bushing in the handling position. The dimension P can be taken as one-half E plus 1/4 inch, but it should never be less than 1 inch in order to allow room for the finger to be inserted. Fig. 2 shows how the bushing is clamped in operation. When it is flat against the work, chips forced up the flutes of the drill cannot lift the bushing out of place. Fig. 3 gives the dimensions of the clamp hook.

Philadelphia, Pa. HARRY S. KARTSHER



Figs. 1 to 3. Cheap, Handy Slip Bushing



Rapid Method of counting Pieces in a Pile

COUNTING NUMBER OF PIECES IN A PILE

In the December number of MACHINERY there is presented a method for determining the number of pieces in a pile without actually counting them. This method may be simplified as follows: Add the number of pieces in the top row to the number of pieces in the bottom row and multiply the result by one-half the number of rows. To this result add the odd number, if any, at the top of the pile. This can be stated as a simple formula:

$$S = (T + B)\frac{N}{2} + O$$

in which S = total number of pieces;
T = number of pieces in top row;
B = number of pieces in bottom row;
N = number of rows;
O = number of odd pieces at top of pile.

For example, in the case shown at A, $T = 15$, $B = 20$, $N = 6$, $O = 4$. Inserting these values in the formula and solving,

$$S = (15 + 20)\frac{6}{2} + 4 = 35 \times 3 + 4 = 109$$

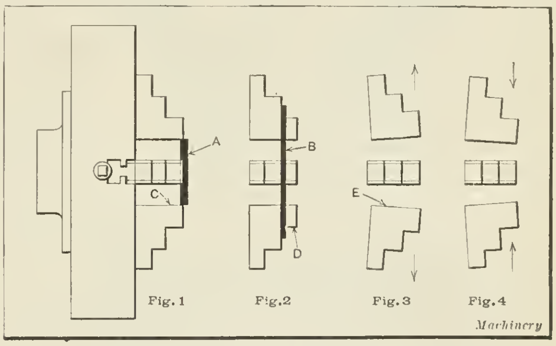
In the case shown at B, $T = 1$, $B = 7$, $N = 7$, $O = 0$. Inserting these values in the formula and solving,

$$S = (1 + 7)\frac{7}{2} + 0 = 8 \times \frac{7}{2} + 0 = 28$$

Flint, Mich. J. W. McDADE

REGRINDING CHUCK JAWS

The truing of lathe chuck jaws, which are usually hardened and therefore require grinding, is an operation that must be performed frequently, especially when the chucks are used



Figs. 1 to 4. Methods of regrinding Chuck Jaws

on accurate work. Some of the errors usually made when doing this work can be easily avoided by a little care. When new, the jaw is a free sliding fit in the body of the chuck; and if worn much, from constant use, it sometimes becomes very loose. For this reason, if the stress on the jaws is similar to that indicated in Fig. 1, they assume a shape like that shown (exaggerated) in Fig. 3; if the stress is like that indicated in Fig. 2, the result is as shown in Fig. 4.

If surface C is to be trued, the usual way is to chuck a ring by the inside as shown at B. The stress on the jaws is then as indicated by the arrows in Fig. 4, and all the pressure will be at point E, and not distributed along the length of jaw as it should be. A better method is to chuck a smaller ring, as shown at A, and grind up as close to it as conditions will permit. Afterward, the jaws may be taken out of the body

and the small surface covered by ring A ground, either by the use of a small cutter grinder or free hand, the previously ground surface being used as a guide. In the same way, if it is required to true up the steps D for inside chucking, the stress on the jaws, while it is being done, should be as indicated in Fig. 4, or similar to that existing when the chuck is actually in use. The ring B used for this purpose can be made very thin, so that the surface covered by it will be small and easily removed later.

Philadelphia, Pa. A. Dane

FIVE-OPERATION COMBINATION DIE

The combination die described in the following performs five distinct operations in the making of the cup shown in Fig. 2. This die is comparatively simple in construction and yet is very effective for manufacturing cups like that illustrated, although limited somewhat in the thickness of metal of which the cups may be made. In this case, the cup is made of a good quality of tin, 0.008 inch thick. It is half of a float for indicating the oil or gasoline level in automobile engine crank-cases or gasoline tanks.

The die, Fig. 1, is intended for use in a simple single-stroke power press, the operations of blanking, forming, piercing, embossing and trimming all taking place consecutively or simultaneously. For the best results the die is preferably made of the four-post type, thereby affording accurate alignment for the upper and lower working members. As the upper member descends, a circular piece a little larger than the required size is blanked out, leaving about 1/16 inch to be trimmed off the edge, thereby giving uniform depth. This blanking is done by the punch A entering the die B. As the upper member descends farther the spring pad C is forced downward and the blank contacts with core D, which commences the cupping. The inside edge of punch A forces the metal over core D, and knockout E recedes as the punch descends. Just before the end of the stroke, the excess metal from the lower edge of the cup is sheared or pinched off between the edge of core D and the internal radius b on punch A, thereby accurately trimming the cup. This method of trimming is employed in jewelry manufacture in making shallow cups at one stroke of the press. These tools are generally known as pinch tools. The ring of scrap which is removed from the edge of the cup in trimming is raised to the surface at the up stroke of the press by the spring pad C together with the cup. At the end of the stroke the punch G pierces and embosses the small central hole in the cup. The scrap drops through a clearance hole in the core into the scrap pan. It is important that the radius b on the inside of the punch be as small as possible without causing the metal in the cup to wrinkle or pull excessively when drawing. The more nearly this radius approaches a square corner, the more positive is the shearing action when the cup is being trimmed.

Fig. 2. Cup made in Die shown in Fig. 1

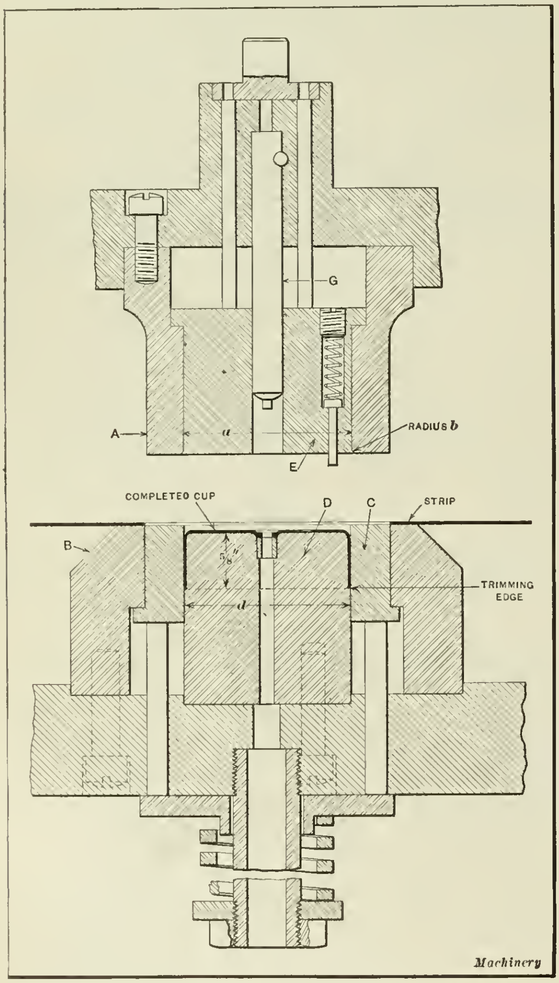


Fig. 1. Cross-sectional View of Combination Die

A few of the dimensions of this die must be very accurate to make it a successful working tool. For instance, the diameter a of the hole in the punch should not be more than 0.0005 inch larger than the dimension d of core D. This is essential to insure the correct trimming action of the die. Except as previously described, this tool is similar in general construction to any other well designed die. It is essential that most of the working faces be highly polished. Compressed air and a spring pin knockout, together with the positive knockout, are used for removing the completed cup and scrap at each stroke of the press. The die operates successfully in a press making between 75 and 85 revolutions per minute, and when accurately made will turn out many thousand pieces without attention.

Ypsilanti, Mich. A. E. Sanford

SECOND ANNEALING OF FORGINGS

Much care is being taken in many shops to obtain correct feeds and speeds in order to produce maximum output with minimum labor cost, but the economy of second annealing is generally overlooked. Often small parts that have been forged and annealed in the blacksmith shop and sent to the machine shop are found to be difficult to machine. If a light roughing cut is taken and they are again annealed, the machining is more easily accomplished. In one case, as soon as a quantity of grinding-wheel spindles was received from the blacksmith shop, one was put in the lathe and centered; when the first cut was taken, the spindle ran out of true and had to be straightened. After being straightened, it was again put into the lathe, but cutting a thread on it was still very difficult. Because too much time was occupied in machining, it was decided to take a slight roughing cut off all the spindles and then anneal them. By taking a light cut before annealing, the strain was taken off the pieces and the thread was cut in about one-third the time; besides, a much better job was produced.

New Haven, Conn. Eric Lee

FOUR-GEAR EPICYCLIC TRAIN

In the March, 1916, number of Machinery there appeared an article entitled "Four-gear Epicyclic Trains," which described two types of gears, one "imperfect" and the other "mechanically perfect." The latter was a train composed

wholly of gears with a standard tooth and space. No doubt this is more to be desired, in some instances, than what is known as a mongrel tooth. The writer takes exception, however, to the statement regarding the imperfect mechanism which was here described as the nearest approach to the perfect. This mechanism was shown with a planet pinion mounted on a pulley and in mesh with two gears of different pitch diameters, which causes great wear on the teeth as well as a prohibitive amount of backlash, not to mention noise.

The gear shown in Fig. 1 was designed, and twelve units have been built, for use in connection with a chucking machine. This supplied the power for feeding an 11/16-inch drill through eight inches of chrome-nickel steel. Fig. 1 shows the driving pulley, together with the cast-iron casing that completely encloses the gears and forms an oil-tight case. With the proper oil channels, this construction provides lubrication for all parts subject to wear.

For purposes of explanation it will be assumed that all gears are cut with 10-pitch cutters and, with the exception of gears A and F, have a standard form of tooth and space. Gears A, D, F, and G have a pitch diameter of four inches. Gears D and G have the required forty teeth, while A and F have thirty-nine teeth. Gear G is keyed to the shaft O. Pinions B, C, and E have a pitch diameter of 1.5 inch and have fifteen teeth. Gears A and F have long hubs extending into the support, these hubs being pinned together as a unit. The screw S locks the whole integral with the support to prevent turning. The web of the pulley contains a boss into which is forced a bronze bushing that acts as a bearing for the shaft to which are keyed pinions B and C. The pulley revolves on the long hub of gear F, the bronze bushing taking the wear.

Plates H and K are joined rigidly by the segment blocks R, Fig. 3. These plates contain bronze bushings in which revolves the shaft to which pinion E is keyed. This unit is screwed and doweled to gear D through plate H.

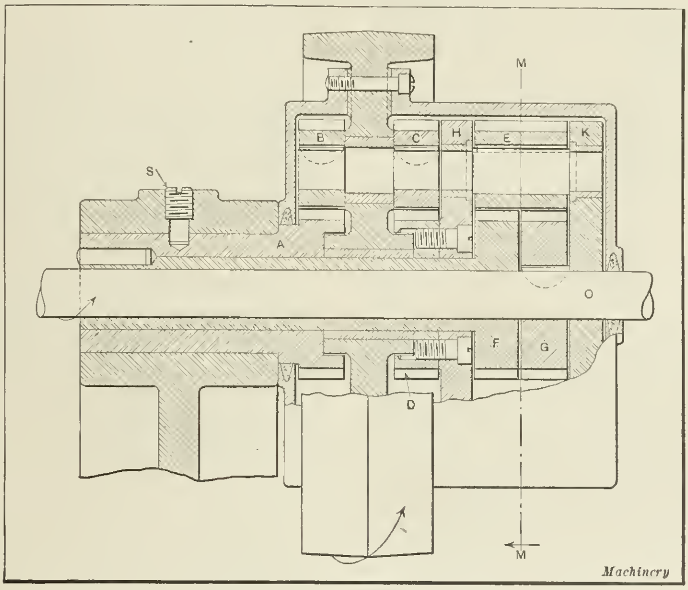


Fig. 1. Longitudinal Section of Four-gear Epicyclic Train

As gears A and F have thirty-nine teeth, they will have a corresponding circular pitch of $\frac{4\pi}{39} = \frac{4\pi}{40} + \left(\frac{4\pi}{40} \div 40\right) = 0.322$

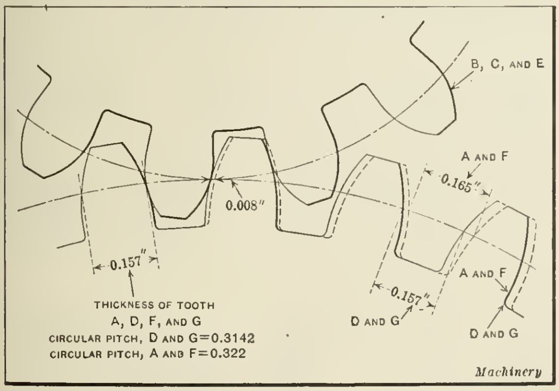


Fig. 2. Showing Differential Action of Epicyclic Gears

inch, while the circular pitch of D and G is $\frac{4\pi}{40} = 0.314$ inch, giving a minimum backlash of 0.008 inch per tooth. It is evident that as the pitch is increased, the backlash is decreased proportionately, and *vice versa*. It is shown in Fig. 2 that as the pulley revolves and pinion B passes over each tooth of A, gear D is moved the difference between the circular pitch of these two gears, or 0.008 inch. One revolution of the pulley will advance this gear one tooth, and forty revolutions will produce one complete revolution of D, which being connected to pinion E of the second unit, through H and K, causes gear G to advance one tooth. As a result, to produce one revolution of shaft O the pulley must make $40 \times 40 = 1600$ revolutions.

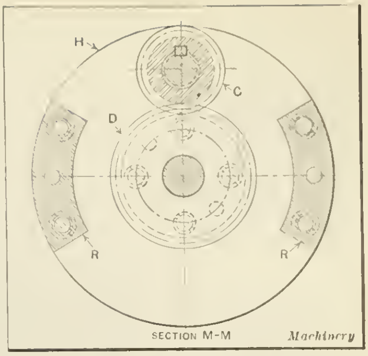


Fig. 3. Showing Section on M-M, Fig. 1

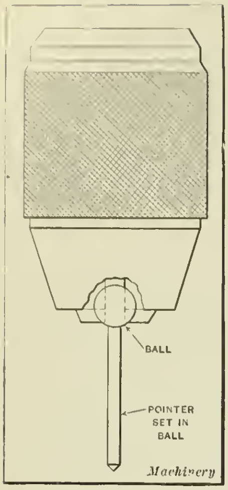
It is quite practical, if occasion requires, to extend this gearing by the addition of more units, which will greatly reduce the diameter but will slightly increase the length. The possibilities of a large reduction are unlimited. One big advantage of this type of reduction is the facility with which the gears may be chosen for known reductions. If this is of such proportions as to prohibit the use of a single unit, on account of the large diameter required, the square root or cube root of the reduction may be taken and two or three units used, thus reducing the diameter, as stated. The root is always the reduction ratio of one unit, and represents the number of teeth in gears D and G. For this reason it must be a whole number.

If it should be necessary, the driving pulley and shaft O may be made to run in opposite directions by transposing the number of teeth in the stationary and the movable gears. The former in that case will have forty teeth and the latter thirty-nine. Because of its compactness and the small amount of attention necessary, when provided with a proper oil opening for refilling, this gear seems to be especially fitted for hard usage where great reduction is necessary.

Hartford, Conn. A. S. Burrill

LOCATING WORK FOR BORING

The boring of a hole accurately in a certain position is one of the things in machine construction that requires both care and skill. It is only natural, therefore, that quite a number of devices have been developed for facilitating such operations. The December number of Machinery describes a tool with which satisfactory results have been secured. The method is to designate the location of the hole in the work by means of accurately scribed lines on the face where the hole is started. The work is then set up square and parallel on the



Pointer used for locating Center

milling machine and the intersection of the lines made to coincide with a pointer that, by means of an indicator, has been adjusted so that the point is known to run true with the boring spindle. Good results can be obtained in this manner, as when the surface is properly prepared fine, clean lines from a height gage or a scribing block will be close enough for quite accurate work. In the final polishing before marking, the grain should be laid so that it will not run parallel with the lines to be marked, as that will make them difficult to see; and by using a glass it is quite possible to set the lines on the work to coincide with the accurately adjusted point. It has been found by experience that work can be kept within ± 0.001 inch by such a method. In the illustration is shown the tool which the writer uses in locating work by the above plan; this has the merit of being very easy to make and use. It is made from a steel ball, 1/4 or 5/16 inch in diameter, that is annealed and drilled for the rod that is to act as the pointer. The simplest way of drilling this hole is to hold the ball in the draw-in chuck in the bench lathe. When drilled, the ball is rehardened. In the case of a 1/4-inch ball, the writer has made the pointer from 0.08-inch drill rod about 1 3/4 inch long. One end of the rod is fitted to the ball and the other is turned to a 50- or 60-degree point. It is then hardened on the pointed end only. The point should be ground so that it will be sharp and true. The hole is a drive fit for the rod, so by holding the rod carefully in the vise the ball can be lightly yet securely tapped on; the tool is completed by rounding the end of the rod where it comes through the ball.

In use, this tool is held in a three-jawed chuck in the milling-machine spindle, but it should be tightened very lightly, as the pointer must be readily deflected by a gentle pressure. Then the machine is started, running on one of the faster speeds; and as the work on the table is moved close up to the pointer, the hand is carefully steadied and, by a gentle pressure of the thumb-nail, the point of the tool is brought into its true position, which of course is determined by the entire absence of any side movement of the point. This should be verified by means of a glass. Then with the spindle still running, the work is brought almost in contact with the point and moved up, down and sidewise until the lines are exactly located; a glass should also be used for this purpose.

While the tool is very simple to make and use, the writer prefers it to the various more or less complicated adjustable instruments that have been suggested for locating holes by lines on the milling machine. But for satisfactory results, the lines must be sharp and clean; prick-punch marks must not be placed where the centers come, the lines themselves must be used; the chuck should be tightened very lightly; the pointer must not touch the work; and the machine used should not stand on a weak, shaky foundation.

Woonsocket, R. I. ARTHUR W. SUITER

MULTIPLE KEYWAYS IN MILLING CUTTERS

I have seen milling cutters made with three keyways in the bore, the purpose being to increase the length of time between grindings. The operator is instructed to mount the cutter on the arbor first with No. 1 keyway engaged with the key; then, when the teeth become somewhat dull, to change to No. 2 keyway; and then again to No. 3. The theory is that the teeth of a milling cutter approximately opposite the key always cut deepest and dull first because of the clearance of the cutter hole on the arbor. Thus, by changing the position of the cutter on the arbor in succession, the teeth are dulled equally all around, and the life of the cutter between sharpenings is increased. The scheme is one that could be used probably with satisfaction by careful operators, but even then I doubt if the gain would pay for the trouble of loosening the arbor nut and changing the cutter position on the driving key in order to lengthen the life between grindings. It seems as though the gain would be small.

But the idea of three keyways in the cutter suggests the question: why not cut four keyways in all milling cutters and provide multiple spline arbors to drive them? There would be no sheared keys and the drive would be stronger than with the present common single key arrangement. The cutters would run with less eccentricity, do better work and revolution marks on finished work would not be so common.

M. E. CANEK

COLD-ROLLED STEEL SHAFTING

In answer to the request in the February number of MACHINERY for information on cold-rolled steel shafting, the writer would call attention to the tests made by Prof. R. H. Thurston of Cornell University in 1902. The results of these are published in Jones & Laughlin Steel Co.'s catalogue of power transmission machinery. According to these tests, the elastic limit is increased from 15 to 97 per cent and the tenacity from 20 to 45 per cent. The resistance to transverse loads is increased from 11 to 30 per cent at the elastic limit, and from 13 to 69 per cent at the yield point. Resistance to torsional stress is increased at the elastic limit from 28 to 40 per cent, and at the yield point, from 31 to 64 per cent; at the point of fracture there is a decrease of from 4 to 10 per cent. Professor Thurston says that the effect of cold-rolling extends undiminished to the center of a bar. The results of tests with bars that were turned down from 1 3/4 inch in diameter are given in the accompanying table.

Pittsburg, Pa. B. OLSEN

RESULTS OF TESTS ON COLD-ROLLED AND HOT-ROLLED STEEL BARS

Diameter of Bar, Inches	Load, Pounds per Square Inch: Elastic Limit	Yield Point	Maximum	Ultimate	Elongation in 8 Inches, Per Cent	Reduction of Area, Per Cent	Resilience, Pounds Per Cubic Inch: Elastic Limit	Ultimate	Modulus of Elasticity
Cold-rolled Steel									
0.349	54,000	62,500	73,637	51,613	7.50	53.70	48.14	5,600	30,393,000
0.526	59,500	66,000	75,739	55,060	10.12	54.10	56.21	7,340	31,560,000
0.772	53,500	66,000	76,636	54,548	12.31	55.70	47.02	9,000	30,476,000
1.019	52,000	62,000	73,778	50,205	14.87	57.80	42.25	10,480	30,056,000
Hot-rolled Steel									
0.355	30,000	35,250	58,606	40,164	22.06	68.0	15.32	10,900	29,418,000
0.509	31,900	35,500	58,809	41,569	24.31	61.7	17.51	12,860	29,073,000
0.754	29,750	35,750	59,747	41,793	29.25	64.2	15.67	15,280	28,337,000
1.010	30,250	35,250	61,210	43,392	30.00	63.8	14.43	16,740	29,126,000

Machinery

CHAMFERING PINS IN AUTOMATIC SCREW MACHINE

In chamfering pins in automatic screw machines, a production of 8100 a day, four seconds for each pin, as given in the January number, seems slow. When the writer had Bessemer steel wire spindles to cut off with the tool arrangement there illustrated, he ran the machine at the rate of two seconds for each piece, with a net daily production of 16,200, which is just double the speed mentioned; and they had to be cut off without much of a teat showing. The writer made 200,000 pieces at that rate; but as this is faster than the machine is scheduled to run, the next time this job came through it was run at the rate of one piece every three seconds (the fastest listed speed of the machine). The two-second speed was obtained by compounding the gears. The cutting-off tool was fed at 0.001 inch per revolution, and the 200,000 pieces were made with no trouble. A straight high-speed steel cut-off blade was used as close to the collet as possible. The cams could have been made with double lobes (giving a production of four seconds for two pieces) but for the fact that the limit in length was too close, being ± 0.001 inch, and it is difficult to get the lobes of the lead cam exactly the same height.

Bayonne, N. J. JOHN NEUPAUER

THEORY OF ENLARGED HERRINGBONE PINIONS

The article entitled "Theory of Enlarged Herringbone Pinions" in MACHINERY for January, advocated enlarging the pitch diameters of both the gear and the pinion, which increases the center distance and the pressure angle. The result is a new pair of gears and, in the example there given, a pair of gears of odd pitch, odd pressure angle, and odd center distance. The writer of that article proceeded by finding a new pitch diameter for the pinion that entirely avoids interference with the standard addendum rack tooth, and then gave to the gear a proportionately larger pitch diameter. This gives a new and larger center distance and, since the base circle diameters remain the same, there is also a larger pressure angle.

The formula suggested there for finding the new pitch diameter gives a pressure angle that is higher than necessary to avoid interference. The formula given was as follows:

$$\frac{\text{Number of teeth}}{\text{Diametral pitch}}(\cos \text{ pressure angle})^2 + \frac{2}{\text{Diametral pitch}} =$$

nominal pitch diameter.

In Fig. 1 are shown the pitch circle for a 20-degree pressure angle and the new pitch circle given by this formula. It will be seen that the interference line for the rack given by the new pitch diameter is within the original interference line. This is not taken care of in the formula and results in a pitch diameter and pressure angle that are unnecessarily high. The addendum could be made equal to the dimension A, which would be greater than standard, and still avoid interference.

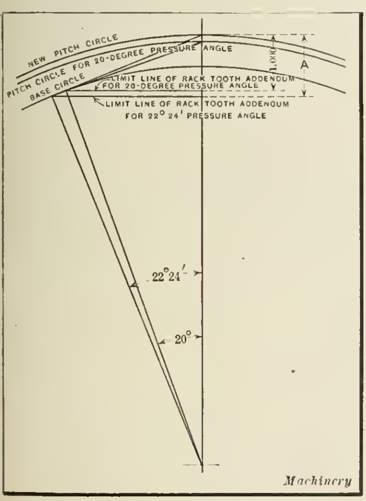


Fig. 1. Diagram showing how Suggested Formula gives Unnecessarily High Pressure Angle

It seems to the writer that a much better way to solve the problem of interference would have been to find the lowest pressure angle at which the fifteen-tooth pinion would mesh with the standard addendum rack without interference. The standard center distance and the standard pitch can then be maintained, which is an obvious advantage. The formula for finding the lowest pressure angle at which a gear of any number of teeth will mesh with a rack of standard addendum without interference is obtained as follows: From Fig. 2,

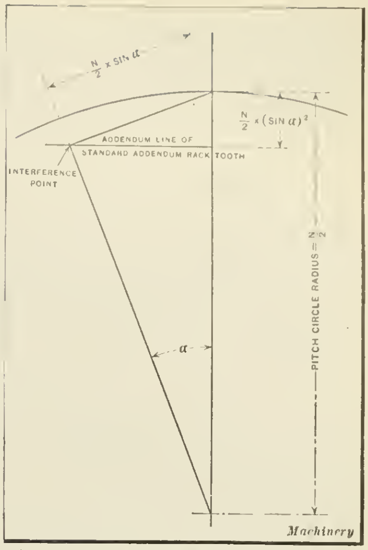


Fig. 2. Diagram showing how Pressure Angle that avoids Interference is determined for Any Number of Teeth

$$\text{Maximum addendum of rack} = \frac{N}{2}(\sin \alpha)^2$$

where N = number of teeth and α = pressure angle. When the addendum is standard, the formula becomes $\frac{N}{2}(\sin \alpha)^2 = 1$, from which $(\sin \alpha)^2 = \frac{2}{N}$, or $\sin \alpha = \sqrt{\frac{2}{N}}$. For fifteen teeth, the angle α is 21 degrees, 25 minutes, whereas the formula suggested in the article referred to gives α as equal to 22 degrees, 24 minutes.

The difference between the results obtained by these formulas is that the formula here presented gives the exact results sought, *viz.*, the lowest possible pressure angle with the elimination of interference, while all other dimensions are unchanged; whereas the other formula gives an unnecessarily high pressure angle and changes the center distance and pitch. Excessive sliding action, and the consequent excessive wear on the pinion tooth faces, is avoided in both cases, but this is not quite so important as it might seem since the pinion is almost invariably the driver; therefore, the pinion faces only come into contact on the arc of recess and, when the sliding action is greatest, the load is shared by another pair of teeth being in contact.

Auburn, R. I. ARTHUR BROWN

HARDENING PLUG GAGES

With reference to the article on hardening plug gages made of straight carbon tool steels, in the February number of MACHINERY, the writer would suggest the following method: Place in a pot like that used for cyanide hardening two parts rock salt and one part chloride of barium, and heat to 1525 degrees F., as shown by a pyrometer. Preheat the piece to be hardened to a dull red, and then immerse it in the salt solution, leaving it in the solution until it is the same temperature as the salt. Then quench it in a solution composed of one quart salt, one-half pint sulphuric acid, and ten gallons water. In dipping, the piece should be plunged straight down in the water and given a swirling motion. In the absence of the salt bath, an open charcoal fire can be used for heating, care being taken to heat slowly and uniformly to a good cherry red; the piece should then be quenched in the brine solution. It may be well to mention that "Cello Vanadium," "Ketos," and any of the ball-bearing, chrome-carbon alloys will give better results and last many times as long as straight carbon tool steels.

New Britain, Conn. WILLIAM C. BETZ

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

FORMING CARDBOARD SHAPES

E. S.—Can you give me information as to the method of making dies for cutting cardboard and the manner of forming cardboard novelties? I am particularly interested in the proper procedure to follow in blanking and forming a cardboard lid, oval in shape and one-quarter inch deep; that is, having a rim all around one-quarter inch high.

The question is submitted to readers having had experience in this line of die and press work.

BEVEL GEAR CUTTERS

A. B. G.—How are bevel gear cutters given relief on the teeth, and why are the teeth given side relief? How is the relief calculated?

A.—A bevel gear cutter is a thin spur gear cutter that differs from a regular spur gear cutter in no apparent detail except that of thickness. The standard Brown & Sharpe bevel gear cutters are made of a thickness that permits them to cut bevel gear face widths up to one-third the length of the pitch cone. Hence, the cutter is two-thirds the thickness of the standard spur gear cutter for the same pitch and number. Bevel gear cutters and spur gear cutters are not given side relief except that incident to form cutters in general which are made to be ground without changing the shape. This type of form-cutter, originated by Joseph Brown, provides relief on the sides of the teeth of gear-cutters and all other form cutters in which the tops of the teeth are narrower than the base, because the tooth outline is not concentric with the axis of the cutter but eccentric to it, each tooth having its own center.

DIFFERENTIAL INDEXING

G. M. A.—Will you explain how it is possible to make 59, 60 and 61 divisions on a 39-hole circle, by moving the crank 26 holes, as given in MACHINERY'S HANDBOOK on page 926. There are several other indexings given in the table that I do not understand.

A.—The table referred to is for simple and differential indexing on the Brown & Sharpe milling machine. The divisions referred to are obtained by means of gearing connecting the dividing head spindle with the index plate. As the crank is turned, the index plate is moved slowly backward or forward, and thus the movement of 26 holes in the 39-hole circle to obtain a division of 59, for instance, is apparent but not actual. The gearing moves the index plate the fractional part of a turn required to make up the difference between 26/39 and 40/59; hence the term, differential indexing. You will note in the table that the gearing for the two divisions 59 and 61 differs, and that there is no gearing specified for 60 divisions; 60 divisions are obtained without gearing, the same as on a plain dividing head.

CARBON "POINTS" IN STEEL

E. P. P.—Which is the correct term to use in specifying the carbon content of steel, "percentage" or "points"? For instance, should we say "10 per cent" or "10 points" carbon? What is the difference between the two terms when used to designate the carbon content of steel?

A.—The point system used in specifying the carbon content of steel is based on the division of one per cent into one hundred parts; hence, in the case cited, you should say "10 points carbon," as what you mean is one-tenth of one per cent carbon and not 10 per cent. If you wish to express the carbon content in percentage in the case, say, of 50-point carbon steel, the expression should be "one-half per cent" carbon. The term "points" probably originated in an inversion of the reading of the decimal of one per cent; the decimal 0.40, for instance, was read "40-point" instead of "point 40" in order to emphasize the amount of carbon and not the fact that it was a fraction. Later the term became "points." This is used in stock quotations, but its significance varies with the commodity. When used in cotton quotations a point is one-hundredth of a cent, but when used in stock quotations it is one cent.

POSITION OF CONE PULLEYS ON LATHES

D. M. C.—Will you kindly tell why engine lathes have the large end of the cone pulley next to the faceplate, while on bench and precision lathes the large end of the cone is generally at the opposite end of the spindle?

A.—The reason that the large end of the cone pulley of a back-geared engine lathe is placed next to the faceplate is that it favors design throughout. The large spindle gear, driven through the back-gear to get the maximum torque, should be placed as near the spindle nose as possible in order to reduce torsional deflection to a minimum, and the large end of the cone should be placed close to it. Rational design calls for a larger spindle cross-section at and near the nose than at the opposite end, which means that the cone pulley bearings will be made in proportion to the spindle bearings in the headstock. Hence the large step of the cone is put over the largest part of the spindle. The reason that bench lathes are generally made with the cone pulley facing in the opposite direction is that it favors the use of the compound slide-rest when adjusted for turning angles close to the faceplate. It is possible to make much wider angle settings with the cone pulley in the reverse position than if the cone pulley were placed the same as on back-geared engine lathes. There is also less interference with the belt in doing the common run of faceplate work.

PROBLEM IN TRIGONOMETRY

I. W.—Referring to the illustration, *ACB* is a right triangle, right-angled at *C*. Please show how to find the angle *B* from the dimensions given.

A.—It is first necessary to find the length of *BE* or *AF*; with *BE* known, the angle can be found from its tangent or cosine, and if *AF* is known, the angle can be found from its sine. Let $BE = c$ and $AF = a$; then from geometry, since the triangles *BED* and *DFA* are similar, $a:3 = 1:c$, or $a = \frac{3}{c}$. Also, $(c + 1)^2 + (a + 3)^2 = 10^2$. Expanding this expression we get: $c^2 + 2c + 1 + a^2 + 6a + 9 = 100$, or $c^2 + 2c + a^2 + 6a = 90$. Substituting the value of a, gives: $c^2 + 2c + \left(\frac{3}{c}\right)^2 + 6 \times \left(\frac{3}{c}\right) = 90$. Clearing of fractions and combining terms, $c^4 + 2c^3 - 90c^2 + 18c + 9 = 0$. Solving this equation, preferably by Horner's method, $c = 8.41994$. Therefore, $c + 1 = 9.41994$, and $\cos B = 9.41994 \div 10 = 0.941994$. From a table of natural trigonometric functions, B = 19 degrees, 36 minutes, 39 seconds. To prove that the value of c is correct as calculated, $a = \frac{3}{c} = \frac{3}{8.41994} = 0.356297$; $a + 3 = 3.35630$, to six significant figures; $c + 1 = 9.41994$; and $9.41994^2 + 3.35630^2 = 100.0000$. J. J.

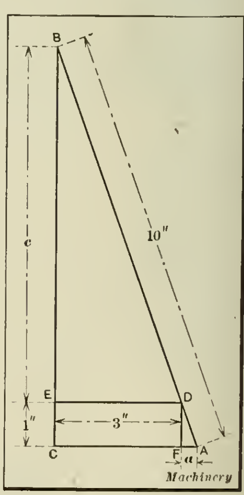
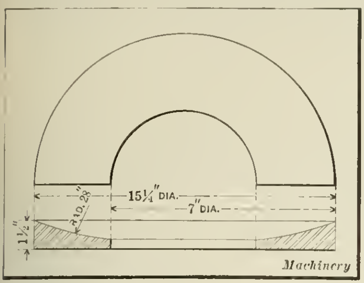


Diagram illustrating Method of finding Angle B in a Right-angle Triangle

TO HARDEN AN ANNULAR DISK WITHOUT WARPING

E. P. F. & M. Co.—We send you a sketch of a steel disk of which we have a number to make, and ask for suggestions as to the method of hardening so that they will not warp beyond reasonable limits for grinding. We machine the disks to within about 1/16 inch of the size shown in the sketch. They are then hardened and ground to finish size. We have had some trouble from warping during the hardening process, and would appreciate advice as to how the trouble can be avoided.



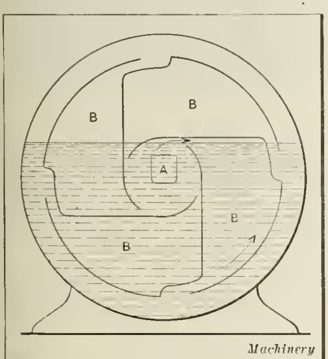
Annular Disk to be hardened

A.—The ring is of a specially difficult shape to harden without warping, because it is so much thicker at the periphery than at the inner edge of the hole, and also because the cross-section is not symmetrical with reference to a center line. Hence, the overhang when heated and chilled tends to contract and force the ring into a conical shape. You might employ the method used by makers of circular saws for holding the disk from warping when hardening. Saws are hardened between perforated circular disks, between which the saw is firmly clamped as it is immersed. Another method that might be used with success, provided the hardener is skillful, is to mount the ring on a revolving mandrel so that about one-half the width of the solid portion is immersed in the cooling bath. The ring should be revolved quickly and immersed all over as it revolves. The object is to cool the exterior first, because of the greater mass of metal, and thus to obtain simultaneous cooling throughout, with little or no tendency to change shape. This condition might also be accomplished by providing a shield of sheet metal to cover the inner part of the ring on both sides to about one-half its width. The shield should be scalloped on both edges so as to permit the water to reach the hot metal beneath, but not as freely as it would without the shield.

VOLUME OF GAS SPACE IN WET GAS METER

J. W.—I should like a formula for calculating the gas space for different heights of water level in a gas meter similar to that shown in the illustration.

A.—It is impossible to give a formula for this purpose, as you have not given sufficient information regarding the interior conditions—the shape of the ends, the shape of the blades *B*, etc. Even if this had been furnished, it is doubtful if a formula could be derived that would be of practical value. It would seem best to make a special calculation for every case; or, better still, to fill the drum with water, using for the purpose either an actual meter or a model of it, and then let the water flow out of holes drilled in one end at the desired heights. (These holes should be drilled and plugged before the drum is filled with water.) After it is filled, remove the top plug and weigh the water that flows out; this weight multiplied by 360/13 will give the volume of space, in cubic inches, occupied by the water. Then remove the second plug and repeat the calculation; the sum of the two calculations will be the volume above the second plug. In this way it is possible to obtain the volume for any desired height. J. J.

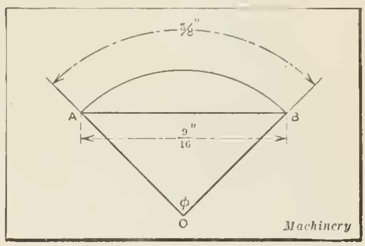


Sectional View of Wet Gas Meter

GIVEN THE CHORD AND ARC TO FIND THE RADIUS

G. H. C.—If the length of a given circular arc is 5/8 inch and the length of the chord is 9/16 inch, how can I find the radius?

A.—The easiest way to solve a problem of this kind is first to find an approximate value for the central angle $AOB = \phi$ (see illustration), then assume several other angles in that neighborhood, and, finally, calculate ϕ by interpolation. Represent the length of the arc by L and the length of the chord by C; then, for the present case, $C \div L = 9/16 \div 5/8 = 0.9$, and $C = 0.9L$. The table on pages 62 and 63 of MACHINERY'S HANDBOOK gives the length of arc and the length of chord (both to a radius 1) from 1 degree to 180 degrees. Multiplying the value of L for different angles by 0.9 until the product is equal to the value of C for that angle or very nearly equal to it, we find that for $\phi = 90$ degrees, $0.9L = 0.9 \times 1.571 = 1.4139$, and $C = 1.414$. As these two values are practically equal, ϕ is very nearly equal to 90 degrees. The radius r evidently equals $\frac{1/2 \times 9/16}{\sin 1/2\,\phi} = 0.3977$. It would not be safe to rely on this value of r to more than three significant figures; hence, if a more accurate value is desired, proceed as given in the following. It is first necessary to use a more accurate table. Using a six-place table, calculate L, C, and $C \div L$ for 90 degrees, 91 degrees, and 92 degrees ($C = 2 \sin 1/2\,\phi$), and then arrange in a table as here shown.



To find Radius when Chord and Arc are given

ϕ Deg.	L	C	C ÷ L
90	1.57080	1.41421	0.900312
91	1.58825	1.42650	0.898158
92	1.60570	1.43868	0.895983

Now using second differences, and applying Newton's formula for interpolation, we find that for $C/L = 0.900000$, $\phi = 90.1455$ degrees = 90 degrees, 8 minutes, 44 seconds. For this angle, $L = 1.57334 = \phi$ radians, $C = 1.41601$, and $0.9 \times L = 1.416006 = C$. Hence, $r = 0.28125 \div \sin 1/2\,\phi = 0.28125 \div \sin 45$ degrees, 4 minutes, 22 seconds $= 0.397243$ inch. Note that $L = r\phi = 0.397243 \times 1.57334 = 0.624998$. J. J.

FOOD VALUES IN CALORIES

J. W. Q.—A short time ago, a test was conducted whereby twelve policemen were fed three meals a day for twenty-five cents each, and it was stated that the food value was about 3000 calories per man per day. What is a calorie and what relation does it bear to the food value?

A.—The calorie is a heat unit and was originally defined as the amount of heat required to raise the temperature of 1 kilogram of water 1 degree C.; this is now called the kilogram-calorie or large calorie, and is the unit used in thermodynamic calculations. The range of temperature is now frequently taken from 17 degrees C. to 18 degrees C., under which conditions, 1 kilogram-calorie is equivalent to about 426.65 meter-kilograms or 3086 foot-pounds. This unit, however, is too large for use by chemists and others who deal in small quantities, and they have therefore adopted what is called the gram-calorie or small calorie, which is 1/1000 of the kilogram-calorie. Consequently, 1 gram-calorie = 3.086 foot-pounds of work or energy. To determine the number of calories in any particular article of food, the food is heated until all the water is driven out; the dried part that remains

is weighed and completely burned in a suitable apparatus (called a calorimeter) containing a known weight of water, and the rise in temperature of the water is noted. From these data, the calorific value of the material is obtained. Now, when food is eaten, the digestive process really produces the same effects as slow combustion, and thus generates heat, the amount generated being exactly the same as when the material is burned. This heat performs several functions in connection with animal life: it keeps the body temperature constant, and it furnishes the energy necessary for breathing, movement, exercise, work, etc. If more food is eaten than is required to produce these effects, the surplus energy is stored in the body in the form of fat and the weight increases; but if less food is eaten than the body demands, it draws first on the fat to supply the extra energy, and when this is gone, it consumes the lean and other tissues, and the weight decreases. A full-grown, normal man, under ordinary conditions, requires about 3000 calories per day in order neither to gain nor lose in weight, and perform his daily work. J. J.

EFFICIENCY OF MACHINES

R. A. F.—Will you please explain what is meant by the word "efficiency" when applied to machines?

A.—Speaking in general terms, the efficiency of a machine may be defined as the ratio of the work delivered by the machine to the work supplied to it. For instance, if 75 foot-pounds of work or energy are supplied to a machine and the machine can deliver only 60 foot-pounds of useful work, the machine is said to have an efficiency of $60 \div 75 = 0.80$, or 80 per cent. It frequently happens, however, that the work will be proportional to a force or some other quantity, in which case the efficiency may be measured by a comparison of two forces or other quantities. For instance, referring to the illustration, let P be a force acting on one end of a rope that passes over a pulley and has a weight Q attached to the other end. If P moves through a distance p, Q will move through a distance q, and, by the principle of virtual velocities, $Pp = Qq$, when it is assumed that there are no wasteful resistances, such as friction of the bearings, bending of the rope, etc. The efficiency in this case would evidently be 1, or 100 per cent.

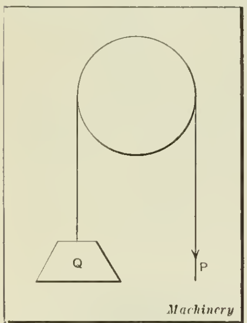


Diagram illustrating Determination of Efficiency of Machines

Since, however, there are wasteful resistances, they may be represented by W and the distance through which they act by w; consequently, the foregoing expression becomes $Pp - Ww = Qq$, or $Pp = Qq + Ww$, and the expression for efficiency becomes $\dfrac{Pp}{Qq + Ww}$. Since every machine or part of a machine offers wasteful resistances, the efficiency must always be less than 100 per cent, *i. e.*, it must always be a fraction less than unity. Referring again to the illustration, let P_0 be the force required to move the load Q when wasteful resistances are neglected, and let P be the force actually required to move the load; then the efficiency may be defined as $c = \dfrac{P_0}{P}$, in which c is the efficiency. If a machine is made up of a number of separate parts, the efficiency of the entire machine is the product of the efficiencies of the several parts, *i. e.*, $c = c_1 \times c_2 \times c_3$, etc. In the case of any heat engine, the energy of the working fluid (gas, air, steam, etc.) is proportional to the temperature; hence, if T_1 is the temperature of the fluid as it enters and T_2 the temperature on leaving (both absolute), the thermal efficiency is $T_1 - T_2 \div T_1$. J. J.

FINDING THE ANGLES OF A TRIANGLE

A. F. O.—I recently had to lay out a triangular piece, the lengths of the sides of which were 1 5/16 inch, 3 1/4 inches, and 3 11/16 inches; later I desired to know the angles, but could not measure them accurately enough with a protractor. Please show me how to calculate the angles.

A.—There are a number of formulas for calculating the angles, one of which is given on page 153 of MACHINERY'S HANDBOOK. This formula may be put into an easier form for calculating by a slight rearrangement and factoring of the terms, thus: $\cos A = \dfrac{b^2 + c^2 - a^2}{2bc} = \dfrac{1}{2b}\left[c + \dfrac{(b+a)(b-a)}{c}\right]$; also $\cos B = \dfrac{1}{2a}\left[c - \dfrac{(b+a)(b-a)}{c}\right]$. In these two formulas, a is the shortest side and c the longest side. Referring to the figure, it will be noticed that the angles A, B, and C are opposite the sides a, b, and c, respectively. The chief advantage of these two formulas is that having calculated the fraction by one formula, the result can be substituted in the second formula; also, it is not necessary to square three different numbers. In the present case, $a = 1\,5/16 = 1.3125$, $b = 3\,1/4 = 3.25$, and $c = 3\,11/16 = 3.6875$; therefore,

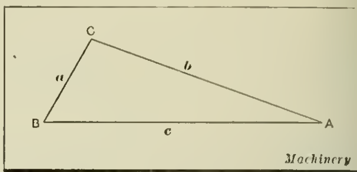


Diagram illustrating Method of finding Angles of a Triangle

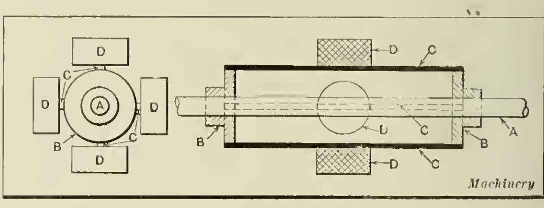
$$\cos A = \frac{1}{2 \times 3.25}\left[3.6875 + \frac{(3.25 + 1.3125)(3.25 - 1.3125)}{3.6875}\right]$$

$= \dfrac{1}{6.5}(3.6875 + 2.39725) = 0.93611$. The angle the cosine of which is 0.93611 is 20 degrees, 35 minutes, 30 seconds. Again substituting, $\cos B = \dfrac{1}{2 \times 1.3125}(3.6875 - 2.39725) = 0.49153$ = cos 60 degrees, 33 minutes, 31 seconds. Angle C = 180 degrees — (20 degrees, 35 minutes, 30 seconds + 60 degrees, 33 minutes, 31 seconds) = 98 degrees, 50 minutes, 59 seconds. J. J.

GOVERNOR FOR REGULATING SPEED OF VICTROLA

F. H. G.—The illustration shows a sectional view and plan of a governor for a victrola. The sleeves B slide up and down the splined shaft A and are connected to each other by four flat springs C that carry lead weights D in the middle. As the weights revolve, the centrifugal force throws them out against the resistance of the springs (and gravity) and brings the sleeves closer together, causing them to move a lever operating a friction device that reduces the speed. I should like a formula fitting this type of governor.

A.—We know of no formula that will apply to a case of this kind, and we doubt very much the possibility of deriving one that would be of any practical value. It is the opinion of the writer that the results to be obtained with a device like this could only be determined by direct experiment. The curve of flexure of the springs will be similar to that of a beam fixed at both ends, and it will be further modified by



Sectional and Plan Views of Victrola Governor

the character of the lead weights; that is, by their size and shape. If a number of such governors were to be constructed, and of different sizes, it is probable that an empirical formula could be derived that would give results sufficiently accurate for practical purposes. J. J.

* * *

Japan has supplanted Germany in furnishing electric light bulbs to Russia and the cheaper electrical devices to China.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

JORDAN AUTOMATIC PROFILE SHAPER

The design of this machine has been so worked out that a die is completely finished without requiring subsequent hand work. Furthermore, the method of operating is so simple that it may be safely entrusted to a boy of average intelligence. In starting to make a die, a templet of the required outline is made from 1/8-inch sheet steel, and if this templet is to be used repeatedly, it is casehardened around the edge of the opening. When the templet is of no further use, it may be employed as a stripper plate. If a number of dies of the same outline are required, it is often practicable to produce several dies at the same time.

A number of machines have been developed to facilitate the making of blanking dies, the idea being not only to save on the high wages paid to toolmakers and diemakers, but also to produce work of the highest quality. Most of these machines have to be operated by hand, and it is generally necessary to employ an experienced toolmaker for this class of work; the contour of the die must also be laid out by hand, no matter how many of one set of dies are required, and after the die leaves the machine it has to be finished by hand. An interesting addition to the group of machines for handling work of this kind has recently been developed by the Luster-Jordan Co., Inc., Franklin Ave. and Washington St., Norristown, Pa. This machine is almost fully automatic, and is said to produce a die which is accurate in every respect, the edge being as clean as that of a hand-made die, and the taper perfect all the way around the die opening. Provision may be made for obtaining any desired taper, and there is no danger of spoiling the die, no matter how long the machine runs without attention from the operator. The control of the machine is so simple that it is claimed that any boy of average intelligence can operate it and obtain results equal to those produced by a high-grade toolmaker working by hand; furthermore, the time required to finish the dies is usually from one-tenth to one-twentieth of that required to do the work by hand, and if a number of dies of the same outline are required, it is possible to make two or three dies at one setting.

This machine is adapted for an extremely wide range of work and is substantially constructed to stand up under severe conditions of service. Its most important feature is the universal table, which is best illustrated in Fig. 4. Probably the best way to explain the operation of this machine is to describe the steps taken in making a die. First it is necessary for an exact templet of the die to be made, 1/8-inch sheet steel being used for this purpose; this is hardened around the opening if the templet is to be used repeatedly. For this purpose cyanide hardening will be found satisfactory. No matter how simple or how complicated the die may be, or whether one or more dies of the same shape have to be made, it is claimed that it is always easier to make a templet from steel 1/8 inch in thickness than to lay out a die and cut it by hand, because this machine completely finishes the die and can be operated by non-skilled labor. After cutting the die, the templet may be used as a stripper plate if it is of no further use. When the templet has been made, the die should be roughed out as far as possible, although this is not absolutely necessary so long as one hole can be made through which to pass the tool. The die is placed on the machine, and if it happens that the die is smaller than the hole in the table, a pair of parallels is placed underneath it; then the templet is put in position on top of the die with a space of about 1/4 inch between the templet and the die. This space serves as a clearance for the

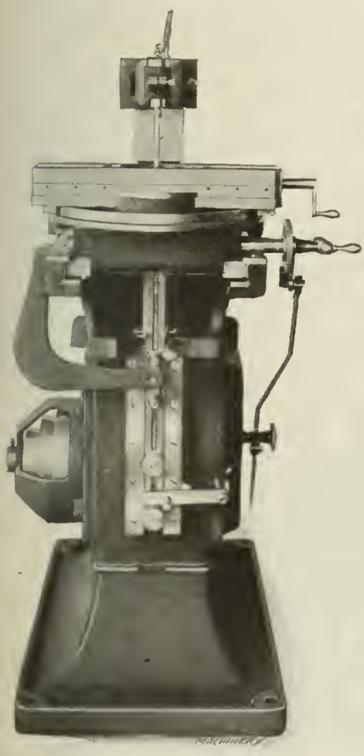


Fig. 1. Front of Automatic Profile Shaper

Fig. 2. Side View of Machine, showing Arrangement of Universal Table and Tool

Fig. 3. Back of Machine, showing Drive, etc.

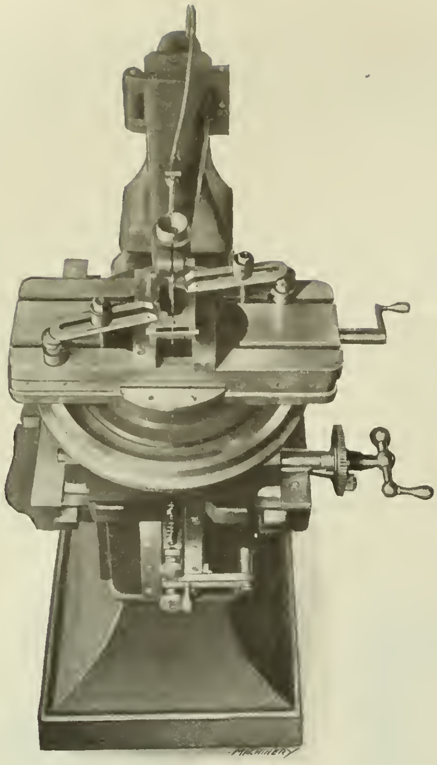


Fig. 4. View looking down on Machine, which shows Construction of Universal Table

tool, and the die and templet are held by two clamps which are adjustable for varying thicknesses of the die.

The tools used on this machine are generally made from a piece of drill rod, which is milled in the center to a triangular form with the cutting edge obtained by recessing the lower part of the tool; for instance, if it is required to cut 1/8 inch at a time, the tool is recessed 1/8 inch. The tool is inserted in the ram of the machine and guided from above by the supporting arm. Lubrication is obtained by a geared pump, which not only supplies the tool with lubricant, but also takes care of the entire lubrication of the machine. Adjustment of the length of stroke may be obtained, so that at the highest position of the ram, the cutting edge of the tool is in the space between the die and templet. It will be apparent that the tool works up and down as on a vertical shaper, and transverse, longitudinal and rotary motions of the table are available for feeding the work to the tool. The cutting action of the tool continues until the upper part strikes the templet, this portion of the tool serving as a guide. From this it will be apparent that the tool can never cut below the "finishing line" on the die, *i. e.*, it is practically impossible to spoil the die. Two locks on the ram make it an easy matter to adjust the stroke from the front of the machine.

Three self-aligning roller bearings provide for easy sliding of the table on the bed of the machine, and provision is made for counterbalancing the table under different conditions, the counterweights being applied in such a way that they press the work carried on the table toward the tool. At the end of every up stroke of the tool, the table is automatically locked and remains locked while the tool takes its cut. This is effected by a brake shoe on the upper part of the ram. Upon the completion of the up stroke, this brake shoe, by means of friction, moves an eccentric lever which presses the gib of the table into such firm contact that the table is secured against movement. When the down stroke has been completed, *i. e.*, after the cutting has been finished, the ram automatically releases the brake shoe so that the table may slide back for the next cut. In order to facilitate removal of the tool, the upper supporting arm swings on a hinge. It will be seen that the main drive of the machine is by a two-step cone pulley which is furnished with a friction clutch and accelerates the return of the tool.

The regular equipment furnished with this machine includes two clamps and adjusting locks, three cutting tools of various diameters, and one complete set of wrenches for making all adjustments on the machine. In this connection it may be mentioned that cutting tools are furnished in sizes ranging from 1/8 to 1 inch, inclusive, by intervals of 1/8 inch. Special tools and tool-holders equipped with ordinary tool bits may be furnished as extra equipment for slotting and keyseating operations, and a file-holder on the ram may also be supplied as extra equipment. The principal dimensions of the machine are as follows: capacity for circular work, up to 8 inches in diameter; capacity for oval work, up to 12 by 6 inches in size; size of table, 22 by 8 inches; distance from center of cutter to supporting arm, 16 1/2 inches; stroke of ram, 1/4 to 6 inches; speed of countershaft, 225 R. P. M.; power required to drive the machine, 2 horsepower; range of cutting speed, 20 to 35 feet per minute; dimensions of cone pulley steps, 8 and 10 1/2 inches in diameter by 2 inches face width; over-all height of machine, 58 inches; distance from floor to table, 48 inches; and floor space occupied, 28 by 38 inches.

MEDINA DRILLING AND SPACING MACHINES

In general respects, the design of this heavy-duty drilling and boring machine follows standard practice in the construction of tools of this type. The same is true of the universal spacing machine with the exception of the table and the provision of a vernier adapter for making accurate settings of the work preparatory to boring holes. By means of this adapter, which is described in detail, settings can be made accurate to 0.00001 inch.

The illustrations presented in connection with the following description show a heavy-duty drilling and boring machine, and what is styled a "universal spacing machine," which are products of the Medina Machine Co., State Rd., Medina, Ohio. It will be apparent that the design of the two machines is the same, with the exception of the base and table, which have been modified as shown in Fig. 2 to adapt the spacing machine for performing those classes of precision boring for which it

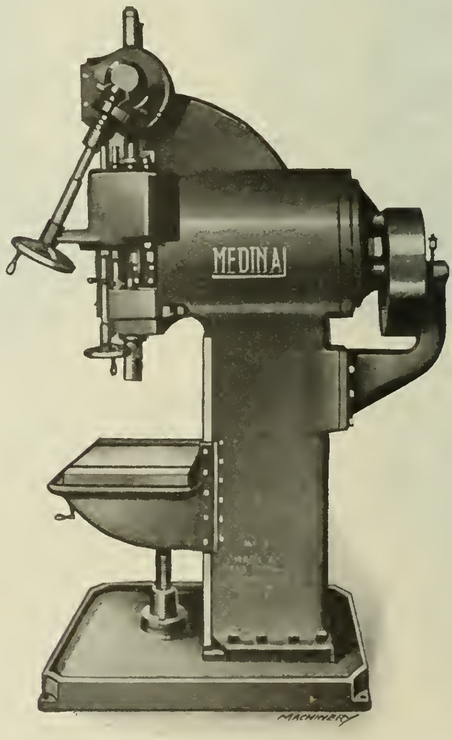


Fig. 1. Medina Heavy-duty Drilling and Boring Machine

is intended. A general description of the drilling and boring machine will be presented, and this will apply also to the spacing machine, with the exception of features of design of the table, which will be described in detail.

Heavy-duty Drilling and Boring Machine

This machine has been especially developed to meet the requirements of heavy-duty work, and the bed is well ribbed throughout to adapt it for severe conditions of service. On heavy work, lubrication is of exceptional importance, and to provide for continuous circulation of cutting compound, a reservoir is provided in the base to receive the fluid which is first drained through a screen to remove chips and dirt. The column is of heavy box construction, and the ways are planed up far enough to provide for mounting special heads for multiple-spindle drilling. In working out the design, care has been taken to make the machine of simple construction and easy to operate. All control levers are placed within easy reach of the operator when standing at the front of the machine, and all gears are guarded to comply with the safety laws in various states.

The spindle is so designed that perfect alignment and adjustment may be maintained without the bearings tending to bind or become heated. The driving gear is mounted close to the working end of the spindle, so that torsional strains are practically eliminated. As the machine is intended for heavy work, provision of means for taking the spindle thrust is a matter of importance, and such means are provided by an S. K. F. ball thrust bearing. The spindle and spindle sleeve are of forged crucible steel, accurately ground for the entire length; the spindle slides through the sleeve, and only the sleeve runs in bearings. There is a conical shaped journal at the lower end of the spindle sleeve; the upper end is straight and has a close fitting conical sleeve that extends over the spindle sleeve proper, and is driven simultaneously with it by means of a key.

This arrangement provides for variation of the spindle sleeves through expansion, and has no effect upon the conical bearings, although the spindle and sleeves are maintained in perfect alignment. The spindle head is rigidly fastened to the column and is self-contained in a unit with the spindle,

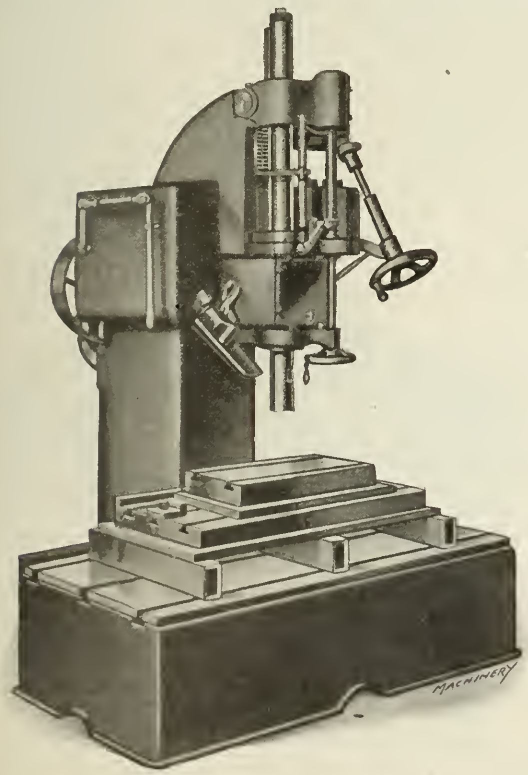


Fig. 2. Medina Universal Spacing Machine for Jig Boring and Similar Operations

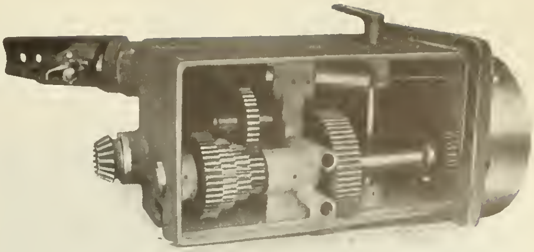


Fig. 3. Type of Gear-box used on Both Spacing and Drilling Machines

driving gear, and feed works. This head contains a housing for the driving bevel gear and feed worm and worm-wheel, so that these members run in grease. The spindle drive is direct from the bevel pinion of the geared speed-box to a large driving bevel gear mounted on the spindle sleeve, which drives the spindle through the sleeve with two steel keys of special design, the arrangement being such that there is no torque in the driving sleeve. The spindle is driven at its point of largest diameter, and as previously mentioned, the driving gear is placed close to the work.

Starting and stopping the machine is effected by a powerful Johnson friction clutch, which is easily adjusted without disturbing any other parts. A tight fitting cover closes the speed-box, which is oil-tight to enable the driving gears to run in oil, and this also provides thorough lubrication for the Hyatt roller bearings which are used. The box contains nine machine-steel hardened change-gears and four semi-steel wide-faced gears that operate from the clutch. Only two idle gears are in mesh when the machine is in operation. Speed changes are made by a roll-in gear. Whether the machine is driven by belt or motor, the drive may be constant speed, variations being obtained by the gears in the speed-box. When motor drive is employed, the motor can be mounted on a bracket at the rear of the machine, and if a variable-speed motor is employed, speed changes may be obtained from the motor, no speed-box being used. In single-purpose manufacturing the speed-box can sometimes be eliminated and a single-speed drive or a three-step cone pulley and countershaft made to give the desired service. The gear-box is aligned with the spindle center by a boss turned on the front end of the box, which fits into a bore in the head which provides for obtaining proper alignment.

Changes of feed are obtained through a feed-box with semi-steel gears and a slip key that provides for engaging the particular pair of gears that are required. Bearings in the feed-box are bored and bronze-bushed, so that accurate alignment is maintained, and one feed gear is provided with a safety friction which prevents danger of stripping the teeth. An automatic knock-out is provided to disengage the feed clutch at any desired point, and handwheels within easy reach of the operator provide for obtaining hand feed and quick return to the spindle. The table is of plain box section, strongly ribbed, and has a channel extending around the edge to carry away cutting compound. Heavy straps are provided to secure the table to the column and maintain the required alignment. The table is raised and lowered by telescopic jack-screws, so that it is not necessary to cut a hole through the floor to provide clearance for the lower end of the screw.

The principal dimensions of the machine are as follows: diameter of spindle, 3½ inches; Morse taper in spindle, No. 5; maximum spindle traverse, 14 inches; maximum distance from spindle to table, 32 inches; distance from center of spindle to face of column above knee, 12 inches; working size of plain table, 19 by 20 inches; maximum lift of table, 16¾ inches; range of eight spindle speeds as follows, 54, 85, 108, 132, 170, 207, 265 and 414 revolutions per minute; range of four available power feeds as follows, 0.006, 0.011, 0.016 and 0.032 inch per spindle revolution; size of driving pulley, 20 inches in diameter by 5 inches face width; recommended speed for driving pulley, 400 revolutions per minute; power required to drive machine, 10 horsepower; capacity, up to 3-inch high-

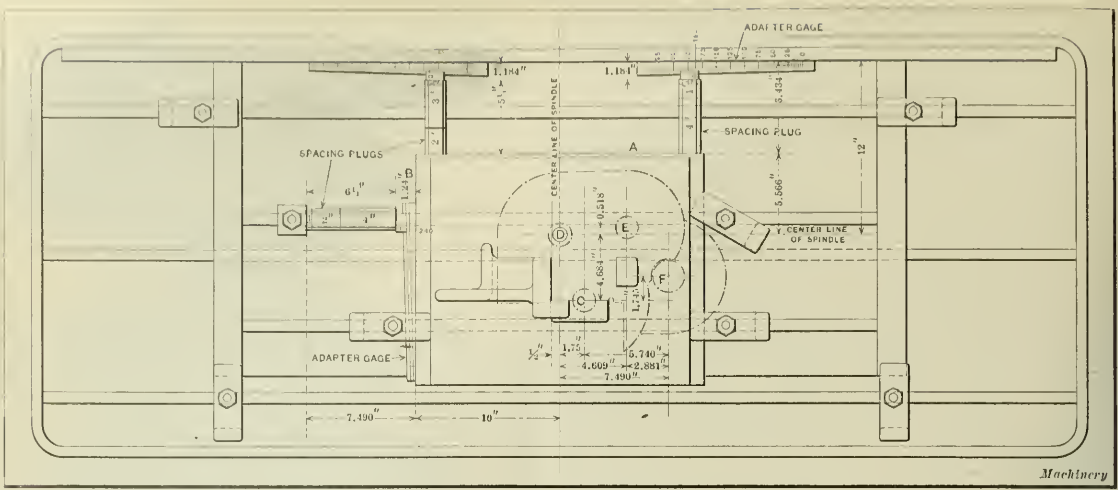


Fig. 4. General View of Table, showing Method of using Vernier Adapter to get Settings Accurate to 0.00001 Inch

speed drills; maximum over-all height of machine, 9 feet, 3 inches; floor space occupied, 34 by 65 inches; and weight of machine, 5000 pounds.

Universal Spacing Machine

To meet the requirements of jig boring and similar operations, the Medina Machine Co. has developed a machine known as a universal spacing machine, which is shown in Fig. 2. In addition, the machine is suitable for manufacturing work where it is required to bore holes to close limits without the use of jigs. This is done through the use of set-blocks and an adapter gage, which make it possible to space holes within 0.00001 inch. It will be seen that the base of the machine is provided with three T-slots running lengthwise to provide for clamping jigs, angle-plates, or other work-holding devices. This base is provided with a planed strip at the rear, which runs the entire length of the base and is used in connection with hardened blocks, against which the gage blocks may be set. This strip is made accurate for square and straight, so that it constitutes a reliable reference point. The platen is also provided with three T-slots for holding work or clamping down a small auxiliary table. This platen is provided with finished edges which are planed square and provided with hardened strips, as in the case of the base. Clamp strips are provided at the ends and sides for clamping down work in the desired position. The smaller or auxiliary platen is used in connection with either the base or main platen of the machine, according to the requirements of the work. As will be seen, two T-slots are provided for securing the work in place. In many cases it is desirable to set up the large platen on parallels, as shown in the illustration.

A gage block end stop with a hardened steel face is provided to fit in the center slot of the base or large platen. Clamp bolts hold the stop in any desired position. Gage blocks are provided in sets of three, which are made of tool steel, hardened, ground and lapped, two ends and one flat being square and the ends parallel to each other. These blocks are made in the following lengths: 0.250, 0.5, 0.750, 1, 2, 3 and 4 inches. They are of approximately this length, any variation under or over this amount being etched in the block and expressed as decimals carried out to the fifth place, so that they are correct to 0.00001 inch. These blocks are used in connection with an adapter gage and also with Johansson blocks when so desired. This adapter gage is furnished with a tapered strip of non-shrinkable steel, which is hardened, ground and lapped. The taper is 0.250 inch in twenty-five millimeters, so that each millimeter space represents 0.001 inch. The vernier splits one millimeter into fifty spaces, making each vernier space equivalent to 0.00002 inch, and by estimating half spaces settings are made to 0.00001 inch. This degree of accuracy may be obtained in making settings, but in practice there are other limitations that prevent securing quite such precision in the spacing between holes. Three of these adapter gages are provided with gage blocks, using one on one end against the gage block end stop, and two on one side of the platen next to the machine for spacing. The scales are placed so that they are visible when the adapter rests on the platen, making two of one hand and one of another.

SAYLOR SHELL WASHING MACHINES

The line of shell washing machines developed by the Pottstown Machine Co., Pottstown, Pa., was designed with the intention of washing the shell as thoroughly inside as outside. The smaller machine shown in Fig. 1 is made to accommodate shells up to six inches. It consists of a large rectangular tank in which revolves a six-station wheel having a cradle for accommodating six shells. The construction of this wheel is similar in every respect to the well-known ferris wheel. The wheel is revolved constantly and the operator removes a shell and loads one from the two stations of the wheel that are raised out of the tank, unloading and loading being accomplished with the small crane.

The cradle in which the shell is laid is free to swivel, and it is so balanced that the tendency is to tilt the nose of the shell downward. Two of these cradles are out of the tank all the time; the one to the right is in a position for unloading while

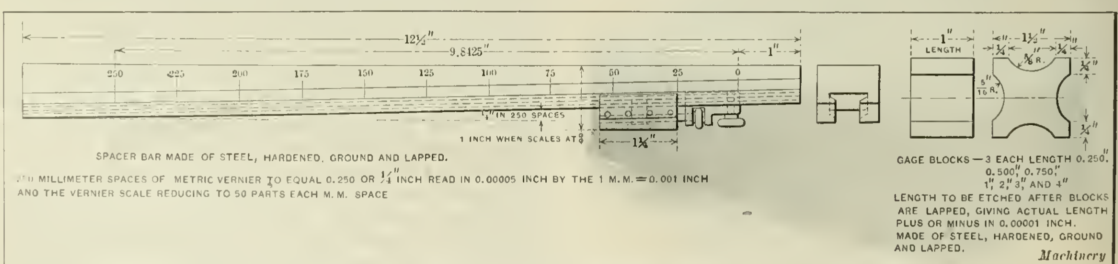


Fig. 5. Detail View of Vernier Adapter and Gage Block of Type shown in Use in Fig. 4

Fig. 1. Saylor Continuous Shell Washing Machine for Six-inch Shells

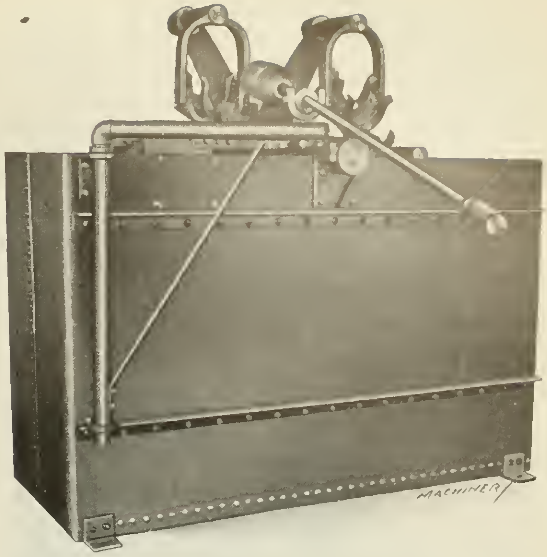


Fig. 2. Opposite Side of Saylor Shell Washing Machine shown in Fig. 1

the one to the left is in a position for loading. In the loading position, the cradle is prevented from tilting the shell nose downward by a rest on which the end of the cradle bears. The shells enter the liquid, heel downward, and are held in this position for a sufficient time to allow them to be filled with the liquid. This is effected by a barrier of sheet metal that is interposed in the path of the cradles, causing them to tilt in a backward position.

After each cradle has remained tilted with the shell nose in an upward position for a sufficient time to allow it to become filled with liquid, it breaks contact with the barrier and tilts to an angular position with the shell nose pointing downward. This causes it to line up with the nozzle of a steam pipe which blows a strong jet of steam directly into the shell, greatly agitating the liquid and causing every particle of dust, dirt, and chips to be effectively removed. The shell is then moved on to the next position, where a second jet of steam repeats the process. These two jets of steam not only clean the shell thoroughly inside, but they also agitate the entire mass of liquid and keep the temperature raised. One operator is used on this machine to load and unload the wheel, and the machine has washed as many as 2000 shells in a ten-hour day.

The shell washing machine shown in Figs. 3 and 4 is made on practically the same lines, with the exception that the motion instead of being continuous is intermittent. The ferris wheel has six positions, as in the other machine, but the machine must be tripped by the operator for every shell that is loaded, and the wheel revolves one-sixth revolution when the clutch is thrown out. The mechanism is tripped by the operator who presses a hand-lever that transmits power through the hollow shaft to a bellcrank at the back of the machine. The movement of the bellcrank is transmitted to a lever which throws the clutch into engagement, at the same time throwing the trip lever out of the path of the trip pin, of which there are six equally spaced around a disk which is integral with the main shaft and bears a fixed relation to the six arms of the ferris wheel. Aside from this one feature, this shell washing machine is essentially the same as the one previously described and takes shells up to twelve inches.

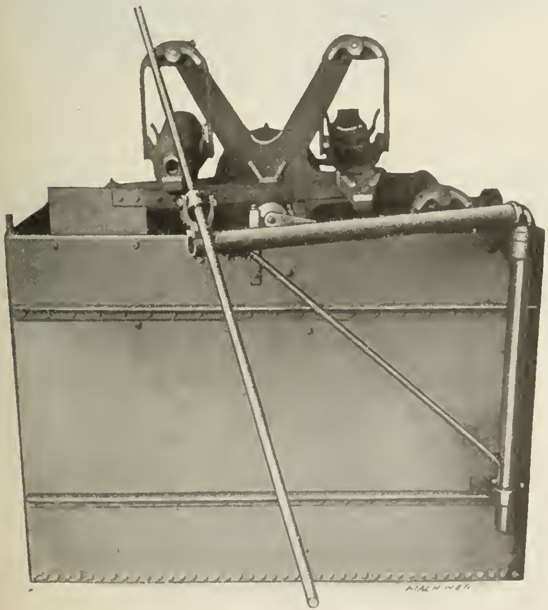


Fig. 3. Saylor Intermittent Shell Washing Machine for Twelve-inch Shells

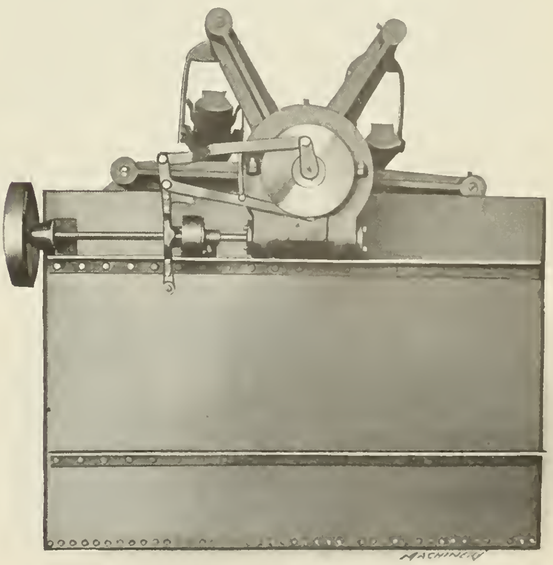
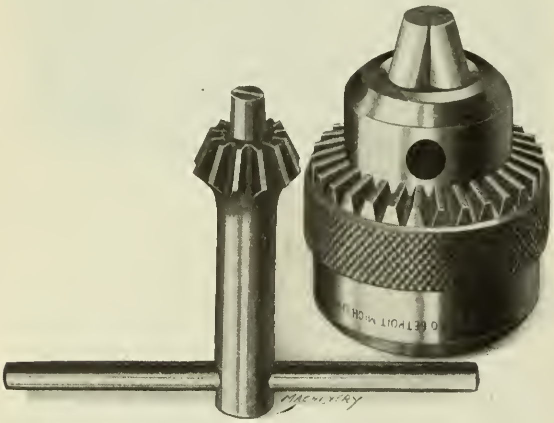


Fig. 4. Opposite Side of Saylor Shell Washing Machine shown in Fig. 3

PARKER DRILL CHUCK

To meet the requirements of high-speed drilling operations, the Parker Mfg. Co., 410 Kerr Bldg., Detroit, Mich., is now making a drill chuck that forms the subject of this description. Six sizes of this chuck are made for the requirements of general drilling operations, and six sizes for use on portable tools. The body is made of steel and extends nearly to the extreme diameter of the chuck, the purpose being to eliminate distortion under severe strains and to prevent the jaw hole or runway from breaking through the metal in the body. This permits the use of jaws of large diameter and affords a firm seat for the nut that controls the jaws in operation. If so desired, a hole can be drilled in the body to permit the use of a piece of drill rod for preventing rotation should the operator lose



Drill Chuck made by Parker Mfg. Co.

his pinion and wish to open or close the chuck by hand when in use on a portable drill or drill press. The pinion holes are equipped with hardened bushings so that the holes will not become elongated when the operator is adjusting the jaws to the required diameter.

The split nut is made of alloy steel, properly hardened and ground, and the shape of the thread is especially designed to withstand tremendous strain. By a special process of heat-treatment, the jaws are left hard on the gripping surface and threaded portion, while the metal is soft farther back to insure toughness and tensile strength; each jaw is ground all over to the correct diameter, insuring interchangeability. The ferrule is made of chrome-nickel steel and heat-treated to give the desired physical properties; the teeth are milled in such a way that when the teeth of the ferrule and pinion are in mesh the lines converge to a given point. The pinion is made of vanadium steel and is of large diameter, with the teeth cut to insure their meshing properly with the teeth on the ferrule.

SCOTT BORING-TOOL HOLDER

The G. H. Scott Machine Co., Cleveland, Ohio, has recently placed on the market a new boring-tool holder, which is illustrated and described herewith. The method of adjusting this

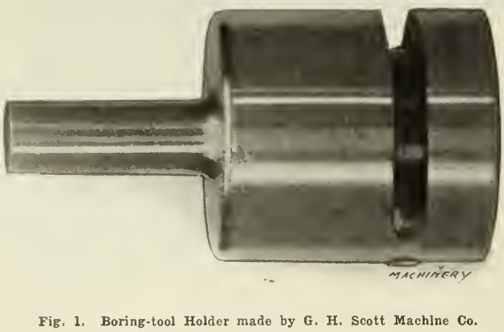


Fig. 1. Boring-tool Holder made by G. H. Scott Machine Co.

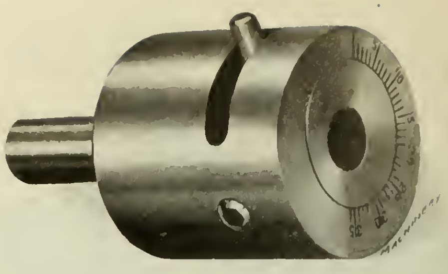
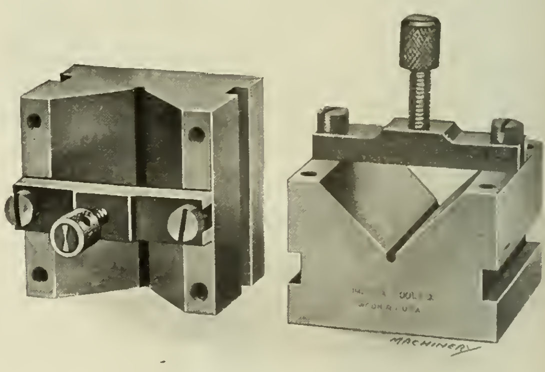


Fig. 2. Graduations on Scott Tool-holder that facilitate Setting

tool consists of offsetting both the inner and outer parts; it is possible to offset the tool up to ¼ inch by intervals of 0.001 inch. The graduations provided on the tool enable the mechanic to bore several duplicate holes without resetting his tool each time, by simply throwing the tool to the central position and then working back to the same graduation mark. The inner rotating part of the holder is made of hardened steel; the inserted tool is held in place with a safety set-screw, and the inner rotating center is securely held by another set-screw. The construction of this tool-holder insures absolute rigidity in all positions. It is furnished with a ½-inch straight shank to fit either the drill or milling machine chuck. It has a capacity for tool shanks up to 7/16 inch.

SIMPLEX V-BLOCKS

The Simplex Tool Co., Woonsocket, R. I., is now making the V-blocks illustrated and described herewith. These blocks are 2½ by 2½ by 1¾ inch in size, and are made of steel which is hardened, after which the blocks are ground on all the surfaces. Attention is called to the following features. The vee is



V-blocks made by Simplex Tool Co.

ground to a 90-degree angle and is in perfect alignment with the sides and base, at right angles to the ends, and central with the sides. The clamp is designed so that it will not interfere when the block is used on its side. Two grooves are provided in the sides for convenience in clamping, thus leaving the top clear for the work. These V-blocks are made in pairs to insure perfect alignment when used together, but they may be bought either singly or by the pair.

INTER-STATE LUBRICANT PUMPS

The Inter-State Machine Products Co., Inc., Rochester, N. Y., is now building two types of the "Sterling" circulating oil pump, which are illustrated in Figs. 1 and 2. It will be seen that these are of practically the same design except that one is provided with an automatic relief valve for controlling the maximum pressure, while the other is not. These pumps are of the geared type with which most mechanics are familiar, and are suitable for use on all classes of machine tools in which it is desired to deliver oil or cutting compound to the work. "Sterling" pumps are made to operate in one or both

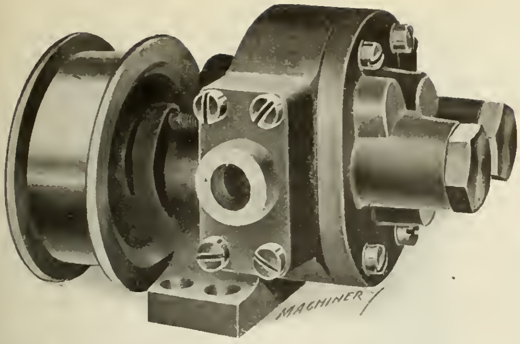


Fig. 1. Inter-State Machine Products Co.'s "Sterling" Lubricant Pump with Automatic Relief Valve

directions, and on the type provided with an automatic relief valve the operator can shut off the fluid at the point of discharge without creating pressure in the pump. It is not necessary to provide an auxiliary relief valve beneath the pump. The recommendation is made that the suction be provided with a strainer, and it is also an advantage to place the pump as near the level of the fluid as possible. The principal dimensions are as follows: diameter of inlet, 3/8 inch; diameter of outlet, 3/8 inch; size of driving pulley, 3 1/2 inches in diameter by 1 1/8 inch face width; capacity, 1 3/4 gallon at 300 R.P.M.; 2 1/4 gallons at 400 R.P.M., and 2 3/4 gallons at 500 R.P.M.; and weight of pump, 11 pounds.

"BELTOL"

E. R. Senn & Co., 405 Lexington Ave., New York City, are now manufacturing a compounded oil known as "Beltol." This oil is applied to leather belting for the purpose of bringing out those physical properties which will enable advantage to

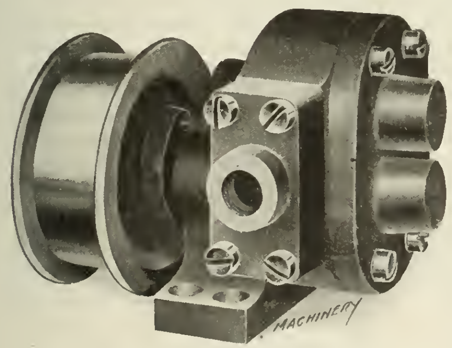


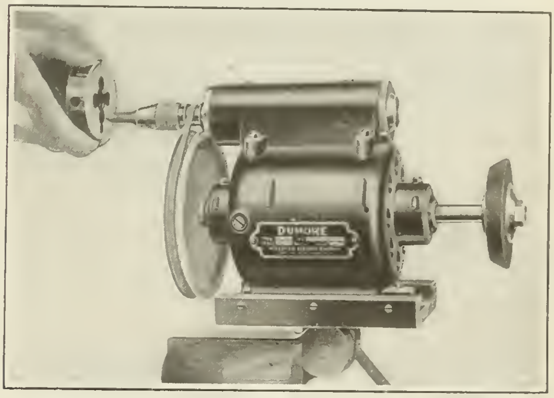
Fig. 2. Inter-State Machine Products Co.'s "Sterling" Lubricant Pump without Automatic Relief Valve

be taken of the maximum efficiency in power transmission. The oil is applied from a small container and is poured slowly onto the inside of the belt half way between the two pulleys while the belt is in motion. It is recommended that application of "Beltol" be made once every seven days, and the claim is made that this treatment will result in an increase of efficiency in power transmission ranging from 3 to 28 per cent, according to the original condition of the belting. "Beltol" was developed in 1899 by the French chemist M. Du Puis, and is being manufactured in England and France as well as in America.

HIGH-SPEED "DUMORE" GRINDER

In the April, 1914, number of MACHINERY, an illustrated description was published of the "Dumore" grinder made by the Wisconsin Electric Co., 1402 Dumore Bldg., Racine, Wis. This machine was designed for operation at 30,000 revolutions per minute. To meet the requirements of shops turning out large quantities of automatic screw machine products, where difficulty has been experienced in keeping button dies in condition for operation at maximum efficiency, a grinder known as a "high-speed equipment C" has recently been placed on the market by the same company. The motor is of the same design as that on the regular "Dumore" grinder, but to adapt this machine for the use of a 3/4-inch round carborundum "pencil" and obtain an efficient cutting speed, the machine has been designed for operation at the unusually high speed of 50,000 revolutions per minute.

In order to employ this high speed, it was necessary to make changes in the design of the internal spindle, which is made shorter and more rigid than the spindle of the standard machine; also a specially balanced chuck has been made. In place of the regular driving pulley, a large pulley is cast and this pulley is carefully balanced; power can then be transmitted from the large pulley to a small pulley on the internal spindle to give the required speed. In addition to the usual

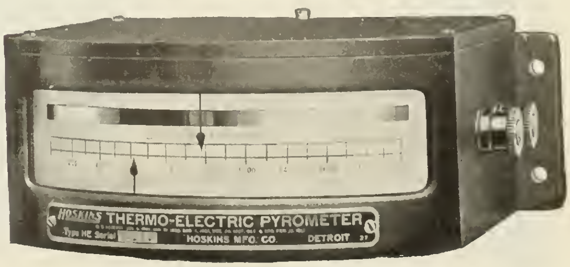


"Dumore" Grinder made by Wisconsin Electric Co. for Operation at 50,000 R. P. M.

grinding of button dies, some shops are using the machine to grind a chamfer on the front of the dies in order to break the chips whichever way is most convenient on the class of work that is being handled, *i. e.*, the man who dresses the tools grinds this chamfer to break up the chips or take off a long, continuous shaving as required.

HOSKINS HIGH-RESISTANCE PYROMETER

The utility of any equipment is fixed by the utility of the various units of which it is composed. Thus the worth of a pyrometric equipment depends upon the accuracy and durability of the instrument itself, and upon the desirable properties of the thermo-couples. The one is worth nothing without the other, and the dependency of the instrument is defined exactly by that of the thermo-couple which supplies the operating millivoltage. Inasmuch as it is the thermo-couple, rather than the instrument, that requires renewal, the couples should all have the same properties if they are to be used with a given instrument; that is, they must all generate the same millivoltage under identical conditions, and this millivoltage must not change while the couple is in service. If they do not possess uniform properties, it becomes necessary to calibrate them to fit a given instrument. If the pyrometer itself is of low resistance, it is obvious that the variation of the resistance



Hoskins High-resistance Pyrometer

of the couple is an important consideration. On the other hand, if the instrument is of high resistance, a variation in the resistance of the couple becomes negligible.

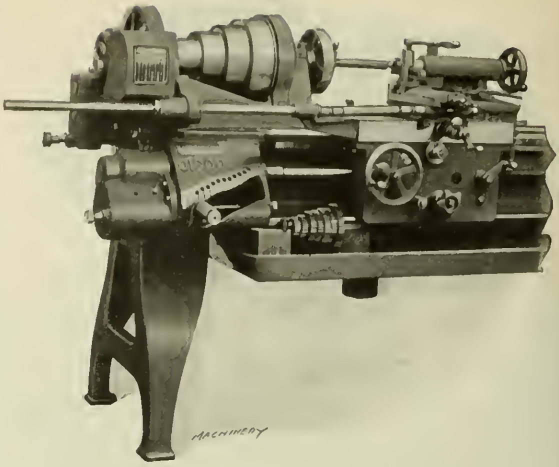
The Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich., has developed a new high-resistance pyrometer, together with a special thermo-couple which has one important advantage. The couple requires absolutely no calibration, so that it is possible for the user of this equipment to purchase material for making the elements, in coils, by the pound. When in need of a new thermo-couple, it can be made merely by cutting off suitable lengths of wire and twisting and welding the ends together. No calibration is necessary because of the uniform properties of the wire. The user is thus assured of continuous service from his pyrometric equipment, because of the elimination of delays caused by calibration of new couples. The elements forming this thermo-couple are special chromium and nickel alloys known by the trade name of "194-343." They generate high millivoltage and are said to be long-lived because of their immunity to the action of hot gases.

The illustration shows the instrument to be of the so-called "horizontal edgewise" type; it is said to be more accurate than the vertical type because the balance errors of the needle are practically eliminated. The advantages claimed for high-resistance meters are well known, the principal one being that long couple extension leads may be used, since a change in their resistance caused by outside temperature variations is of no consequence. These meters are made in six ranges, the upper temperatures being 800, 1100, 1400, 1500, 2000 and 2500 degrees F., and it is possible to use thermo-couple "194-343" on all the instruments having any of the three last-named temperature limits.

"CISCO" RELIEVING ATTACHMENT

The Cincinnati Iron & Steel Co., Cincinnati, Ohio, has recently added to its line the "Cisco" relieving attachment for use on lathes of its manufacture. It is claimed that while this attachment is simple and easily operated, it is thoroughly efficient. The drive is taken from a gear on the outside end of the spindle, which replaces the spindle bushing and necessitates no change in the spindle construction. This gear is engaged by an idler which, in turn, drives the change-gears on the swinging quadrant; only six change-gears are required to obtain the correct changes for relieving cutters with the following numbers of flutes: 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16 and 20.

The quadrant swings on a gear-box which is bolted to the front of the headstock and contains the gears for driving the sliding shaft. The shaft is journaled in a bracket on the carriage, so that it does not limit the travel of the cross-slide when relieving. The drive from this shaft to the cam-shaft is through universal joints and a shaft and sleeve, which compensate for slide and swivel adjustments. The swivel can be turned to an angle of 30 degrees, and all bottom slide and top slide adjustments can be made in connection with the relieving attachment in exactly the same way as in the regular lathe. Relieving can also be done in connection with the taper attachment.

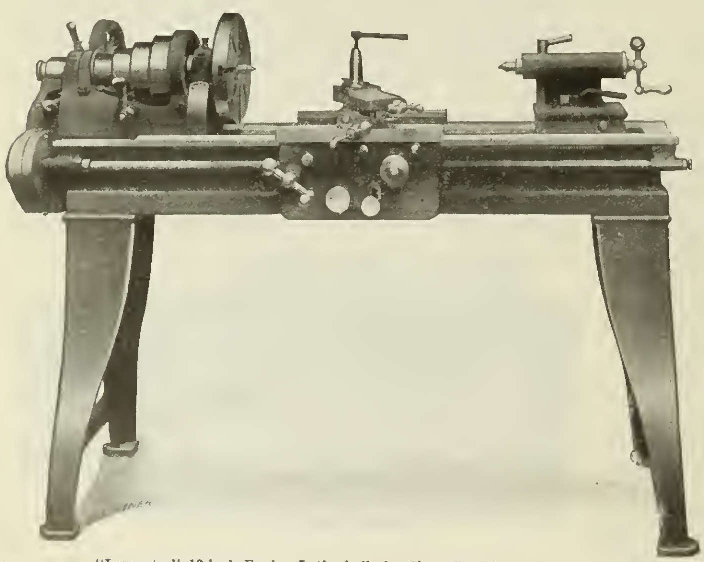


"Cisco" Lathe equipped with New Relieving Attachment

The cam-shaft is readily removed for changing cams, two of which are furnished with each attachment; these are single and double impulse. The cam operates against a hardened steel roller held in a hardened steel slide, which is connected to the top slide screw, and has a spring rod with two adjusting nuts governing the amount of throw or relief, or it can be made to hold the slide and roller away from the cam when the compound rest is required for regular work. The change-gears are well guarded and an index-plate is furnished, which shows the correct gear arrangements. This relieving attachment can either be fitted to new lathes in course of construction or it can be shipped for attachment on lathes originally bought without means of relieving cutters.

CHAMPION ENGINE LATHE

A recent product of the Champion Blower & Forge Co., Lancaster, Pa., is a machine known as the "Lancaster" 13-inch engine lathe, which forms the subject of the following description. It will be seen that this lathe is equipped with a four-step cone pulley, back-gears, positive geared feed, automatic longitudinal feed and power cross-feed, a compound rest, and a screw chasing dial. All parts of the lathe are manufactured with jigs and fixtures so that they are interchangeable. The lead-screw is made of high-carbon steel of special analysis to give the desired durability. All sliding surfaces are carefully scraped, and the spindle and other cylindrical parts are ground to obtain the desired accuracy. Three changes of feed are obtained by simply moving the handle to one of three stations, and the gears are easily changed for cutting threads of different pitch, the range for thread cutting being from 4 to 40 per inch, either right- or left-hand, and including the 11½ per inch pipe thread. By compounding gears, many other threads may be cut.



"Lancaster" 13-inch Engine Lathe built by Champion Blower & Forge Co.

To adapt this lathe for heavy work, the bed is cross-ribbed with box section braces cast at intervals over its entire length. There are three vees and one flat bar for the slot guides of the headstock and tailstock. The rack is made from a solid steel bar. A bearing 15¼

inches in length is provided for the headstock on the bed; and the spindle, which is made of 60-point carbon crucible steel, has a 3/4-inch hole for its entire length. The front spindle bearing is 1 3/4 inch in diameter by 3 1/4 inches long, and the spindle is bored No. 3 Morse taper. Phosphor-bronze bushings are provided in the spindle bearings, and these are carefully scraped to fit the spindle. The tailstock is offset to allow the compound rest to swing parallel with the bed. A safety device is provided on the apron which prevents throwing in the half-nuts when either feed is connected.

The principal dimensions of this lathe are as follows: swing over shears, 13 1/2 inches; swing over compound rest, 8 inches; swing over carriage, 9 inches; maximum distance between centers for 5-foot bed, 30 inches; size of front spindle bearing, 1 3/4 inch diameter by 3 1/4 inches long; size of rear spindle bearing, 1 1/2 inch diameter by 2 3/8 inches long; taper of centers, No. 3 Morse; size of cone pulley steps, 7, 5 3/4, 4 1/2 and 3 1/4 inches in diameter by 2 inches face width; ratio of back-gears, 8 1/2 to 1; number of spindle speeds, 16; maximum travel of tailstock, 5 inches; maximum travel of compound rest, 4 inches; size of tools used, 1/2 by 1 1/8 inch; and weight of machine with 5-foot bed, 1000 pounds. The regular equipment furnished with this lathe includes a plain or compound rest, follow-rest and steadyrests, change-gears, large and small faceplates, double friction countershaft, and the necessary wrenches for making all adjustments.

GARDNER HEAVY-DUTY DOUBLE GRINDER

The Gardner Machine Co., Beloit, Wis., has recently developed and added to its line of disk and ring wheel grinders, a new double-spindle grinding machine. Prior to the time of bringing out this new No. 15 grinder, the largest of this type on the market had a capacity for 18-inch ring wheels or 20-inch disk wheels. The machine here described carries 20-inch ring wheels or 24-inch disk wheels, both of which types of grinding members are interchangeable. All disk grinding is done dry, but the machine is equipped with a complete water system so that wet grinding may be done when ring wheels are used. A covered opening in the rear of the machine, shown in Fig. 1 directly behind the sliding work-table, is provided for attaching a dust exhaust system. The spindles are 3 inches in diameter by 37 3/4 inches long. They are accurately ground to size and mounted in removable bronze bushings lined with high quality babbitt, bored, reamed and scraped to a close running fit. Each bearing is 10 inches long. Hardened and ground collars 6 inches in diameter by 1 inch thick are placed on the outer end of the spindles. The fully machined cast-iron spindle pulleys are 12 inches diameter by 8 1/2 inches face width.

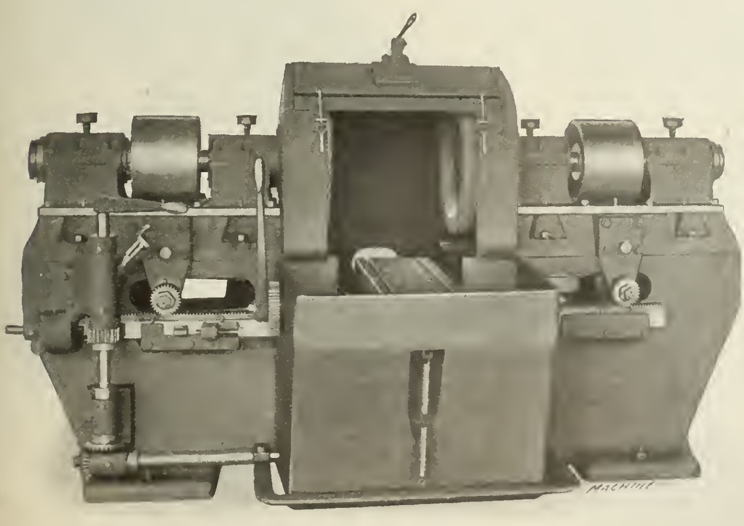


Fig. 1. Front View of Gardner No. 15 Disk and Ring Wheel Grinder

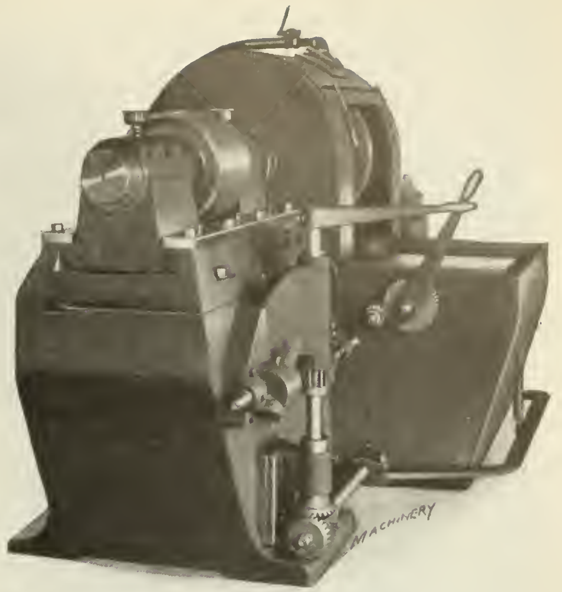


Fig. 2. End View, showing Arrangement of Spindle Head and Sub-base

Fig. 1 shows a front view of the machine. Each spindle is mounted in a sliding head, which, in turn, moves in a sub-base, the latter being firmly bolted in the desired position on the machine base. This construction is shown quite plainly in Fig. 2. The cast-iron hood ends are fastened to the sub-base and move only when the latter are adjusted for position. The sliding heads work through a felt-lined hole in the hoods and have a combined lateral travel in the sub-base of 3 1/2 inches, which is more than would be required in actual practice. As shown in Fig. 1, the sub-bases are set for grinding opposite sides of very wide pieces; but, if it were desired to grind parallel sides, the sub-bases would be moved toward the center and bolted down. A wrench placed on the two pinions appearing beneath each pulley makes this adjustment an easy matter. It will be seen that with this hood construction the ways for the sliding heads are always protected against grit and dirt.

The sliding work-table in the center of the machine is shown in Fig. 1. The fixture holding the piece of work to be finished is mounted on this table, and the whole is moved in and out between the grinding wheels by means of a hand-lever, pinions and rack attached to the under side of the table. The lever and gears are shown more distinctly in Fig. 2. As shown here, the large gear is the driver, but these two gears can be reversed when a slower and more powerful stroke is required. The shafts carrying the gears are extended across and underneath the sliding table through the other side, so that if desired the same gears and lever can be mounted on the right-hand side of the water basin. The entire base of the machine is cored out with solid bottom and connected to the water basin in front, giving a capacity of approximately seventy gallons of water or grinding compound.

Fig. 3 is a close view of the left-hand end of the machine, showing the feed mechanism, micrometer stop-screw and adjustable back-stop. A 3-inch square steel bar, carrying a rack on the top, is supported in ways at each end and extends practically across the entire front of the machine. At the left-hand end of this bar is attached in front a short rack which engages with a pinion on the hand-lever shaft. By pulling the

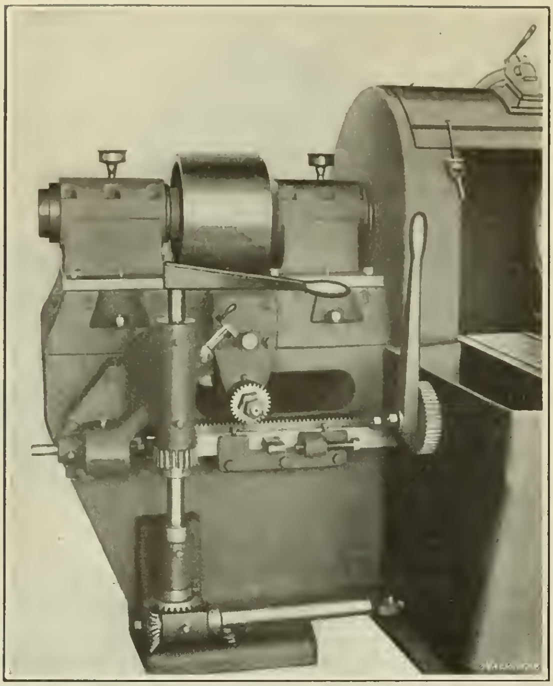


Fig. 3. Close View of Feed Mechanism, Micrometer Stop-screw and Adjustable Back-stop

horizontal hand-lever to the right the long feed-bar moves to the left, which action causes the two feed-gears to turn in the opposite direction. These gear shafts carry bevel pinions which engage with a gear on the bottom of the vertical shafts mounted in the sub-bases. At the top of these vertical shafts, pinions are attached which mesh with racks fastened to the under side of the sliding heads. The rack on the left-hand head is fastened on the front side of the head center line, and on the right head the rack is attached back of the center. This relation causes the heads to move in opposite directions, or toward and away from each other. By means of bevel gears the hand-lever is connected to the foot-treadle. A coil spring attached to the foot-treadle forces the heads back when the pressure is removed.

A micrometer stop-screw is located at the extreme left in line with the feed-bar. As previously explained, the sliding heads move toward the center of the machine, the feed-bar moves to the left and butts against the micrometer screw. A worm nut adjusts this hardened screw and is acted upon by a worm on the inclined shaft which terminates directly behind the hand-lever with a small graduated handwheel. The back-stop screw is located a little farther to the right and forms a part of the feed-bar gib. A hardened block is attached to the feed-bar and comes in contact with the hardened back-stop screw, thereby limiting the backward travel of the sliding heads. It should be mentioned that suitable covers are regularly provided for all gears and racks, but are removed in the illustrations in order that the construction may be more plainly seen.

It will be seen from the preceding description that both heads move simultaneously toward the center, but if desired either may be locked in position and only one moved. The greatest opening between the disk wheels is 24 inches, and between the ring wheels, 20 inches. The over-all dimensions of this machine are 95 inches long by 51 inches wide. Its weight, exclusive of any grinding wheels, wheel press or countershaft, is 5000 pounds.

IMPROVED DRAFTING-BOARD

It is generally known that the draftsman's work subjects him to considerable physical strain, and this is particularly true when he is working on large drawings. Men of different stature naturally need drafting-boards set in different positions if they are to work in the most comfortable posture. With the view of enabling advantage to be taken of this condition, the Improved Drafting Board Co., Nashua, N. H., has recently developed what is known as the "Universal" drafting-board, which is designed to suit the tastes and requirements of all draftsmen, whether users of the horizontal or upright boards. This new drafting-board may be used in either a horizontal or upright position with equal effectiveness, and it may be set at intermediate angles between these positions.

Three advantages are claimed for the "Universal" drafting-board when used in a horizontal position: First, the board is generally inclined a few degrees from the true horizontal, but the angle of inclination may be quickly increased or diminished to meet requirements. This enables the draftsman to bring the upper edge of the board nearer his eyes when necessary, instead of forcing him to stretch over the board and strain both his body and eyes. Second, the same board can be used by both short and tall men, either sitting or standing, since the height can be easily adjusted to suit men of different stature and draftsmen who work in various postures. Third, when set to the required angle and height, the drafting-board is held absolutely stationary.

Used in a vertical position, this drafting-board will be found useful by those who are finding in this position a way to more efficient and hygienic work. When used upright, the board is generally inclined a few degrees from the vertical, but this inclination can be adjusted according to the requirements of different users. Attention is called to the fact that the convenience of the "Universal" drafting-board in this position lies in the fact that the draftsman can raise or lower the board by applying a slight pressure of the hand, and the value of this feature is not likely to be overestimated. Draftsmen using an upright board are frequently required to bring different sections of the board opposite the eye, and if the making of such changes requires considerable physical effort, this not only leads to unnecessary fatigue, but interruptions are likely to cause important details to be overlooked in working out designs. Using the board in a vertical position, draftsmen may either sit or stand, and the board may be instantly set so that it is stationary in any required position.

Both the horizontal and vertical positions are frequently used, but, as its name implies, the "Universal" drafting-board can also be set to any other position between the horizontal and vertical. The board is provided with an automatic parallel rule which is capable of being set to any angle with the horizontal, and so attached to the board that there is no inter-

"Universal" Drawing-board made by Improved Drafting Board Co.

ference with the length of drawings. The lower part of the frame is designed to form a foot-rest, and wooden blocks covered with felt prevent scratching the floor. Directly beneath the board there is a cabinet fitted with compartments for storing instruments and other drawing equipment. The board may be furnished with or without the cabinet, and with or without the Improved Drafting Board Co.'s standard reference table. The metal frame is enameled white and finished with nickel-plated fixtures, while the board is made of narrow strips of kiln-dried pine. The standard board takes drawings up to 28 by 40 inches in size, while larger drawings may be attached to the back of the board and rolled over the edge.

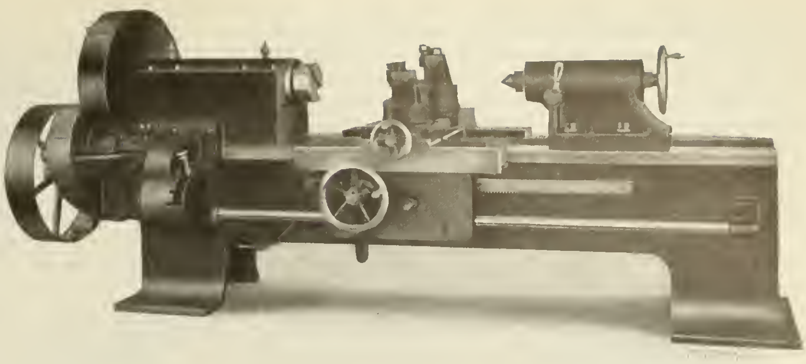


Fig. 3. Pottstown 24-inch Lathe for machining Shells from 9 to 12 Inches

POTTSTOWN LATHES

The machine illustrated in Fig. 1 is fundamentally a single-purpose lathe, being designed for the rapid machining of 3-inch shells. It is constructed along simple lines, with the primary idea of removing metal at the maximum rate. As there is no necessity for a cross-feed, the carriage only has longitudinal power feed. There is a choice of three feeds, *i. e.*, 1/64, 1/32 and 1/16 inch per revolution. The feed is changed by a handle on the simply constructed gear-box, which is placed conveniently in front of the lathe to the left of the operator.

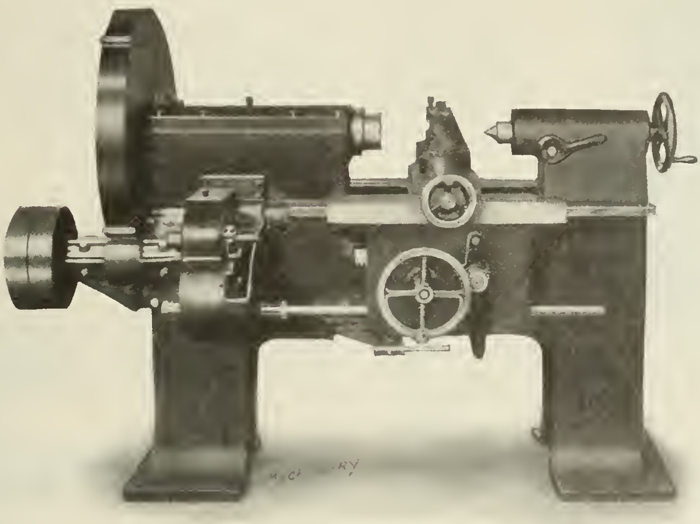


Fig. 1. Lathe for machining 3-inch Shells, built by Pottstown Machine Co.

Power is transmitted from a motor to a single pulley, attached to the end of the shaft shown on the front of the lathe; this is a high-speed shaft, which runs in bronze bearings and is supported by the bracket attached to the front of the frame. This driving shaft carries a 4-inch pinion which engages with the 28-inch master gear on the main spindle, affording a positive drive. The driving pulley is 12 inches in diameter by 5 inches wide. The diameter of the main spindle is 3 15/16 inches, and it runs in scraped babbitt bearings of liberal proportions. The headstock as well as the tailstock are cast integral with the lathe bed, thereby affording the greatest possible rigidity.

The diameter of the tail-spindle is 2 15/16 inches, and it is provided with a No. 4 Morse taper. The distance between centers is 14 inches maximum, this being sufficient provision for 3-inch shells. The carriage is provided with two toolposts and an automatic trip for the feed. The lever which throws the feed into engagement has an extension that contacts with an adjustable rod held by a bracket fast to the bed of the lathe. By setting this rod at the correct position, the carriage may be stopped automatically wherever desired.

The general lines of the 17-inch lathe, illustrated in Fig. 2, are similar to the one just described, and it was designed primarily for the making of 6-inch shells. Unlike the 3-inch lathe, this machine has a separately attached tailstock that may be adjusted in the ordinary way. The general dimensions are as follows: diameter of spindle, 4 7/16 inches; distance between spindle head and tailstock, 30 inches, maximum; diameter of tail-spindle, 2 15/16 inches; size of driving pulley, 20 inches diameter and 6 inches face width; ratio of pulley speed to spindle speed, 7 to 1; diameter of spindle gear, 28 inches; and swing over bed, 17 inches. The carriage is provided with two toolposts, and there are three variations of feed, namely, 1/64, 1/32 and 1/16 inch per revolution.

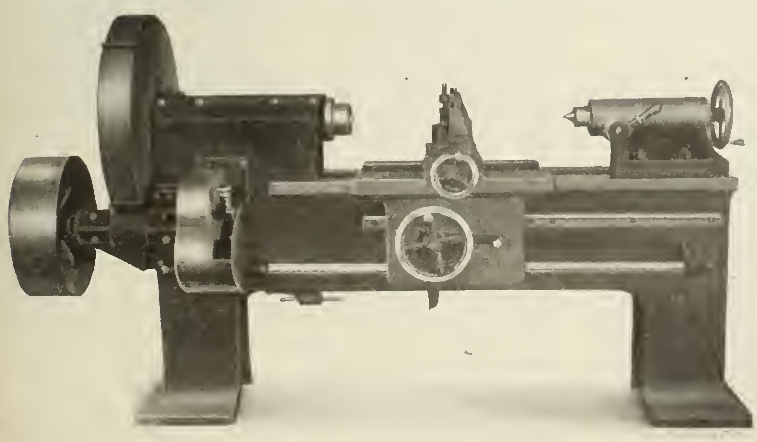


Fig 2. Pottstown 17-inch Lathe for machining 6-inch Shells

The 24-inch lathe, shown in Fig. 3, was designed primarily for machining

shells from 9 to 12 inches, and it is not only adaptable for large shell work, but is also well suited for turning rough forgings. This lathe is ordinarily 10 feet long over-all, but it may be had in any length up to 20 feet. The general dimensions are as follows: diameter of spindle, 6 inches; distance between spindle head and tailstock, 4 feet, 9 inches, maximum; size of driving pulley 28 inches diameter and 6 inches face width; pulley ratio to spindle, 16.6 to 1; diameter of spindle gear, 28 inches; swing over bed, 24 inches; and diameter of tail-spindle, 3 15/16 inches. The carriage is equipped with two toolposts, and the lathe is provided with a range of three feeds, *viz.*, 1/32, 1/16 and 1/8 inch per revolution. The length of the carriage on the ways is 36 inches and the width of the cross brace on the carriage is 12 inches. All of these lathes, which are built by the Pottstown Machine Co., Pottstown, Pa., have no provision for change of spindle speed within themselves, although various speeds are obtainable from a variable-speed motor with which they are equipped.

M. E. C. THREE-JAW AIR CHUCK

The Manufacturers Equipment Co., 175-179 N. Jefferson St., Chicago, Ill., has recently added to its line a three-jaw air-operated chuck intended for handling light, medium and heavy work. With the view of furnishing ample strength, all parts of the chuck are made of steel, and reference to Fig. 3 will show that the mechanism consists of a combination of gears, racks and levers, the design being worked out in such a way that large contact surfaces and high leverage ratios are provided for handling heavy work. Provision of high leverage ratios also permits using a smaller air cylinder than would otherwise be possible, and for exceptionally heavy work a larger cylinder can be provided to afford the necessary grip.

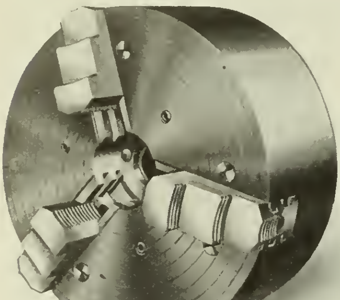


Fig. 1. M. E. C. Three-jaw Air-operated Chuck

This three-jaw air-operated chuck may be used in place of manually operated chucks for work handled in small quantities, and where manufacturing operations are being performed on large quantities of work of the same kind, the rapidity of operation is the means of making a material saving in the cost of production. These chucks are furnished with regular step jaws or with jaws for use in connection with "false" jaws for chucking pieces of irregular shape. The claim is made that these air-operated chucks are the means of increasing production from 25 to 75 per cent. The way in which this saving is effected will be readily understood when it is

Fig. 2. M. E. C. Three-jaw Air-operated Chuck in Use on Lathe

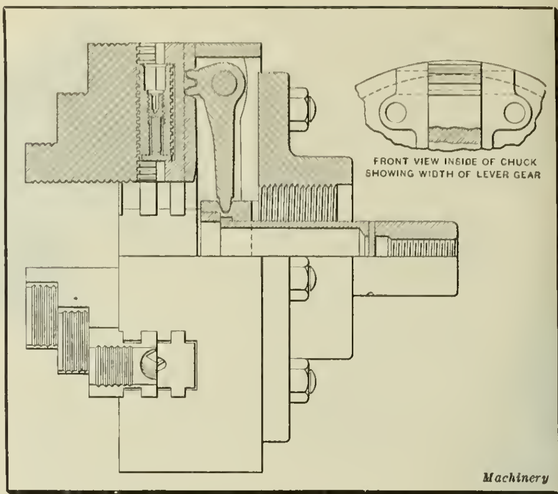
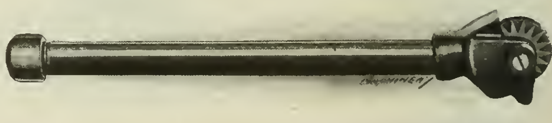


Fig. 3. Mechanism of M. E. C. Air-operated Three-jaw Chuck

realized that a large proportion of medium-sized work can be chucked and released without stopping the machine spindle; this fact, together with the ease of operation, which merely requires the moving of a valve handle, enables the operator to pay more attention to the maintenance of a high rate of production than would otherwise be the case. M. E. C. three-jaw air-operated chucks are regularly made in 8-, 10-, 12-, 15- and 18-inch sizes, while larger chucks will be made to special order.

HETHERINGTON-McCABE GRINDING WHEEL DRESSER

A tool known as the "Brandenburg" self-lubricating grinding wheel dresser is now being manufactured by the Hetherington-McCabe Co., Piqua, Ohio. In working out the design, particular care has been paid to developing a construction that makes it practically impossible to wear out the bearings. This result is obtained by the combination of a hardened steel spindle and a cast-iron bearing lubricated with flake



"Brandenburg" Grinding Wheel Dresser made by Hetherington-McCabe Co.

graphite. The particular claim made for the graphite is that it does not tend to catch emery dust and hold it in the bearings. Not only does the graphite prevent trouble from holding abrasive which would rapidly destroy the bearing, but it also fills the pores of the cast iron and provides a bearing surface that is not affected by heat and that is practically frictionless. The cutters start to spin almost immediately when placed in contact with the wheel, so that they perform their function of dressing and truing the wheel instantly without grinding off the points of the cutter. It is claimed that this dresser will never become hot and will never draw the temper of the cutters. A safety hood provided over the cutters prevents sparks or abrasive from flying into the workman's eyes, and the chamber or hollow handle is filled with flake graphite, a sufficient supply being carried to last for several months.

This tool is always ready for use without requiring attention, and a feature of the graphite lubrication, in addition to eliminating the tendency that oil has to hold abrasive in the bearings, is that no oil can be thrown on the grinding wheel and cause it to glaze. Graphite is fed to the bearings by gravity and vibration. This dresser uses standard cutters, 1⅛ inch in diameter, as well as a larger cutter 1⅝ inch in diameter with a ⅜-inch hole, which are said to give increased service on wheels down to 6 inches in diameter by ½ inch face width, although, possibly, greater accuracy can be secured

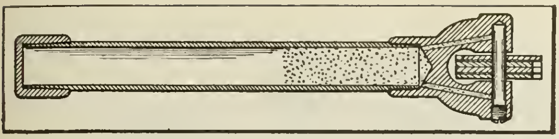


Fig. 2. Sectional View of "Brandenburg" Grinding Wheel Dresser, showing Provision for Lubrication

with the standard cutters of 1⅛-inch diameter. From the preceding statement it will be apparent that the two sizes of cutters are interchangeable in the "Brandenburg" holder.

OLIVER SAWING, FILING AND LAPPING MACHINE

In the December, 1915, number of MACHINERY a description was published of a bench type of combination sawing, filing and lapping machine which had just been placed on the market at that time by the Oliver Instrument Co., 1168 Cass Ave., Detroit, Mich. Recently this firm has brought out a floor type of machine, the upper part of which is of similar design to the bench type formerly manufactured. This machine is intended for the heaviest classes of work in making dies, gages, templets, and similar parts, in addition to which it may be employed in certain classes of manufacturing.

All moving parts are enclosed and run in a bath of oil, and all bearings are carefully protected from dirt and dust; the reciprocating parts are balanced so that the action of the machine is quite smooth. The table is 12 inches square and tilts to any angle up to 10 degrees either way from the center. This table is fitted with a slide which has a travel of 5 inches and is operated by a screw; the slide is 4 inches wide and has three rows of tapped holes, by means of which the piece being operated upon can be solidly clamped and fed to the saw or file. Various fixtures are provided for holding the work.

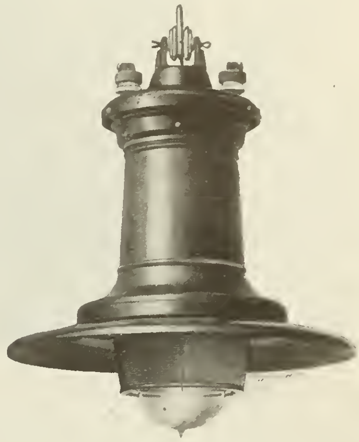
Oliver Sawing, Filing and Lapping Machine with Pedestal Base

An over-arm is used for sawing, and the depth of throat is sufficient to provide for working to the center of a 19-inch circle. Saws of various widths can be used, and the irregular outline of a die may be followed closely, leaving a minimum amount of metal to be removed by the filing operation. As illustrated, the machine is equipped with motor drive, and it will be seen that the motor is attached to the pedestal and belted to a jack-shaft at the base, a three-step cone pulley allowing various speeds to be obtained for working different materials. Tight and loose pulleys can also be provided for belt drives, and the shifter extended through the pedestal and actuated by a treadle at the base of the machine. Doors in the pedestal open out against stops and have pockets on the back to hold fixtures and tools.

G. E. LIGHTING FIXTURE

In one of the suburbs of Buffalo, there has recently been installed a new type of ornamental street lighting unit, which is both efficient and economical. This type is equally suitable for lighting large open spaces, such as docks, lumber and railroad yards, platforms at railroad and interurban street railway stations, and streets and open places in industrial plants. In the old type of lighting unit, a large proportion of the rays are thrown upward and lost, while those of the new unit are all directed at a downward angle to the surfaces where illumination is needed.

An artistic fixture contains a prismatic refractor used to collect the upward rays of the 100 candlepower Mazda C lamp used in this case, and directs the light outward at a slight downward angle. This saves and applies to a useful purpose the light which is thrown upward and wasted with the average installation. The candlepower of the light with this unit may vary, but the Mazda C lamp should be used without exception. This unit is the latest addition to the line of out-of-door lighting fixtures made by General Electric Co., Schenectady, N. Y.



G. E. Ornamental "Refractor" Lighting Fixture

AMERICAN AMMUNITION CO.'S THREAD MILLER

For performing internal and external thread milling operations in munition factories, the American Ammunition Co., Inc., Bordentown, N. J., has recently developed a semi-automatic machine that is used in connection with either hand- or power-feed milling machines. While especially developed for the class of work referred to, this thread miller is also adapted for cutting threads in many other classes of work.

The spindle is fitted with a collet that has a capacity of 1¾ inch on pieces not more than 4 inches long, and 1 inch clear through the spindle. It is adapted for either inside or outside milling, and by changing the lead-nut and screw provision can be made to cut any pitch up to ½ inch, either right or left hand. It is used with a multiple-tooth straight, relieved cutter, and finishes the work at one revolution. Where a final finishing cut is required, by changing one screw the machine will automatically make two revolutions, one for roughing and the other for finishing. The spindle, gears and lead-screws are casehardened, and the nut is made of bronze, with provision for taking up wear. It will fit any hand- or power-feed milling machine, and where a greater angle is being

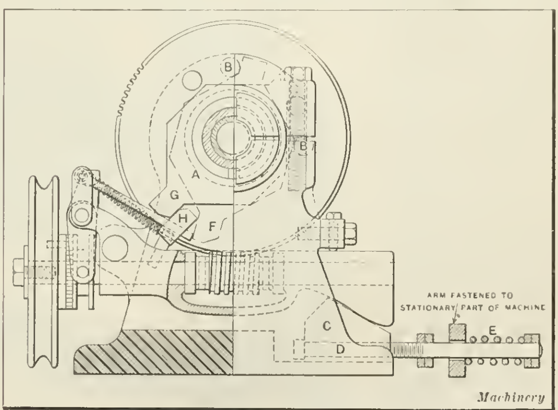


Fig. 1. Mechanism of American Ammunition Co.'s Thread Miller, showing Principle of Semi-automatic Operation

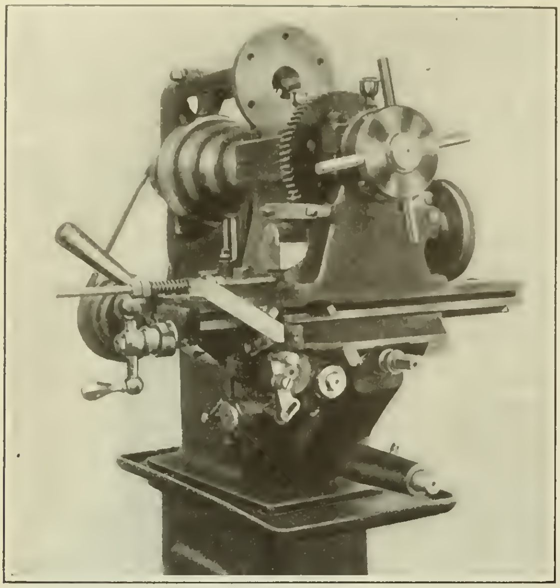


Fig. 2. American Ammunition Co.'s Thread Miller for Internal and External Threads

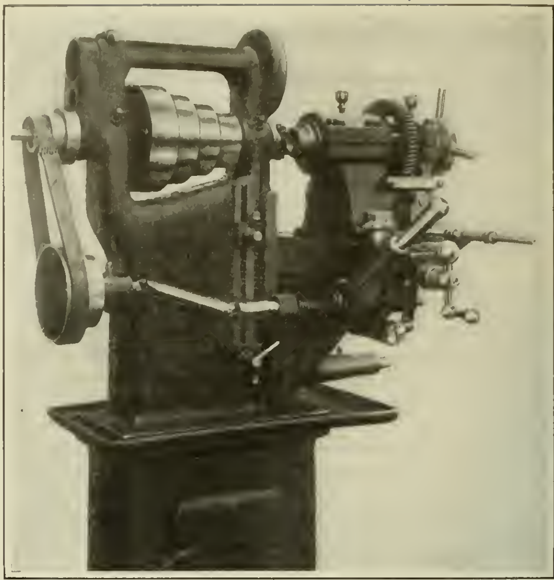


Fig. 3. Side View of American Ammunition Co.'s Thread Miller set up on Hand Milling Machine

cut than can be taken care of with the clearance of the cutter, this milling attachment can be raised or lowered so that the cutter will be directly underneath or on top of the work, when the attachment can be set at the proper angle to clear the threads.

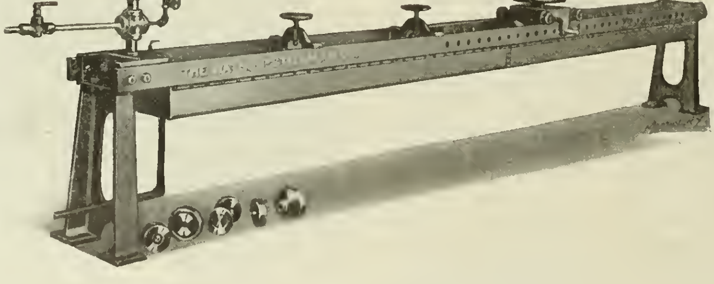
A stop-plate *A*, Fig. 1, revolves loosely on the gear hub and is stopped by the two pins *B* giving a total of about 1 1/10 revolution to the spindle. The worm is brought into contact with the worm-wheel by wedge *C*, which is attached to a stationary part of the frame or knee of the milling machine, so that a forward motion of the table with the milling attachment automatically raises the worm into contact with the gear and starts the machine, while a withdrawal of the work reverses this motion and releases the worm. Rod *D* passes through a hole in the arm, being regulated in its motion by two pairs of lock-nuts. Behind the lock-nuts for raising the arm is a spiral spring to bring the arm into full contact and start the work revolving before the cutter is in contact, additional forward motion of the table to the full depth being possible by the compression of spring *E*. The feed pulley is driven by a round belt from the countershaft and operates continuously.

With the table run back, the piece to be threaded is placed in the collet, and the collet is closed by a pilot wheel; this motion revolves the spindle until the loose stop-plate *A* comes against the stop *H*. The table is then run forward by a lever or screw, which automatically brings the worm into mesh and starts the work revolving, the motion beginning just before the cutter comes into contact with the work. It begins revolving and runs continuously until the loose stop-piece comes into position *F*, which throws out the clutch and leaves the machine standing. On bringing the table back, the worm drops and releases the wheel, when the collet may be opened by means of the handwheel, allowing the threaded work to be taken out and another piece substituted in the collet; the screwing up of the collet again brings the wheel to the starting point *G*. The machine is automatic in its operation, the only hand operations being the backward and forward movement of the table, and the opening and closing of the collet. For internal work it is also necessary to move the cross-slide of the machine.

WATSON-STILLMAN BOILER TUBE TESTING MACHINE

The Watson-Stillman Co., 192 Fulton St., New York City, has added to its line of hydraulic machinery a new testing machine for subjecting boiler and other tubing to internal hydrostatic pressure. This machine is designed to be used either with a hand- or power-driven pump, so that it is adaptable either for use in shops doing only occasional testing or for large capacity. The machine consists of a frame with two rectangular tie-bars, at one end of which is a stationary abutment; and at the other end there is a moving abutment in the form of a carriage mounted on rollers, which can be adjusted to the length of the tubes to be tested and secured to the side frames by pins; and a high-pressure hydraulic pump to subject the tubes to a predetermined internal hydraulic pressure.

The tube to be tested is placed in the machine with one end against the fixed abutment; the moving abutment is then brought to bear against the other end of the tube pinned to the frame, and the tube is made pressure-tight by turning the handwheel. Two intermediate clamps operated by small handwheels prevent the tube from buckling while under pressure. The tube is then filled from a water main, overhead tank or by the low-pressure pump. After the tube is filled, a high-pressure hand or power pump is used to raise the pressure to the desired test, as shown on the gage.



Boiler Tube Testing Machine built by Watson-Stillman Co.

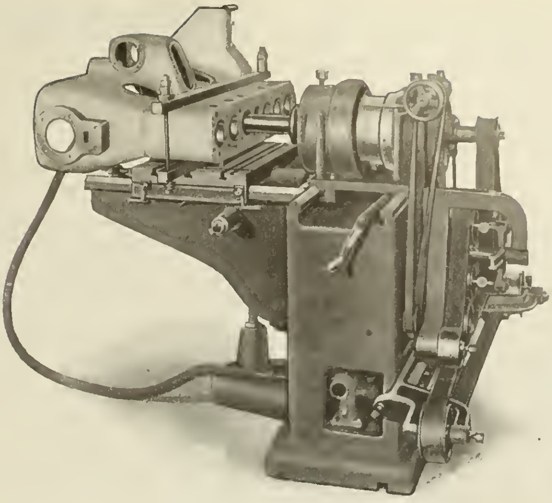
There is a pan under the bed of the machine to catch the waste water, which

serves also as a reservoir if a pump is used for the initial filling. The machine illustrated is designed to test boiler tubes up to 4½ inches outside diameter to a pressure of 1200 pounds per square inch. The minimum opening is 5 feet and the maximum opening 15 feet, and the weight of the machine is 2000 pounds. Other sizes of the same general design can be built to meet special requirements.

OLSON CYLINDER GRINDING MACHINE

The Olson cylinder grinding machine which forms the subject of the following description is manufactured by the T. C. Olson Machine Co., Madison, Wis., and the E. A. Fuller Sales Co. of the same city is the sales agent. This machine was first developed by T. C. Olson, who operated a machine shop doing repair work for several garages, in the handling of which there was need for a cylinder grinder. Machines available at that time for handling work of this kind were so expensive that Mr. Olson did not feel justified in investing in a cylinder grinding machine. Eventually he reached the conclusion that a satisfactory grinder for his work could be made at moderate cost, and this led to the design and construction of the original machine of this type. It proved very satisfactory in operation, and several machine tool salesmen and garage owners were so favorably impressed with the results obtained that Mr. Olson finally decided to put the machine on the market. With this object in view, the T. C. Olson Machine Co. was formed.

Among the features of design of this machine the following may be mentioned: An automatic belt-tightening device maintains a uniform tension on the belt regardless of the position of the head on the body of the machine. After the cylinder has been set, it is only necessary to shift the grinding head in order to bring successive holes into position for grinding. The table has only a forward and backward motion, which takes care of the feed and gives a particularly rigid construction for the table. An adjustable automatic feed tripping device is provided, and after this has once been set, the feed is automatically tripped at each end of the travel. The head which carries the grinding spindle is adjustable by means of a double eccentric motion, which enables the grinding wheel to move from the center to the position of maximum capacity. This grinding head is furnished with a fine micrometer adjustment to facilitate grinding work to exactly the required size. The machine will handle any cylinder from that of the smallest motorcycle engine up to cylinders 8 inches in diameter, and work ranging from single-cylinder blocks up to blocks with six holes may be handled with equal facility. The drive may be by either individual motor or belt; and the regular equipment includes a pair of angle-irons for truing up the castings on the table.



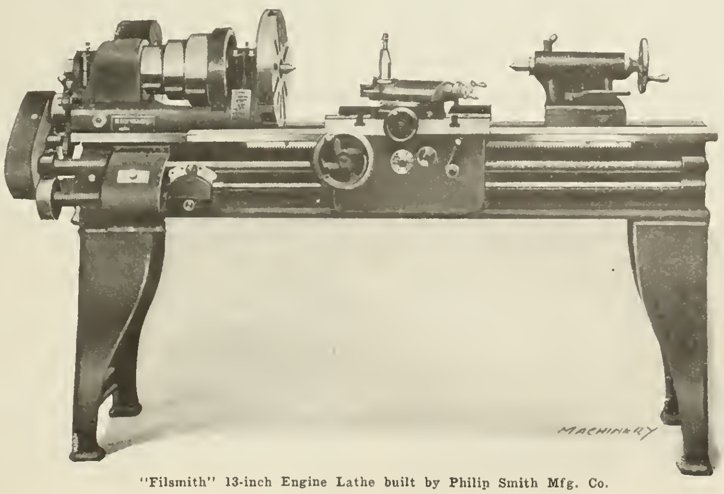
Olson Cylinder Grinding Machine with Work set up for grinding

The principal dimensions of the machine are as follows: minimum size cylinder that can be ground, 2⅜ inches in diameter; maximum size cylinder that can be ground with 5-inch wheel, 8 inches in diameter; maximum capacity of head and spindle in cross adjustment, 27 inches; maximum travel of table or length of hole that can be ground, 15 inches; maximum vertical distance from top of table to spindle center, 9 inches; minimum vertical distance from top of table to spindle center, 3 inches; speed of wheel-spindle, 5000 R. P. M.; rate of feed, 1/8 and 3/16 inch; diameter of revolving head boxes, 7¾ inches; length of revolving head boxes, 4 inches; length of bronze wheel spindle bearings, 6 inches; power required for driving, 3 horsepower; maximum height of machine, 44 inches; floor space occupied, 64 by 56 inches; and net weight, 1600 pounds.

"FILSMITH" ENGINE LATHE

The Philip Smith Mfg. Co., Sidney, Ohio, is now manufacturing the "Filsmith" 13-inch engine lathe equipped with a three-step cone pulley and double back-gears. The headstock is braced with heavy webs to insure rigidity under the heaviest cuts. Fifty-point carbon crucible steel is used for making the spindle, which is finished by grinding; and the spindle bearings are lined with phosphor-bronze. Rigidity is further provided for by making the bed with heavy walls and box girders cast at frequent intervals. The tailstock is so shaped that the compound rest can be set at right angles when turning work of small diameter.

A bearing 18 inches in length is provided for the carriage on the vees, and the bridge is 7¼ inches wide and furnished with T-slots for clamping special work. The compound rest is provided with taper gibs and graduated in the usual way for handling angular work. The apron and its bearings are cast in one piece, making a stiff, rigid construction; and all holes in the apron are drilled, tapped and reamed in a jig. All small gears are made of steel, and the studs are of steel, hardened and ground. A safety device prevents throwing in half-nuts when either feed is connected, thus preventing breakage. Screws for actuating the power cross-feed and compound rest are provided with the usual graduated dials; and the lead-screw is cut from a master screw which is frequently tested for accuracy. The spindle bearings in the headstock are of the self-oiling type. It will be seen that a quick-change mechanism is provided by means of which four changes of feed are instantly obtainable. All gears are thoroughly guarded to meet the safety requirements of the different states. Steel is used for making the feed-rack, and all sliding surfaces are carefully scraped to a bearing, while all cylindrical parts are ground to size.



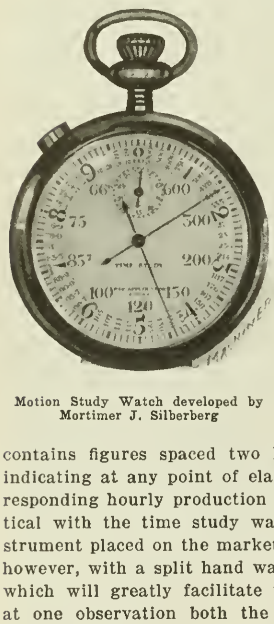
"Filsmith" 13-inch Engine Lathe built by Philip Smith Mfg. Co.

The standard equipment furnished with the machine includes a compound rest, follow-rest, steadyrest, double friction countershaft, and the necessary wrenches for making all adjustments. Special equipment obtainable for use in connection with this machine includes the following: No. 3 draw-in chuck, with capacity up to 7/8 inch; No. 2 draw-in chuck, with capacity up to 5/8 inch; chuck plates; taper attachment; automatic stop; and chasing dial. This lathe is built with beds 6, 8 and 10 feet in length.

The principal dimensions of the machine are as follows: swing over bed, 13 1/4 inches; swing over carriage, 8 1/4 inches; distance between centers for 6-foot bed, 35 inches; maximum tailstock travel, 5 1/4 inches; diameter of tailstock spindle, 1 3/4 inch; size of front spindle bearing, 2 3/4 by 4 inches; size of rear spindle bearing, 1 13/16 inch by 3 inches; diameter of hole through spindle, 1 5/16 inch; diameter of spindle nose, 2 1/16 inches; capacity for thread cutting, 4 to 20 threads per inch; size of cone pulley steps, 5 1/2, 6 3/4 and 8 inches in diameter by 2 1/2 inches face width; ratio of back-gears, 3 to 1 and 8 to 1; number of spindle speeds, 18; countershaft speeds, 300 and 400 revolutions per minute; range of spindle speeds, 27 to 600 revolutions per minute; toolpost capacity, 1 1/4 by 5/8 inch; and net weight of machine with 6-foot bed, 1250 pounds.

SILBERBERG MOTION STUDY WATCH

The instrument illustrated has recently been brought out by Mortimer J. Silberberg, 122 S. Michigan Ave., Chicago, Ill., and its design comprises an improvement on previous time study watches and stop watches, inasmuch as a decimal computed dial has been combined with a high-grade split hand watch. The split hand watch with a decimal computed dial has become a necessity, as time and motion study has been steadily advancing and our industries have been demanding a greater refinement of the original single hand instruments, in order to keep pace with the more complicated motion problems which are constantly arising.



Motion Study Watch developed by Mortimer J. Silberberg

This watch has a decimal dial, divided in tenths and hundredths of a minute, and contains figures spaced two hundredths of a minute apart, indicating at any point of elapsed time exactly what the corresponding hourly production would be. This feature is identical with the time study watch which was the original instrument placed on the market. The combination of this dial, however, with a split hand watch constitutes an improvement which will greatly facilitate time and motion study in that at one observation both the productive and non-productive time of an operation can be obtained, whereas, heretofore, on the single hand instruments two readings were necessary to obtain this result.

The computations on the dial have been described in the past, but it may be mentioned that they denote pieces or operations per hour. The watch embodies two hands, one of which is controlled by the side plug, and the other by the crown; or if it is desired to use both as a unit, both hands may be controlled by the crown. The crown-controlled hand may be used to determine the gross time, and the plug-controlled hand to take out the non-productive time, or delays, thereby at one reading giving an observer both the gross and net of an operation.

* * *

Belgian diamond cutters have opened a factory in Birmingham, England. It is possible that at the close of the war this city will become a rival of Amsterdam and Antwerp in this industry.

NEW MACHINERY AND TOOLS NOTES

Lathe with Relieving Attachment: Springfield Machine Tool Co., 631 Southern Ave., Springfield, Ohio. This lathe is made especially to cut metric threads and has a cutter relieving attachment.

Precision Gages: Superior Machine & Engineering Co., Detroit, Mich. This company is now making precision gages of all kinds and is paying especial attention to thread gages of both the plug and ring type.

Solidified Oil: Sun Co., Toledo, Ohio. "Nusco" is an oil solidified with tallow to a jellylike consistency, which is intended for use in grease cups; it is claimed that the mixture can be used satisfactorily at temperatures much below 0 degrees F.

Universal Square: D. J. Kelsey, New Haven, Conn. This instrument, which is made of celluloid, consists of a square, to the inner angle of which a movable arm is attached. The piece above this arm is graduated and the arm may be quickly set to the more common angles and held firmly by a thumb-screw.

Double Back-geared 18-inch Lathe: Flather & Co., Nashua, N. H. This lathe is double back-geared in ratios of 1 to 3.5 and 1 to 11.04; the speeds are in geometrical ratio, with an increment of 1.5 and range from 15 to 371 revolutions per minute. Gear ratios can be quickly changed and the back-gears are easily thrown in by a gear shift which controls either back-gear ratio.

Combination Holders: Eclipse Interchangeable Counterbore Co., Detroit, Mich. This tool is an Eclipse holder with an integral Wiard collet shank. As the holder is supplied with a knurled collar, it may be securely grasped when being placed in or removed from the chuck while the spindle is running. The holders are made in sizes to correspond with chuck sizes Nos. 0, 1, 2, and 3.

Sectional Steel Shelving: National Scale Co., 6 Mechanic St., Chicopee Falls, Mass. The shelving known as the "Multi-Unit" is designed to withstand long-continued severe use. All parts are interchangeable and can be had in plain steel or black or olive-green enamel. Although only the standard size, 36 by 12 by 12 inches, is made at present, a variety of sizes will soon be available.

Transformation-point Recording Apparatus: Leeds & Northrup, Philadelphia, Pa. With this apparatus, it is possible to locate accurately the transformation point of a steel while it is being heat-treated. The changes in temperature of both the steel test piece and of a piece of material which has no transformation point are recorded on a chart, and the transformation point is the place where the lines cross each other.

Two-pronged Electric Soldering Iron: Clemens Electrical Corporation, Buffalo, N. Y. With this iron the heat is generated by touching the object to be soldered, brazed, or annealed with the two high-resistance points of the iron; removing the iron from the work breaks the circuit. The heating points are made of solid brass and are held in position and separated by an asbestos bushing. From 6 to 5 volts only is required.

Vise-jaw Attachment: Universal Equalizer Co., Cincinnati, Ohio. This attachment is designed to hold pieces of any shape firmly in the vise. It is made of cold-rolled tempered steel in sizes that will fit any standard vise and consists of a number of lugs arranged with curved contacts in a channel. These lugs act as compensating wedges and force the grip lugs to protrude from the channel and equalize any pressure that may be applied.

Atlas Double Back-geared Lathe: Cleveland Lathe & Machinery Co., Cleveland, Ohio. The feed-rod and lead-screw drives of this machine are both reversing in the head. The apron has a separate reverse for feeds and the carriage has an indicating dial for thread cutting. The spindle is bored for No. 5 Morse taper shanks. The lathe has power cross-feeds and a positive quick-change drive feed shaft. There are eighteen available speeds.

Machine for Facing Shell Bases: Chandler & Farquhar Co., Boston, Mass. This machine, which was designed for rough-facing the bases of 6-inch shells, has a magazine in which four shells may be placed. This magazine is driven by a worm 33 inches in diameter to feed the shells over the tools. Hardened steel inserts hold the shells in the magazine while they are being faced. The tools are arranged on the cutter-head in three rows.

Locomotive-cylinder and Valve-chamber Boring Machine: Newton Machine Tool Works, Inc., Philadelphia, Pa. With this machine the cylinder and the cylindrical valve chamber in locomotive-cylinder castings may be bored at one setting. The spindle is 7 inches in diameter and it has a feed of 12 inches, by power or by handwheel. An attachment is provided for facing the cylinder heads, either when the cylinder is being bored or at some other time. There are six changes of feed.

Rivet Cutter: Rivet Cutting Gun Co., Cincinnati, Ohio. The manufacturer claims that with this machine 75 per cent of the cost of cutting rivets and bolts by hand will be saved; the machine may also be used for punching plates when the holes are afterward to be reamed to size. The machine consists of a cylinder in which is a piston mounted on slides. A cup-shaped casting at the lower end of the cylinder carries the cutting tool, the shank of which passes through the casting at the lower end of the cylinder.

Roller Lock-nut: Roller Lock Nut Co., New York City. The locking device of this nut is a steel roller which is held in place by a brass spring. This roller permits forward movement of the nut, but backward movement forces the roller into the threadway. The application of wrench pressure causes the roller to bite deeper into the threadway, but the movement of the nut causes the roller to drop into a recess in the side, so that the nut can be spun off by hand. It is claimed that the thread of the bolt is not injured in any way.

Heavy-duty Quick-change Lathe: Axelson Machine Co., Los Angeles, Cal. With this lathe only two levers are required to secure changes for cutting any of the thirty-two threads, which range from three to forty-six per inch; these changes can be made while the machine is running. The lathe is built in 16- and 18-inch sizes; the standard bed is 6 feet long, but other lengths up to 12 feet can be furnished. The spindle speeds of the larger lathe range from 12 to 349 revolutions per minute and for the smaller lathe from 6.67 to 420 revolutions per minute.

Miller with Oscillating Head: Superior Machine & Engineering Co., Detroit, Mich. This machine is especially suitable for milling small parts, and takes mills up to 3/8 inch in diameter. All parts are easily accessible and are protected from dirt and chips. The head is oscillated by a crank disk 2 1/2 inches in diameter, the pin of which works in a slot. The feed is operated by a pawl and ratchet and may be made as coarse as required for work of this kind. As both the pin in the crank disk and the spindle head are adjustable, there is considerable range in the length of the slot that may be cut.

Riveting Machine: Hanna Engineering Works, Chicago, Ill. This machine, which is sold by the Vulcan Engineering Sales Co., Chicago, uses a combination of toggles, levers, and guide links to give a gradual increase in the amount of pressure applied. The toggle action takes place while the piston is traveling through the first half of its stroke, during which time the die covers the greater part of its travel. The die completes its stroke while the piston travels through the remaining half of the cylinder. This slow movement of the die gives the metal in the rivet time to flow and fill the hole; besides, the rivet has a chance to set before the pressure is released on the return stroke of the die.

Duplex Turning Carriage: Amalgamated Machinery Corporation, Chicago, Ill. Although designed for use on shell-turning machines, this carriage will fit any lathe of sufficient strength and size. It consits of two tool-slides mounted on a single carriage driven by a single feed-screw. The radius-turning tool-slide is carried directly on the radius arm, the under side of which is recessed to form a seat for a large swivel bearing that fits over a male swivel seat on a free traveling lower slide. This device permits any form of tool to be used and to be set in any way, because it is always carried at the same position relative to the shell radius. With this device the operator gages his speed by the limits of the cutting tool used for the straight cut.

Gear-tooth Rounding Machine: Cross Gear & Engine Co., Detroit, Mich. This machine was designed for rounding the ends of the teeth of any sliding gears and will cut any degree of roundness on the end of a tooth, from simply taking off the edges to a full half circle. It will remove burrs from spur gears or bevel pinions quicker and more neatly than by filing, as well as sharp angular corners and burrs left on spiral gears by the hob. When desired, a bevel gear can be cut on one side of a tooth. The machine has rounded to a full half-circle all the teeth of a 133-tooth, 7-pitch, cast-iron flywheel in twelve minutes, and of a 17-tooth, 5-pitch, chrome-nickel, steel gear in two minutes. It will round the teeth of spur gear flywheels up to 30 inches in diameter and 12-inch face and with any number of teeth from 8 to 250, including odd numbers.

Rolls for Straightening 16-foot Plates: Hilles & Jones Co., Wilmington, Del. The rolls in this set are made of 0.55 per cent carbon open-hearth steel forgings. They have a finished diameter of 16 inches and are arranged in two tiers, three rolls in the upper and four in the lower. The rolls in the upper tier are spaced to alternate with those in the lower and are journaled in a single casting at each end. Each of these castings may be raised or lowered by means of two screws which are operated by a twenty-horsepower motor. The main driving gear is keyed to one of the inner rolls of the lower tier; the other rolls are driven by pinions meshing with idlers. These rolls are driven by a 125-horsepower motor. The two end rolls in the lower tier have a vertical adjustment of 1 inch, the device for which is operated by a fifteen-horsepower motor.

Automatic Polishing and Buffing Machine: Chase Turbine Mfg. Co., Orange, Mass. This machine can be used for polishing or buffing any circular or cylindrical work. The wheel-spindle is made to hold three wheels at one time, each wheel having a 2-inch face. This makes it possible to have a cutting, polishing, and coloring wheel on at the same time, with the result that when the work is mounted in the chuck the three wheels may be applied in succession, so that when the work is removed it is ready for the plater. The machine may have a vertical or a horizontal work-head. In either case, the work is held on an expanding chuck that is operated by a rod extending through a spindle in the head. Levers operated by a treadle force the expander out of the chuck body, so that the work may be put in or removed. At the same time, the clutch is released from the pulley, thus stopping the spindle. The work-head may be swiveled so as to bring the work into any position with relation to the wheels.

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NOTES ON LOCK MAKING

Locks are old and common devices for securing the safety of possessions. They were made by the Egyptians four thousand years ago, and until late in the nineteenth century were produced by hand work only. When they began to be made in large numbers the manufacture was long conducted on the plan of making the lock first and fitting the key to the lock, the same as the old hand lock-makers had done. The result was unsatisfactory, as much time and skill were required to fit the keys properly. Finally a genius reversed the process, made the key first and fitted the lock to the key. The reversed practice revolutionized lock making and helped to put it on a sound manufacturing basis.

The practice followed in the manufacture of Yale locks is to mill the steps in the key blanks on a special milling machine, which in a measure resembles a typewriter in having a number of finger keys. The lock keys are usually made in duplicate, and are milled simultaneously. The operator is furnished with a typewritten list for the lot of keys to be milled, and each finger key on the machine has a number; the list gives the combination desired to be milled in each pair of keys.

The keys are clamped in the machine vise and the designated finger keys are depressed and locked in position. The machine is then started and the lock keys are milled. They then go to the lock assemblers—generally girls. The girl picks up a lock barrel, pushes a key into the slot and then drops the required number of pins into the holes, using long and short pins, which are so selected that the tops of the pins stand approximately flush with the periphery of the barrel when supported by the key beneath, being then in the unlocked position. When the excess is filed off flush with a flat file, the barrel is ready to assemble in the lock which has corresponding pins and springs placed in position. These latter pins hold the barrel in the locked position when the key is out of the lock.

Another interesting phase of the manufacture of Yale locks is broaching the keyway in the barrel. The Yale locks are fitted with so-called paracentric keys—that is, keys having a cross-section of alternate grooves and ridges. The keyholes are broached on special vertical broaching machines, using broaches about six feet long. These broaches are made of paracentric cross-section, and finish a keyhole at one stroke, cutting on the downward stroke without feed. The effect of feed is produced by tapering the broach so that the teeth cut into the barrel progressively as the broach descends. The broaches virtually are vertical saws that cut their way into the barrel, making a paracentric path instead of the straight cut produced by the ordinary saw blade.

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MUNITION EXPERTS APPOINTED

The Council of National Defense has appointed a munition standards board composed of qualified experts in the manufacture of munitions, as follows: Frank A. Scott of the Warner & Swasey Co., Cleveland, Ohio; W. H. Vandervoort of Root & Vandervoort Engineering Co., East Moline, Ill.; E. A. Deeds of the Dayton Engineering Laboratories Co., Dayton, Ohio; Frank Pratt of the General Electric Co., Schenectady, N. Y.; Samuel Vauclain of the Baldwin Locomotive Works, Philadelphia, Pa.; and John E. Otterson of the Winchester Repeating Arms Co., New Haven, Conn.

USING MACHINES FOR DIFFERENT OPERATIONS

BY W. D. FORBES[1]

The standard machine tools that make up the equipment of machine shops carry with them certain presupposed mechanical operations. The lathe—the most useful of all tools—was developed with the idea of turning material on centers, in the chuck or on the faceplate. The planer has for its primary object the production of linear surfaces; so also have the shaper, slotter, and milling machines. The drilling machine was designed to rotate a drill, either feeding it into the work or feeding the work over the drill. The vertical boring mill is adapted for facing flat surfaces, boring cylinders, or finishing exteriors; while the horizontal type is designed more especially for boring cylinders and facing. But these machines are often used for other operations. For instance, a limited amount of milling can be done on the lathe by mounting a milling cutter on an arbor and clamping the work to the carriage. The horizontal boring mill can be conveniently and advantageously made to do the same class of work, especially those makes having power feeds provided in all directions. Milling machines can be used for boring and drilling.

These operations, however, may properly be called makeshifts, except in the case of horizontal boring mills provided with feeds. Makeshifts are generally uneconomical efforts, although they are often justified and necessary because of the lack of proper tools or because the proper tools are doing work that cannot be interrupted without producing more uneconomical conditions than the employment of the makeshift. To put it another way, the use of standard tools except for the purposes for which they were designed cannot properly be called economical manufacturing. An exception to this was brought to the writer's attention a short time ago by a manufacturer who used sensitive drilling machines as milling machines with most satisfactory results. He was making good deliveries on a large contract for war materials when an old customer brought to him a large number of small composition articles that required four narrow milled slots about 1/16 inch wide the entire length of the piece, which was 1½ inch, the depth of the cut being about 1/16 inch. These slots were placed 90 degrees apart, but exact spacing was not demanded. Between the four milled slots, and at right angles to them, four milled cuts of the same width had to be made and the cutter had to be sunk into the piece to a depth of ⅜ inch, producing a circular recess. The cutter had to be of such a diameter that when the last cut was made the longitudinal slots and the semicircular ones would be connected.

The manufacturer had no milling machines available for this work; and besides his milling machines were too large for such light milling. He was loath to sidetrack an old customer and inquiries among machine-tool men showed that it was impossible to obtain light milling machines, so he considered the possibility of doing the work on some other class of machine tool. The only available machines he could find were sensitive drilling machines. Now, a sensitive drilling machine is a light tool and hardly one that most persons would consider available for milling-machine work; yet this manufacturer saw that it was exactly the tool for this particular job, as the pieces that had to be milled were composition.

First of all, he made a special vise—small, of course—which was so designed that it would hold one of the composition pieces lengthwise at the end of the jaws and hold the piece vertically by semicircular recesses of the proper depth near the center of the vise. This vise was designed to rest in a dovetailed piece, in which it could be moved by means of a screw, and the base was bolted to the platen of the drilling machine. A milling cutter of the proper thickness and diameter was fitted to a taper shank arbor that fitted the spindle of the machine; of course, this cutter revolved in a horizontal plane. By means of proper stops in the vise jaws, the piece was clamped by its ends so that it overhung the edge of the vise; these stops were adjustable in order that the depth of the cut in the piece could be readily regulated both for the first cut and to accommodate the smaller diameter of the cutter after being ground. When the piece was clamped in the vise and the cutter started, the piece was fed horizontally past the cutter by means of the feed-screw. After the first cut was made, the piece was turned 90 degrees by bringing the milled slot to a mark on the top of the vise jaws. After the four straight milling cuts were made, the semicircular slots were milled by placing the piece vertically in the jaws in the recess. The four slots that were milled first were used for indexing for the position of the semicircular ones. Of course, a stop was provided to bring the piece to the same position each time, which would give the proper depth.

[1]Address: 236 Homestead St., New London, Conn.

A careful study of this improvised milling arrangement proved that notwithstanding the fact that a hand feed had to be used, more rapid work was produced than was possible on the regular type of hand milling machines. Besides this drilling-milling machine cost less than half as much as a light milling machine, and subsequent use showed that in many ways this makeshift was really an economical manufacturing arrangement.

All machine-tool designers have in view the production of a tool that will function satisfactorily. This is, of course, the primary idea; the second is to design a tool that will meet as large a demand as possible. But it seems to the writer that machine-tool designers have been tied to certain ideas that result in putting on the market machine tools with too great a range of work and it would be advantageous to break away from these traditions or usages. A record of the length of cuts made on a universal milling machine used for jobbing shows that for over a year the cuts averaged slightly less than two inches, yet the machine was able to cover a surface of over five times this length. This record also showed that the vertical adjustment averaged less than ½ inch while there was a possible adjustment of over 8 inches on the machine. It must be remembered, however, that often a short milling cut has to be taken at one end of a shaft while a second, third or fourth cut must be taken on other parts of the shaft, which demands that the platen be moved several inches between the cuts. It is therefore evident that a machine having only a two-inch cut would not do for a jobbing machine.

There are, however, manufacturing propositions where it would undoubtedly be wise to change this system of wide possibilities to much narrower limits by producing milling machines, for instance, that are adapted only for the shorter cuts. This idea was forcibly brought to the writer's attention when he was shown a room full of milling machines that were making cuts as short as ⅛ inch and none longer than 1 inch; yet every one of these machines was able to mill many times these lengths and this range was known when they were bought. Had these machines been designed for special work, three machines could have been made from the material in each one. This would have materially reduced the cost of the plant besides resulting in quicker work and lessening the power required to run the machines. It would be a bold machine builder who would risk his money by placing on the market a milling machine with only, say, a 2½-inch travel of feed; and the purchasers of such machines would be few in number; yet when it comes to a manufacturing proposition, such special designs should have far more consideration than is now given to them.

Another illustration is the screw-cutting feature of a lathe. Usually, the lead-screw has sufficient length to cut a thread in any position between the centers, when farthest apart, or the entire length between centers. This demands a considerable outlay of money if the feed-screw is really well made, and about 80 per cent of the length of the lead-screw is doing nothing the majority of the time. Now, on lathes up to 16 inches swing, threads more than 6 inches long are rarely cut. Why not, therefore, design the lathe so that the lead-screw will be of sufficient length to cut a thread, say, 12 inches long and have this short lead-screw moving with the carriage so that it can cut the thread anywhere between its centers? This would reduce the cost and make for accuracy, as it is much easier to produce a short accurate lead-screw than a long one. We are constantly confronted with the high cost of production, and it seems manifestly absurd for manufacturing

machines to be designed with the idea of doing anything more than a single operation. The case of a light sensitive drilling machine of low cost performing milling cuts that are usually done on high-priced milling machines seems to open up a line of thought in this direction.

* * *

THE MASTER CATALOGUE

One way to reduce the cost of buying and selling is to do away with the present system of making catalogues of all shapes and sizes and adopt a uniform size sheet for data sheets, price lists, catalogues, etc. When outlining the idea to the National Association of Purchasing Agents, W. L. Chandler, assistant treasurer of the Dodge Sales & Engineering Co., said that this plan would make the information more available and increase the value of the catalogues to the buyer. Much of the printed matter which is thrown into the waste basket yearly because the buyer has no place to file it would be kept for reference by the adoption of this plan. It was suggested that the details of this scheme, or "master" catalogue, be worked out by a board composed of representatives of national trade, engineering, and other associations, but the following plan was outlined.

The sheets should be 8½ inches by 11 inches in diameter so that they can be kept in standard vertical letter files; market reports and correspondence pertaining to the different price lists, such as quotations, discounts or letters giving weights, freight rates, and other data can be filed with the sheets to which they apply. To prevent the master catalogue from becoming obsolete, colored paper may be used. For example, say that in 1917 all sheets will be printed on white paper and will bear the date of issue, and in 1918 they will be printed on yellow paper while other colors will be used for 1919, 1920 and 1921. White will again be used in 1922 and the other colors repeated in regular order. Thus five colors will carry through the life of the catalogue. The seller will have a record to show that buyers have received white sheets, and during, say, December, 1921, he will notify them that such sheets are still in effect and entitled to remain in the catalogue if the buyer is still interested in such material. Upon such advice, the sheet will be stamped by the buyer "O. K. 1922" and left in the catalogue. During January, 1922, the buyer will remove from the catalogue all white sheets that have not received this stamp. If his interest in the material has ceased, the sheet will be destroyed; if his interest remains, he will notify the seller about such sheets as are open to doubt.

On classes of material for which data five years old is not dependable the sections of the catalogue known to contain this data may be revised as often as judgment dictates. The colored sheets lend the same help in a revision of any frequency. The use of this master catalogue will greatly reduce the waste circulation and expense of printing catalogues. It will not limit the quantity of the information contained on the sheets or in the books and will not in any way restrict advertising matter, except that which the seller desires to have the buyer retain in his file. The sheets or books may be printed from any plates used for bound catalogues and will give every opportunity for the proper treatment of the subjects involved. The catalogue may be printed on paper of a quality equal to that of any book now used for the purpose; the illustrations may be just as effective as desired; and the ink may be of any color to best present the goods. The only restriction will be as to the size of the sheets or books (thickness is not restricted) and the issuance of separate sheets or books where one seller might handle goods of more than one classification.

* * *

The date of the spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio, has been changed from May 22-25 to May 21-24. A feature of the spring meeting will be a joint session on May 22 with the National Machine Tool Builders' Association. The session will be in charge of the Cincinnati local committee and a committee representing the National Machine Tool Builders' Association. Papers will be presented on employes' service work and industrial education as developed in Cincinnati.

CUTTING INTERNAL HELICAL GEARS ON THE FELLOWS GEAR SHAPER

BY REGINALD TRAUTSCHOLD[1]

On page 526 of the article "Internal Helical Gearing" which appeared in the February number of MACHINERY, a method of cutting internal helical teeth on the Fellows gear shaper is described, which calls for further explanation. The method described presupposes the employment of a regular Fellows gear shaper such as the No. 6 designed for spur gears, and necessitates inclining the work-arbor so that the reciprocating path of the cutter is in line with the gear teeth. This is not the method, however, by which helical gears are cut on the gear shaper; while theoretically a gear might be cut in this fashion, there are certain practical difficulties which thorough research makes plain. In order to complete the gear teeth properly with the work-spindle inclined at an angle coinciding with the helical angle of the gear to be cut, it would be necessary to move the blank axially on its work-spindle as it rotates. Otherwise the teeth would not be properly finished. The center distance of cutter and work would be at a minimum in only one position as the cutter moves up and down. It would be necessary to generate the teeth in all planes at this minimum position. From this it becomes obvious that the axial movement would be a necessity. As the maximum gear face which may be handled upon the gear shaper is 5 inches, it is evident that with 1/20 inch feed per rotation of the blank the work must be rotated 100 times to complete a gear of 5 inches, and in all probability the teeth would not be smoothly cut. Wavy feed lines might be in evidence.

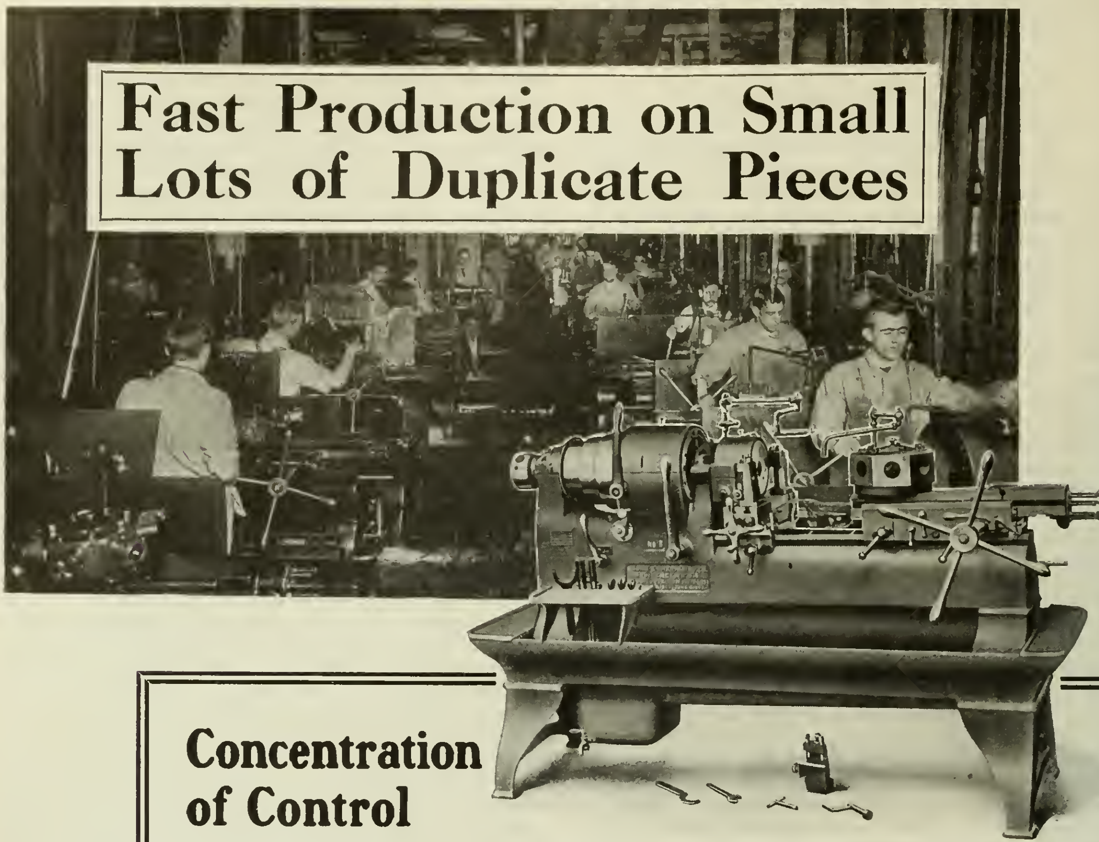
The action of helical gears rotating on parallel axes is identical with that of spur gears. In the Fellows helical gear shaper the cutter is a helical gear provided with proper clearance. The axis of the cutter-spindle is parallel with the axis of the work-spindle. The cutter-spindle is provided with a helical guide of a lead corresponding to that of the cutter. As the cutter-spindle reciprocates, the guide imparts the necessary twisting motion to pass the cutter through the proper path for shaping the gear. The work is relieved on the return stroke by a slight movement of the apron which carries the work-spindle. The mechanism which performs this duty is identical with that of the standard spur gear machine. If a section were taken through the work and the cutter at right angles to the axes of the two, the outlines of two involute spur gears would appear, one being the cutter and the other the work. When the helix advance in a helical gear is slightly in excess of the circular pitch measured in the plane at right angles to the axis of the gear, all possible advantage of the helical gear has been obtained. Further increase is of no advantage and results in setting up undue endwise thrust. It has been ascertained that two helical angles, *viz.*, 15 degrees and 23 degrees, cover nearly all cases which may arise. The fact that helical teeth are much stronger in action than spur teeth permits the use of finer pitches with the corresponding decrease in helical angle. For this reason it is usually possible to so design the gears that the helical angle falls within the scope of those mentioned above, which are the standards laid down. When a special case arises which cannot be covered by the guides and cutters as standardized, special cutters and guides are furnished.

* * *

CHANGE OF DATE OF SPRINGFIELD EXPOSITION

The date of the industrial exposition and export conference to be held in Springfield, Mass., has been changed from May 26-June 2, to June 23-30, in order to meet the wishes of a number of manufacturers who require more time to make ready their exhibits. F. H. Page, president of the National Equipment Co., has been made chairman of a general committee representative of a wide variety of American business interests, which is planning a series of small meetings in manufacturing centers to acquaint the trades generally with the opportunity to reach a great home market as well as to cooperate for a united front in the foreign field. John C. Simpson is general manager of the exposition.

[1]Address: 39 Charles St., New York City.



Concentration of Control

This is our No. 6 Wire Feed Screw Machine. Roller feed. Hole through spindle 2 1-16" diameter. Turns any length to 10".

reduces setting-up time to a minimum and speeds up every stage of production from the feeding of the bar to the cutting off of the finished piece. All operating levers, clamps and wheels are right under the hands of the operator. All working parts are simple and positive and can be operated without the necessity of the operator shifting his position. Round, square or hexagonal bar stock can be handled. Automatic feed advances stock through spindle where it is automatically and positively gripped in chuck.

On small lots and hurry jobs

Brown & Sharpe Wire Feed Screw Machines

maintain a rate of production that will satisfy the demands of the most exacting production men.

In our line of screw machines you'll find just the one that fits your particular needs. Let us tell you about the complete line. Send for catalog today—NOW.

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OFFICES: New York, N. Y., 20 Vesey St. Philadelphia, Pa., 652-654 The Bourse. Chicago, Ill., 626-630 Washington Blvd. Rochester, N. Y., 415 Chamber of Commerce Bldg. Syracuse, N. Y., Room 419 University Block. Pittsburgh, Pa., 2538 Henry W. Oliver Bldg. REPRESENTATIVES: Baltimore, Md., Carey Machinery & Supply Co. Cincinnati, O. Indianapolis, Ind., The E. A. Kinsey Co. San Francisco, Calif., Pacific Tool & Supply Co. Cleveland, O. Detroit, Mich., Strong, Carlisle & Hammond Co. St. Louis, Mo., Colcord-Wright Machinery & Supply Co. Seattle, Wash., Perine Machinery Co. Portland, Ore., Portland Machinery Co.

PRODUCTIVE CAPACITY A MEASURE OF VALUE OF AN INDUSTRIAL PLANT

BY H. L. GANTT[1]

If there is any one thing which has been made clear by the war, it is that the most important asset which either a man or a nation can have is the ability to do things. The recognition of this fact is having a far-reaching effect, and makes clear that the real assets of a nation are properly equipped industries and men trained to operate them efficiently. The money that has been spent on an industrial property and the amount of money needed to reproduce it are both secondary in importance to the ability of the plant to accomplish the object for which it was constructed.

To determine the value of an industrial property, it is necessary to know the cost at which the plant can produce its product as well as the amount produced. While there are many methods of cost accounting, they are based mostly on one of two propositions: (1) The cost of an article must include all the expense incurred in producing it, whether such expense actually contributed to the desired end or not; (2) the cost of an article should include only those expenses actually needed for its production, and any other expense incurred by the producers must be charged to some other account.

By the first proposition, the expense of maintaining in idleness any part of a plant is charged to the cost of the product made in the part of the plant that is in operation; by the second, the expense is deducted from the profits. When plants are operated at full capacity, both plans give the same cost. When they are operated at less than full capacity, the expense of carrying the idle machinery makes the cost of the product greater; while by the second plan, the cost remains constant. It is most interesting to note that when costs are figured by the second plan, an immediate effort is made to determine why the machinery is idle and to put it in operation. It is realized at once that this machinery should be operated even if only a part of the expense of maintaining it is earned.

In many large plants charts that show the idle time of the machines and the reasons for this idleness are prepared each month; they have already had an educational influence on the managers of those plants, as they make it possible to contrast the efficiency of the management with that of the workmen. They show that idle machinery which cannot be used should be disposed of, and the money received and the space occupied put to some useful purpose. Simple ownership of a machine costs money, inasmuch as it takes away from available assets. For instance, if a machine is bought for $1000, the firm loses the interest on that sum, say at 5 per cent per year, and must pay taxes on the machine at, say, 2 per cent, and an insurance of 1 per cent. Further, the machine probably depreciates at the rate of 20 per cent per year, and $50 or more per year must be paid as rent for the space it occupies. All these expenses, together amounting to $330, go on whether the machine is used or not. So the simple fact of having bought this machine and kept it takes from the available assets approximately one dollar per day.

If the cause for idleness is ascertained each day, it is possible to find the expense of each cause of idleness as shown by the chart. However, no conclusions should be based on the figures for one month, but on the results of a series of months during which the problem has been carefully studied. That idleness which is due to lack of orders shows that the selling policy is wrong or that the plant is larger than it should be. If it is due to lack of help, the labor policy needs investigation. If it is due to lack of material or poor material, there is inefficiency in the purchasing policy and the storekeeping system. While such a chart will not give a measure of the efficiency with which these functions are performed, it does give an indication of that efficiency. In several cases where such charts have been gotten out, they have resulted in the scrapping of machinery that had been idle for years; the space thus made available was then put to more useful purposes. In one case, this chart resulted in the renting of temporarily idle machinery at a rate which went far toward covering the expense of carrying that machinery.

Under the first system of cost accounting, the facts brought out by this method are not available, and the increased cost that a reduced output must bear is a great source of confusion to the salesman. The second system with its constant costs shows that non-producing machinery is a handicap to the industry, just as workmen who do not serve some useful purpose in a plant or industry are a handicap to the plant or industry.

Another factor that enters into the value of a "going plant" is the organization. The value of an organization lies not so much in the personality of the manager or leader (who may die or go elsewhere) as in the permanent results of his training and methods, which should go on with the business, and are therefore an asset and not an accident. Andrew Carnegie has said that his organizations were of more value to him than his plants.

[1]Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, December, 1916.

* * *

THE JOHN ERICSSON MONUMENT

Last fall Congress appropriated $35,000 for the erection of a monument in Washington to the memory of John Ericsson, as noted in the October number of MACHINERY. A special commission was appointed by the government to take care of the details in connection with the erection of the monument. This commission met at Chicago, March 10, and it was decided that $25,000 was needed, in addition to the appropriation made by the government, to erect a fitting memorial. It is proposed to raise this amount by private subscription, and all American engineers, organizations and societies are invited to aid in commemorating John Ericsson, who rendered signal service to the country at a time when its very existence hung in the balance. It is the first time that the United States government has made an appropriation for the erection of a monument to an engineer, and engineers generally will no doubt be proud to aid in the efforts of the John Ericsson Monument Commission. Subscriptions toward the monument will be received by Erik Oberg, associate editor of MACHINERY, 148 Lafayette St., New York City, who is a member of the commission, and will be acknowledged by publication as directed by the commission.

* * *

AMERICAN MUSEUM OF SAFETY AWARDS

The jury of award of the American Museum of Safety, New York City, has announced the award of four of the five gold medals given annually for noteworthy achievements in safety work. The E. H. Harriman memorial medal, which is given annually to the American steam railroad that has been most successful in protecting the lives and health of its employes and of the public, has not yet been awarded. The Anthony N. Brady memorial medal has been awarded to the Connecticut Co., with headquarters at New Haven, Conn. The *Scientific American* medal was awarded to the Pullman Co. for originating the Dean end-frame for passenger cars. The Louis Livingston Seaman medal has been given to the Julius King Optical Co. of New York City; and the Travelers Insurance Co.'s medal to the Commonwealth Steel Co. of St. Louis, Mo., for its safety system and protective devices.

* * *

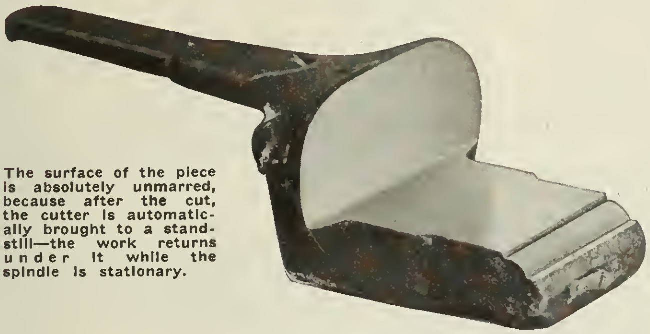
Recently an accident occurred to one of the machines in the plant of Samuel W. Moore & Sons, Inc., Newark, N. J., which brought out a most interesting point concerning the bearings. The machine in question is a special paraffining machine used in the manufacture of paraffined paper containers. The top shaft was accidentally hit and bent to an angle of ten degrees. When the accident occurred it was feared that a new shaft would have to be substituted immediately, thus causing a tie-up of the whole plant for two days while the repair was made. But on investigation the machine was found to be still in good running order. The bent shaft was mounted on S. K. F. self-aligning ball bearings and they carried it without binding, because the self-aligning feature compensated for the bend.

CINCINNATI AUTOMATIC MILLERS

With Intermittent Feed and Automatic Spindle Stop For Manufacturing

RIFLE AND MACHINE GUN COMPONENTS

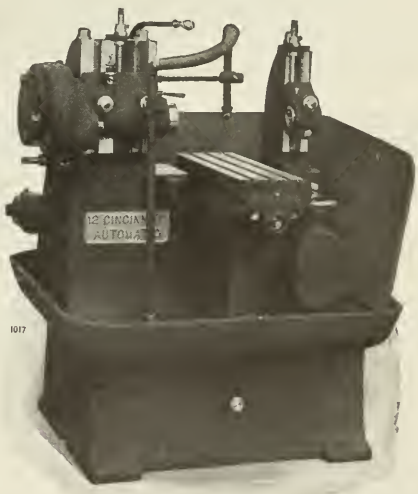
and Similar Parts in Quantities



The surface of the piece is absolutely unmarred, because after the cut, the cutter is automatically brought to a standstill—the work returns under it while the spindle is stationary.

They have the intermittent feeding feature, which has proven so successful on our earlier machines, with this addition — after the cut is taken the spindle is stopped automatically so that the work returns beneath it while the cutter is stationary—no danger of marring the surface of the work because of a revolving cutter.

Consider, too, the advantage of this from the standpoint of safety. The operator removes the finished piece and chucks a new one while the cutter is stationary. He can't get caught by a swiftly revolving although idle cutter. After he chucks the new piece, he moves one lever—and immediately both the spindle and feed movements start again.



This is one improvement on the Cincinnati Automatic. There are others equally vital. Do you wonder this new machine has already made a place for itself in the esteem of a number of big munitions shops?

For manufacturing parts in quantities it offers exceptional advantages.

Bulletin containing details will be sent you upon request.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO

DETROIT PLANT OF PARKER RUST-PROOF CO.

Parker Rust-Proof Co. of America is erecting a large plant in Detroit, Mich., for the rust-proofing of steel and iron parts. The company has secured the patent rights to a number of rust-proofing processes, including the Coslettizing process, and is doing work for the motor car companies in rust-proofing parts. The new plant will cover four and a half acres, and plans have been made for erecting branch plants in all the principal industrial cities. The rust-proofing process employed makes use of chemicals having an affinity for steel and produces a black oxide on the surface which is virtually an integral part of the metal. Hence it is permanent, as a thin film of the metal itself has been changed. In this respect it differs from paint or enamel, which only serves to exclude the atmosphere, but does not necessarily prevent slow rust in the metal beneath.

* * *

NEW RUSSIAN MACHINERY CORPORATION

A large corporation has been organized in Petrograd, Russia, by well-known financiers and engineers to build a full line of small tools, machine tools and wood-working machinery which do not conflict with the lines of American machinery now handled by the M. Mett Engineering Co. The officers of the corporation are A. E. Putilov, president; M. A. Mett, managing director; and L. S. Neuschul, financing director. The latter is well known among American machinery manufacturers, having spent considerable time in the United States in the past two years, during which he purchased several million dollars' worth of machinery for export to Russia. The company has been organized with a large paid-up capital, and has acquired the plants of Fillipov Bros. and Dangayer & Kayser, near Moscow, at a cost of 15,000,000 rubles. The temporary New York office is at the Hotel Vanderbilt, J. M. Wimpie acting as representative.

* * *

HIGH FREIGHT RATES

Ocean freight rates and their effect upon American business have been cited in some striking instances. The freight charges to the Straits Settlements on a hundred or so iron beds invoiced in the United States at $339 were $686; though this place is half way around the world, it is not exactly off the routes of trade. The combined freight and insurance charges to South Africa of a shipment of glassware, which had a value of $526 F. O. B. New York, was $534. To get $1300 worth of nails to South Africa cost $600. Of course, times are abnormal, and so are ocean freight rates.

PERSONALS

Albert A. Dowd, consulting mechanical engineer, has withdrawn from "The Consultants" at 101 Park Ave., New York City.

Carl A. Smarling was made superintendent of the Rider-Ericsson Engine Co., at Walden, N. Y., following the recent reorganization.

George Smart, for the past twelve years editor of the *Iron Trade Review*, Cleveland, Ohio, has joined the editorial staff of the *Iron Age*.

H. B. Ibsen has severed his connection with Wismach & Co. and is now manufacturing reference gages under the name of Ibsen & Co., P.O. Box 572, Milwaukee, Wis.

Cass L. Kennicott, a well-known water softener expert, has associated himself with the Permutit Co., New York City, and has been put in charge of the company's Chicago office, 208 S. La Salle St.

M. C. M. Hatch, superintendent of fuel service of the Delaware, Lackawanna & Western Railroad, has resigned to take the position of assistant to the president of the Locomotive Pulverized Fuel Co., of New York City.

W. E. Wolfram, for the past eleven years superintendent of the projectile department of the Bethlehem Steel Co., South Bethlehem, Pa., has resigned. Mr. Wolfram intends to make an extended trip to the Pacific coast.

E. P. Dillon, formerly assistant to the manager of the railway and lighting department of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has been appointed manager of the power division of the New York office.

E. D. Kilburn, manager of the power department of the New York office of the Westinghouse Electric & Mfg. Co., has been appointed district manager to succeed W. S. Rugg, who has been made manager of the railway department.

Robert L. Arms, for several years connected with the sales department of Manning, Maxwell & Moore, Inc., has associated himself with Sherritt & Stoer Co., Inc., 603-604 Finance Bldg., Philadelphia, Pa., as assistant to the general manager.

W. S. Rugg, formerly district manager of the New York office of the Westinghouse Electric & Mfg. Co., has been appointed manager of the railway department, succeeding C. S. Cook. Mr. Rugg's headquarters will be at East Pittsburg, Pa.

Thomas P. Bradshaw, mechanical engineer, has resigned from the staff of the American Museum of Safety, New York City, to enter the position of mechanical safety engineer with the American Smelting & Refining Co., 120 Broadway, New York City.

L. K. Berry, district manager of New York for the Warner & Swasey Co., Cleveland, Ohio, has been appointed assistant sales manager with headquarters in Cleveland. Eugene R. Gardner becomes district manager for New York, assisted by R. L. Glaser.

Leon P. Alford, editor-in-chief of the *American Machinist* for nearly six years has resigned and has taken the position of chief-of-staff of *Industrial Management*, formerly the *Engineering Magazine*. John A. Van Deventer, managing editor of the *American Machinist*, has been made editor-in-chief.

William H. Reece, of Florence, Mass., for twenty years superintendent of the Northampton Emery Wheel Co., and also of the Reece & Hamman Co., has taken a position in charge of the grinding and polishing machine department of the Noble & Westbrook Mfg. Co., Hartford, Conn. The company is building a full line of grinding and polishing machinery.

Harrison W. Craver, chief librarian of the Carnegie Library in Pittsburg, Pa., since 1908, has resigned to take the position of director of the library of the United Engineering Societies, 29 W. 39th St., New York City. Mr. Craver's new position will put him in charge of what is believed to be the largest engineering library in the world, with approximately 150,000 volumes on its shelves.

Alfred H. Bartsch, for seven years advertising manager of the Bosch Magneto Co., has resigned to become a member of the firm of McLain-Hadden-Simpers Co., advertising and merchandising council, of Philadelphia and New York City. Robert S. Westcott, who has been assistant advertising manager of the Bosch Magneto Co. for the past seven years, has assumed the duties of advertising manager in the company's advertising offices at 1764 Broadway, New York City.

G. K. Atkinson has joined the organization of the Wood Turret Machine Co., Brazil, Ind., as chief engineer. During the past two years, Mr. Atkinson was associated in an executive capacity with the Cincinnati Planer Co., and prior to that connection was with the Steinle Turret Machine Co. He organized and was president of the Modern Machine Tool Co., of Cincinnati, manufacturer of turret machines, since acquired by Greenlee Bros. & Co., of Rockford, Ill.

Edward P. Hughes, for ten years district sales manager of the Cataract Refining & Mfg. Co., Buffalo, N. Y., manufacturer of lubricating oils and cutting compounds, has resigned the position to become sales manager for the Detroit Soluble Oil Co., Detroit, Mich. Mr. Hughes has had years of valuable experience in handling lubricating and cutting oils, having been three years with the Standard Oil Co., prior to his long connection with the Cataract Refining & Mfg. Co.

George Schow, consulting director of the Northern Engineering & Trading Co., Christiania, Norway, is on a business trip in the United States seeking representation for a few more lines, including electrical machinery, sewing machine motors and other household electrical goods. Norway and Sweden offer a great market for electrical household devices because of the low cost of electric power; Russia also offers a market for these devices. Mr. Schow's address while here is 2955 Logan Blvd., Chicago, Ill.

OBITUARIES

S. E. Weir, superintendent of the American Blower Co., Detroit, Mich., died February 13.

Albert Clark Stebbins, a vice-president of the Niles-Bement-Pond Co., 111 Broadway, New York City, died February 28 at his home in Plainfield, N. J., aged seventy-three years. He was born in the town of Monson, Mass. In 1865 he became an apprentice in the machine shop of Lucius W. Pond, Worcester, Mass. He continued as a machinist in this shop until about 1870, when he was appointed New York representative of L. W. Pond, with an office on Liberty St. About 1875, when the Pond business passed into the hands of David W. Pond, son

of Lucius W., Mr. Stebbins returned to the Worcester shop in the capacity of superintendent. In 1887 the shop at Worcester was taken over by the Pond Machine Tool Co., of Plainfield, N. J., and the shop equipment was moved to new buildings in Plainfield. Mr. Stebbins went to the Plainfield works as vice-president and general manager, and directed the construction and equipment of the new shops. He continued in this capacity until the organization of the Niles-Bement-Pond Co., when he was elected vice-president of this company and local manager of the Pond works. Mr. Stebbins left no children; his wife died in 1902. He served a term as member of the city council of Plainfield and at the time of his death was vice-president of the Dime Savings Bank of that city.

FREDERICK E. REED

Frederick E. Reed, whose death on February 18 was briefly noted in the March number, was born in Croydon, N. H. Mr. Reed's parents moved to Worcester when he was young, and he was first employed in 1870 as a bookkeeper for the Wood & Light Machine Co. of Worcester, where his father, John Reed, also was employed. Later he became chief draftsman for the company, and in 1875 he bought the interest of Vernon Prentice in the firm of A. F. Prentice & Co. of Worcester. Mr. Reed early realized the need of a better education, and after having spent two years in the shop, he took a course in Worcester Academy and at Howe's Business College, and studied drawing at the evening school provided by the Worcester County Mechanics Association. He became sole proprietor of A. F. Prentice & Co., after two years' connection, and the name was changed to F. E. Reed in 1877. This firm name was retained until 1890, when John R. Back, who had been the shop superintendent for years, became financially interested and the name was changed to F. E. Reed & Co., and to F. E. Reed Co. in 1894. Mr. Reed organized the Reed-Curtis Machine Screw Co. and the Reed Foundry Co., and was interested in the Mathews Mfg. Co. and the Worcester Lawn Mower Co. He was second president of the Worcester Branch of the National Metal Trades Association, and had been a director of the First National Bank of Worcester. He was a vice-president of the National Machine Tool Builders' Association and later treasurer. He retired in 1912 when he sold his business to the Reed-Prentice Co. for $1,250,000 in cash.

Mr. Reed's success in the machine tool field may be attributed to his thorough and far-seeing business ability, and to his even and courteous treatment of everyone with whom he came in contact. His thoroughness showed itself in his machines, in the refinement of little features that are often neglected or overlooked. When he laid the foundations for his first shop, the same thoroughness showed itself in the planning. In his early days as a machine shop owner, Mr. Reed had hard work to make both ends meet. In panic times in the late seventies, he had but six or eight men at work, and sometimes only one (J. E. Snyder) besides himself. Times were so hard that many weeks the single men had to wait for their wages, but they always got them, and it was a well-known fact that his word was as good as his bond. In his

Frederick E. Reed

accounting, Mr. Reed was also thorough. When he started, he was his own bookkeeper, and it is said that the books of the concern were a remarkably fine example of accounting. For this reason he knew just where he was, at all times, on costs of manufacture and selling and was able to operate on a very close margin when necessary. The overhead expenses were extremely low and the organization had no non-producers. At the outset, Mr. Reed did his own designing. He was an excellent draftsman, and the same attention to details made his work in designing as good as his shop management. He was a firm believer in the policy of keeping up production of machine tools in dull times, and often accumulated large stocks by building persistently when there was little or no market. His foresight was always rewarded when the demand again developed, being then in a position to supply his customers when other makers were struggling to repair their shattered shop organizations and to mend the gaps made in their selling force.

COMING EVENTS

April 23-26.—Annual convention of the National Metal Trades Association in New York City; Hotel Astor, headquarters. Homer D. Sayre, secretary, Peoples Gas Bldg., Chicago, Ill.

April 26.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

May 21-22.—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 21-24.—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

June 13-15.—Annual convention American Railway Master Mechanics' Association at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 13-20.—Annual meeting of the Railway Supply Manufacturers' Association at Atlantic City, N. J., in connection with A. R. M. M. and M. C. B. Associations' conventions. J. D. Conway, secretary and treasurer, 2186 Oliver Bldg., Pittsburg, Pa.

June 18-20.—Master Car Builders' Association's convention at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 23-30.—Industrial exposition and export conference at Springfield, Mass. John C. Simpson, general manager.

August 30-September 1.—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15.—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15.—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Musuem of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

SOCIETIES, SCHOOLS AND COLLEGES

Delaware College, Newark, Del. Catalogue 1916-1917, with announcements for 1917-1918.

Grove City College, Grove City, Pa. Catalogue for 1916-1917 with calendar and courses of study for 1916-1917.

Lowell Textile School, Lowell, Mass. Quarterly bulletin containing annual report of the trustees for the year ended June 30, 1916.

Polytechnic Institute of Brooklyn, Livingston and Court Sts., Brooklyn, N. Y. Catalogue 1917-1918, with calendar and outline of courses.

School of Mines and Metallurgy, University of Missouri, Rolla, Mo. Bulletin for January, 1917, containing an article on "Road Problems in the Ozarks," by Elmo G. Harris, with a list of publications on rural roads compiled by Harold L. Wheeler.

New England Association of Commercial Engineers, 53 Devonshire St., Boston, Mass. Business directory of members for 1917. Those who manufacture, sell, or are in any way connected with concerns that manufacture or sell machinery or supplies used by lighting, railway or power plants, are eligible for membership.

Barber-Colman Association, Rockford, Ill., has just published a typographical work of art called "Knots," 9 by 12 inches, containing 168 pages of text and illustrations. "Knots" is to be a yearly publication that will be issued in the interest of co-operation and good will between the Barber-Colman Co. and its employes. The title was selected because of its emblematic qualities and because the tying of knots in yarn mechanically had an important influence in the development of the Barber-Colman Co. The business was founded principally on the hand knotter and warp-tying machine used in textile mills for tying broken warp. From this small beginning was developed the Barber-Colman power warp-tying machine for mechanically tying the threads or ends of new warp to the corresponding end of an old warp, thereby saving much time and labor compared with hand tying. The manufacture of milling cutters was taken up in 1908, and gear-hobbing machines in 1910. The book is profusely illustrated with halftones showing the plant, departments, personnel of the working forces, and the branch offices in various cities. Much space is given to sports and athletic events which have been popular features of the annual outings of the employes' association.

NEW BOOKS AND PAMPHLETS

Combustion in the Fuel Bed of Hand-fired Furnaces. By Henry Kreisinger, F. K. Ovitz and C. E. Augustine. 76 pages, 6 by 9 inches; illustrated. Published by the Department of the Interior, Bureau of Mines, as Technical Paper 137.

Traveling Engineers' Association—Proceedings of the Twenty-fourth Annual Convention. 414 pages, 5½ by 8½ inches; illustrated. Published by the Association, W. O. Thompson, secretary, N. Y. C. R. R., Cleveland, Ohio.

The Cooperative System of Education. By Clyde W. Park. 48 pages, 6 by 9 inches; illustrated. Published by the Department of the Interior, Bureau of Education, Washington, D. C., as Bulletin No. 37.

This pamphlet gives an account of the co-operative educational system developed in the College of Engineering, University of Cincinnati, Cincinnati, Ohio.

Resistance of an Oil to Emulsification. By Winslow H. Herschel. 37 pages, 6 by 9 inches; eight illustrations. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards No. 86.

When oil is used over and over, as is the usual practice in power plants, it may emulsify in a few days if not of good quality and have to be thrown away, because it will not pass through the filters.

A laboratory test has been devised by means of which it can be predicted, whether or not the oil will give satisfactory service. The test consists of violently stirring a small sample of the oil with water under standard conditions. By the use of the test described any power plant engineer can keep track of the deterioration of the oil, and thus learn when it is time to clean out the lubricating system.

Lettering for Draftsmen, Engineers and Students. By Charles W. Reinhardt. 54 pages, 7¾ by 10¾ inches; 75 illustrations and plates. Published by the D. Van Nostrand Co., New York City. Price, $1 net.

This practical system of freehand lettering for working drawings has had an unusual sale, and now appears in the fourteenth edition, revised and enlarged. The new edition contains the analyzed Greek alphabet, showing various methods of laying out and constructing titles, as well as practice sheets. The book is one that we heartily commend to all draftsmen needing knowledge of better styles in lettering, and that means many. It treats of inclined lettering, upright lettering, freehand lettering applied to working drawings, various freehand alphabets, including the Greek alphabet, lettering of titles, lettering for photo-reproduction, etc.

Export Trade Directory. 536 pages, 6 by 9 inches nearly. Published by the "American Exporter," 17 Battery Place, New York City. Price, $5.

The new edition of the Export Trade Directory just published, comprises 536 pages, as contrasted with only 369 pages in the fourth edition. The directory has kept pace with the increase of the foreign business of the United States and now includes over 2000 firms, of which 1295 are New York export houses. The directory also includes lists of value to every exporter, such as, for example, the large banking houses making a specialty of dealing in foreign exchanges, buying manufacturers' drafts, etc. The new work contains an extension of the lists of foreign trade forwarding agents, including concerns of this character in other cities than New York. Specifications of shipping routes to foreign markets, locations of American consuls abroad and foreign consuls in the United States are also features of value to those interested in developing their foreign trade.

NEW CATALOGUES AND CIRCULARS

Sprague Electric Works of General Electric Co., 527-531 W. 34th St., New York City. Bulletin 41514 of single-phase variable-speed motors.

Sprague Electric Works of General Electric Co., 527-531 W. 34th St., New York City. Pamphlet of Sprague direct- and alternating-current electric fans.

Buda Co., Chicago, Ill. Catalogue containing dimensions and specifications of the four types of electric industrial trucks manufactured by this company.

Medina Machine Co., Medina, Ohio. Circular of the Medina vertical drilling and boring machine, with constant-speed drive, four power feeds, and a speed-box containing hardened change-gears.

American Laundry Machinery Co., Norwood Station, Cincinnati, Ohio. Circular illustrating equipment for washing or reclaiming wiping rags. It is claimed that an appreciable saving is effected by the use of this equipment.

Fiske Bros. Refining Co., 24 State St., New York City. Pamphlet treating of "Climax" mineral lard oil, which is applicable for use on all classes of cutting operations. It can be used straight or as a base for many cutting oils.

Hess & Son, 1031-1033 Chestnut St., Philadelphia, Pa. Circular on "Epicassit," a metallic protective coating for metal articles or structures of all kinds, being a metal powder which is mixed with a liquid and applied with a brush, and then melted by any convenient source of heat.

Universal Equalizer Co., Bell Block, Cincinnati, Ohio. Circular of the "Universal" equalizing vise jaw attachment for gripping irregular shapes. The attachment may be applied to any machinist's vise, and with it in place irregular, tapered, round and other shapes can be held firmly.

Southwark Foundry & Machine Co., Philadelphia, Pa. Catalogue of leather packings, valves, shock absorbers, forging presses, punching and shearing presses, flanging presses, extrusion presses, hydraulic accumulators, hydraulic riveters, hydrostatic wheel presses, and other hydraulic machinery and fittings.

Hy-grade Machine Co., 5606 Curtis Ave., Cleveland, Ohio. Circular of the "Hy-grade" cylinder grinder for grinding the bore of engine cylinders. It has a working space under the machine of 18 by 22 inches, and a grinding spindle 16 inches long, which gives ample capacity for handling the general run of work.

Charles H. Walker, 1565 W. Grand Boulevard, Detroit, Mich. Circular descriptive of the "Cross" gear-tooth rounding machine, especially designed for rounding the ends of sliding meshing gears, such as automobile transmission gears, automobile flywheels, and gears of this kind used in machine tools and other machinery.

Independent Pneumatic Tool Co., Chicago, Ill. Catalogue 10, illustrating and describing pneumatic tools and electric drills. Dimensions of the various tools are given, as well as information on the care and operation. This catalogue shows a new line of piston air drills equipped with pressed vanadium steel connecting-rods and pistons.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa. Catalogue entitled "Ball Bearings in Machine Tools," illustrating various types of machine tools equipped with Hess-Bright annular ball bearings. The catalogue treats of the uses of Hess-Bright ball bearings, special features, and results obtained by their application.

Boston Gear Works, Norfolk Downs, Mass. Catalogue F-7 of gears, racks, sprockets, chains, bearings, universal joints, worms, worm-wheels, ratchets, etc. The Boston Gear Works was established in Boston in 1891 and removed to Norfolk Downs in 1906. The main building contains 29,000 square feet of floor space, and the total floor space available is about 37,000 square feet. The plant is fully equipped for handling all kinds of gear work.

Prentiss Vise Co., 110 Lafayette St., New York City. Catalogue of Prentiss vises, which is the fiftieth illustrated price list of vises issued by the company. The catalogue contains information on the use and abuse of a vise and describes the mechanism of the Prentiss self-adjusting jaw vise. The various parts of the vises are illustrated and the names used to designate them are given, for convenience in ordering repair parts.

Hetherington McCabe Co., Piqua, Ohio. Circular descriptive of the "Brandenburg" self-lubricating emery wheel dresser. This tool has a steel spindle and a cast-iron bearing lubricated with flake graphite, which fills the pores and makes the bearing practically frictionless. This frictionless bearing permits the immediate spinning of the cutters when placed against the emery wheel, so that they dress and true the wheel instantly without the points of the cutter wheels being ground off.

W. S. Barstow & Co., Inc., 50 Pine St., New York City. Catalogue entitled "The Puzzle of Prosperity and Its Solution," treating of the question of increasing production to keep pace with the growing demand for manufactured products, by (1) building new plants; (2) enlarging existing ones; and (3) scientifically rearranging machinery, equipment and processes so that production may be increased without materially adding to the investment. The book contains views of bridges, trestles, industrial plants, etc., built by this company.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 3037, covering the straight-line type of dry vacuum pump. Form 8038, treating of the duplex type of dry vacuum pump. Both types of machines are equipped with Ingersoll-Rogler valves, are capable of maintaining a high vacuum, and will handle discharge pressures of several pounds. The maximum degree of vacuum possible varies in the different machines to within 0.6 inch of the barometer. These vacuum pumps are made in steam- and power-driven types, in a large range of sizes and capacities.

American Pulley Co., 4208-60 Wissahickon Ave., Philadelphia, Pa. Pamphlet entitled "Building No. 25," containing illustrations of a building recently erected by the company for the purpose of safeguarding the health of its employes and for their comfort and convenience. On the first floor is the health officer's room, where his records are kept and reports prepared. The first-aid room is also located on this floor. On the second floor are steel lockers, wash basins, and shower baths. There is also a roof garden, part of which is enclosed for use in bad weather.

Parker Rust-proof Co. of America, Detroit, Mich. Catalogue descriptive of the Parker process of rust-proofing iron and steel. This process will not increase or decrease the size or contour of an article. For example, in rust-proofing screws, the pitch is in no way affected. Machined parts, links and mechanical appliances completely assembled can be treated without affecting their operation. The book illustrates a large number of articles that can be successfully treated by this process, among which are flexible conduit, fans, pinions, shock absorbers, cylinders and miscellaneous motor parts, axles, wheels, twist drills, taps and reamers, chains, furnace registers, balconies, stair rails and metallic window sash, cabinet and builders' hardware, metallic office furniture and equipment, screw machine products, wire mesh screens, steam fittings, cash registers, typewriters, etc. The Parker process forms an excellent base for parts that are subsequently to be japanned, enameled or painted. Bright nickeled parts can also be subjected to the process, and parts formerly made of brass can be made of cast iron, by rust-proofing and brass-plating.

TRADE NOTES

Standard Mfg. Co., Bridgeport, Conn., has changed its name to Bilton Machine Tool Co.

Worcester Lathe Co., Worcester, Mass., has moved from 134 Gold St. to 68 Prescott St.

Oliver Instrument Co., 1168 Cass Ave., Detroit, Mich., has moved its factory to Adrian, Mich.

D. & W. Machine Co., Inc., New York City, has moved its offices from 149 Broadway to 1472 Broadway.

Master Machine Works, 110-112 W. 40th St., New York City, has changed its name to Master Machine Tool Co.

Steinle Turret Machine Co., Madison, Wis., manufacturer of Steinle turret lathes, has completed a fine office building and some additions to the plant to increase the manufacturing facilities.

De Laval Steam Turbine Co., Trenton, N. J., manufacturer of steam turbines and helical reduction gears, has opened a district sales office in the Smith Bldg., Seattle, Wash., in charge of William Pullen.

Edward R. Ladew Co., Inc., manufacturer of leather belting, has removed its New York offices to more commodious quarters at 54-56 Franklin St., where it is equipped to meet requirements with prompt deliveries.

Jackson Machine Tool Co., Jackson, Mich., manufacturer of die-sinking machines, is erecting a new building 280 by 182 feet to provide better facilities for taking care of the rapidly growing demand for its die-sinking machines.

Mott Sand Blast Mfg. Co., 893 E. 134th St., New York City, will occupy its new plant in Brooklyn early in April. The plant has been fitted up with facilities for manufacturing sandblast and allied equipment, in which the company specializes.

J. R. Stone Tool & Supply Co., 24 Goebel Bldg., Detroit, Mich., has been given the agency for the sale of machine tools built by the Greaves-Klusman Tool Co., Cincinnati, Ohio, and will act as exclusive representative in eastern Michigan, Detroit territory.

Wood Turret Machine Co., Brazil, Ind., manufacturer of the "Tilted Turret" screw machine and the automatic chucking turret lathe, has completed a new office building and an addition to its factory that will increase the manufacturing facilities about 50 per cent.

Standard Parts Co., Cleveland, Ohio, a consolidation of the Standard Welding Co. and the Perfection Spring Co., has purchased control of the Bock Bearing Co., Toledo, Ohio. William E. Bock, president of the Bock Bearing Co., has been made a director of the Standard Parts Co.

Lansing Stamping & Tool Co., Lansing, Mich., manufacturer of internal grinding machines and stampings of all kinds, has made plans for the erection of a large factory in the near future to provide better means for taking care of the phenomenal demand for its internal grinder and stampings.

Burdett Oxygen Co., Chicago Ill., has completed the erection of an oxygen plant at Salt Lake City, Utah, and is now in a position to furnish pure oxygen to users in the Salt Lake City territory. The new plant is one of a chain erected by the Burdett Oxygen Co. The capacity of its Los Angeles plant was recently increased 50 per cent.

Dodge Mfg. Co., Mishawaka, Ind., has acquired the properties and control of the products of the Oneida Steel Pulley Co. and the Keystone Steel Pulley Co., both of Oneida, N. Y. This purchase brings under one management the production of Dodge wood and iron solid and split pulleys, and "Oneida" and "Keystone" steel split pulleys.

Kelly Reamer Co., Cleveland, Ohio, has increased its factory floor space 50 per cent. The added facilities were required to take care of the greatly increased volume of orders for Kelly reamers received from automobile, steam pump and engine builders. The pay of the factory and office employes has been raised 10 per cent as a partial offset to the high cost of living.

Bradford-Ackermann Corporation, Forty-second St. Bldg., New York City, a corporation recently formed by A. H. Ackermann and C. C. Bradford, announces that arrangements have been concluded with Ashton, Laird & Co. for the sole selling rights of "Astra" high-temperature gas apparatus and oxygen welding appliances, manufactured from the designs and patents of E. Raven Rosenbaum.

Asia Publishing Co., 280 Madison Ave., New York City, has started a monthly magazine devoted exclusively to the Orient and our relations with it, called "Asia." The new magazine is to be run on broader lines than a trade paper, the effort being to convey through the publication an interpretation of the life and spirit of China, Japan and other great Oriental countries, in terms of their industrial progress.

High Speed Tools Corporation, 71 Broadway, New York City, has taken over the business of the Boerder Process Steel Co. of Toledo, Ohio. The new concern will engage in the manufacture of high-speed steel milling cutters, twist drills, reamers, and other tools cast by the Boerder process. It is incorporated under the laws of New York state with a capital of $1,000,000. Ernest Wolfes is the president, and A. Boerder is general manager.

Reynolds Pattern & Machine Co., Moline, Ill., has moved its plant to Massillon, Ohio. The company was recently incorporated under the laws of Ohio, with a capital of $200,000 and the name changed to the Reynolds Machine Mfg. Co. The board of directors have elected Floyd C. Snyder, president; Oliver F. Binford, secretary and treasurer; E. H. Birney, vice-president; and George D. Reynolds, general manager. Mr. Reynolds was general manager of the Moline plant, which employed about one hundred men.

Rider-Ericsson Engine Co., 20 Murray St., New York City, has been reorganized and plans have been made to extend the business of the company materially. The new officers are Samuel Andrews, president; A. W. Christianson, vice-president and general manager; Sanford Abrams, treasurer; and D. C. Dominick, secretary. The company is prepared to supply the trade with "Reeco" water supply systems, consisting of power pumps, gasoline and kerosene engines and pumpers, electric pumps, hot-air pumping engines, towers and tanks, pneumatic tanks and electric lighting plants.

Brown's Copper & Brass Rolling Mills, Ltd., New Toronto, Ontario, Canada, has awarded the contract to the Southwark Foundry & Machine Co., Philadelphia, Pa., covering the installation of a 2000-ton hydraulic extrusion press equipment for the manufacture of brass rod. The extrusion press will be in operation early in May; and with the present equipment in the company's new rod mill the output will be increased to over 5,000,000 pounds of finished rods monthly. The new mill for sheet metals will be in full operation in May, and the capacity will also be over 5,000,000 pounds monthly. The company has erected a large office building adjacent to its mills on the Lake Shore Boulevard.

Reclamation of High-Speed Steel

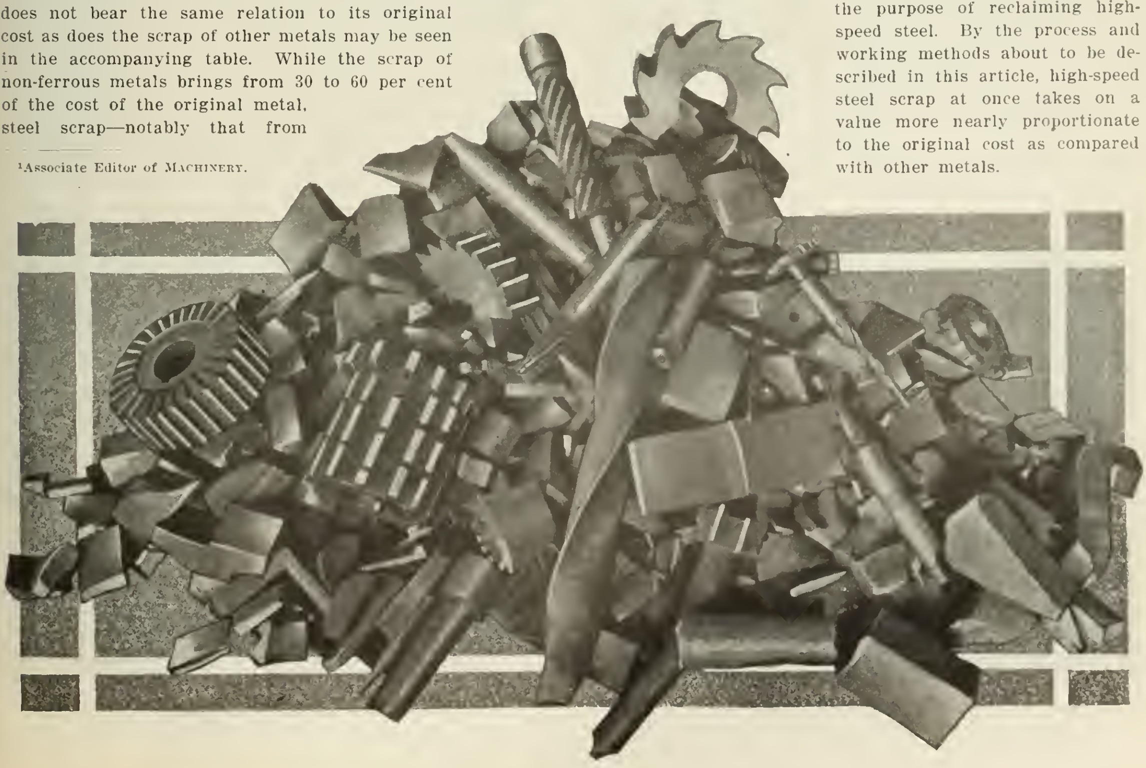
by Chester L. Lucas[1]

The high cost of metals and the need of rigid economy in their use, which must be enforced in order to meet war needs, gives this article on reclaiming high-speed steel scrap unusual interest and value in the present crisis. The scarcity of tungsten has forced the price of high-speed steel to an unprecedented height, and it is imperative that all tungsten be conserved wherever possible. The article describes the practice of utilizing worn-out high-speed tools and converting them into new high-speed steel.

FOR years, the mechanical world has paid a great deal of attention to saving the scrap, chips and sweepings of gold, silver, aluminum, copper, brass, lead and other metals of comparatively high value. Practically no effort has been made, however, to reclaim the scrap from high-speed steel, although it has greater value than any of the other metals except gold and silver. It is true that high-speed steel tool shanks are forged down for tool bits in some factories, but in most cases the scrap is sold for any price that it will bring.

High-speed steel scrap has always been of more or less doubtful quality, and naturally most steel manufacturers do not care to take in the scrap of other brands of steel than their own; consequently the market price for scrap has been low in comparison with the price of the original steel. That this does not bear the same relation to its original cost as does the scrap of other metals may be seen in the accompanying table. While the scrap of non-ferrous metals brings from 30 to 60 per cent of the cost of the original metal, steel scrap—notably that from high-speed steel—brings but a fraction of the original cost.

This discrepancy is probably largely due to the trouble experienced in separating steel scrap, because of the similarity of color and general appearance of all steels, especially after machining. An ordinary laborer can easily separate non-ferrous metal scrap because of its distinguishing colors, but it is a difficult matter to separate high-speed steel scrap from tool steel scrap. For this reason, therefore, high-speed steel scrap has been neglected. Steel manufacturers have sometimes taken back high-speed steel scrap from good customers in order to protect the accounts, but, in general, the practice has been to take back scrap only when necessary, and then to work it off in new steel as "diplomatically" as possible. With high-speed steel selling at $2.50 per pound and up, it would seem to be worth while to reclaim the scrap on a scientific basis, and with this in mind the Onondaga Steel Co., Inc., of Syracuse, N. Y., was formed for the purpose of reclaiming high-speed steel. By the process and working methods about to be described in this article, high-speed steel scrap at once takes on a value more nearly proportionate to the original cost as compared with other metals.



[1]Associate Editor of MACHINERY.

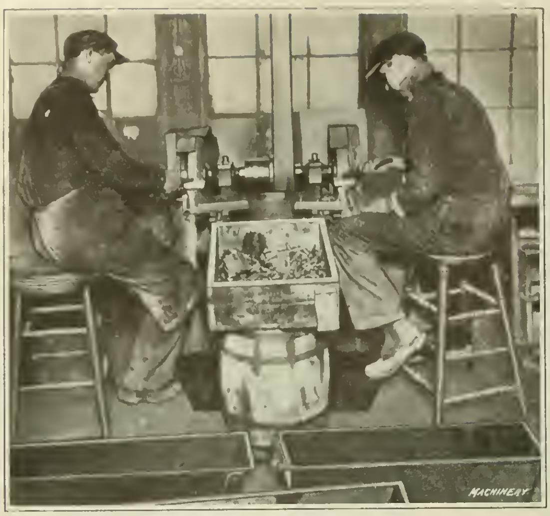


Fig. 1. Sorting High-speed Steel Scrap

Fig. 2. Weighing out Crucible Charge

High-speed Steel Scrap

A view of a typical high-speed steel scrap shipment, as received for reclamation by this company, is shown in the leading illustration. As may be seen, this scrap is a typical shop collection of broken cutters, drills, reamers, tools and end trimmings from the forge shop. The pieces comprise a number of different brands, and undoubtedly ordinary tool steel scrap has become mixed with it to some extent. The problem is to sort this steel into the various grades or qualities, and by properly proportioning each quality, obtain a uniform mixture of scrap to which is added certain carefully determined quantities of new materials, bringing the whole up to the required standard through remelting; then by a selected series of heat-treatments and hammer operations it is worked into a steel of equal or better quality than the original material.

COMPARATIVE PRICES OF NEW METAL AND SCRAP METAL IN FEBRUARY, 1917

Metal	New, per Pound	Scrap, per Pound	Metal	New, per Pound	Scrap, per Pound
Aluminum..	$0.59	$0.21	Zinc	$0.11	$0.085
Tin	0.51	0.38	Lead	0.09	0.07
Nickel	0.45	0.30	H.S. Steel..	2.50	0.10–0.25
Copper	0.32	0.24	Tool Steel..	0.16	0.04
Brass	0.54	0.20	Mch. Steel..	0.07	0.01

Machinery

Sorting the Scrap

The sorting of the high-speed steel scrap into different grades is the first and one of the most important steps in the process of reclamation. Fig. 1 shows two steel sorters at work. Several methods are used to determine the grade. First, and most important, is the "sparking" method. The sorters take each piece of stock and test it for qualities of sparks made in contact with a grinding wheel. From long experience, they are able to tell by the color of the spark, the size and shape approximately to what class the particular piece of steel belongs. The average machinist knows the difference between the sparks from high-speed steel and tool steel or machine steel, but the Onondaga steel sorters have carried this method much further and are able to tell the quality of high-speed steel by the sparks. A series of test-bars are at hand, each one of which is marked with its chemical content, so that in cases of doubt the sparks may be compared with those from a piece of known content. Each piece in every steel shipment goes through this sparking test, and is thrown into the box containing steel of like quality. To assist in this classification, the sorters become acquainted with the average grades of high-speed steels that are used in making drills, reamers, taps, cutters, etc., and this knowledge helps to verify their judgment in sorting the scrap.

Charging the Crucibles

After the steel of a shipment has been properly sorted it is ready to be charged into crucibles for melting. The steel contents for each crucible are carefully weighed, as is shown in Fig. 2, before being placed in the crucible. Irrespective of the quality of the high-speed steel scrap received, it is the aim of the Onondaga Steel Co., Inc., to turn out high-speed steel of uniform quality; that is, with as nearly as possible the same tungsten content. Fig. 3 shows how the tungsten is

Fig. 3. Adding Tungsten to Crucible Charge

Fig. 4. Hardening Tool Bits

Fig. 5. Stripping Ingot Molds

Fig. 6. Drilling Ingot to secure Chips for Analysis

Fig. 7. Rough-cogging Ingots

added to the charge in the crucible. Incidentally, the box of tungsten in the foreground of this illustration represents $600.

Melting and Teeming

The crucibles, properly charged, are lowered into the gas furnaces, and after being heated for four or five hours, the steel is entirely melted, absorbing the tungsten that has been added, and is ready for "teeming" or pouring into the ingot molds. The ingot molds accommodate an ingot about four inches square, and twenty-three inches long. The teeming is shown being done in Fig. 10, and the operation in this plant does not differ materially from the customary steel-making practice.

Fig. 5 shows the way the ingot molds are stripped and the ingots removed. The molds are of the split type and the halves are held together by square rings that are driven tight with tapered wedges. The high-speed steel scrap is now in the form of an ingot containing the proper amount of tungsten and other elements and is ready for hammering down to the finished sizes. As soon as the ingots have been stripped from the molds, they go to the annealing furnaces, where they undergo a heat-treating process before being "cogged" or rough-hammered.

After being thoroughly cooled, the ingots are taken to the grinding department, where they are gone over very carefully, as shown in Fig. 11, to remove any imperfections or blemishes in the faces of the ingots before being forged down to size. It is obvious that should any of these surface defects remain in the ingots, they would be hammered down with the surface and would result in flaws in the finished product.

"Cogging" the Ingot

The ingots are now heated to a full forging heat, and are "cogged" to bars two inches square by five or six feet long. The ordinary type of steam hammer is used, as is illustrated in Fig. 7, and the ingots are rapidly reduced. At this point in the reduction process, the semi-finished bars are again taken to the grinding department to have any imperfections removed and the corners of the bars ground off. This operation is illustrated in Fig. 8.

The two-inch bars are now taken to smaller hammers, where they are "cogged" to the smaller sizes; they then go to finishing hammers, where they are drawn down to the final sizes, as required by the customer. Care has to be used at this stage of reduction, as high-speed steel in the smaller sizes requires most careful treatment in heating and forging.

Inspection

Inspection forms an important part in this reclamation process. In addition to the great care that is used in sorting

Fig. 8. Removing Edges and Imperfections before Final Forging

Fig. 9. Cropping Bar Ends and inspecting

Fig. 10. "Teeming" or pouring Steel from Crucibles

the scrap steel, in charging the crucibles with the right "mix," etc., each of the ingots is tested for chemical content before reduction. Fig. 6 shows how the ingot is drilled, and the drill chips go to the chemical laboratory for analysis. From a report of the head chemist, it is of interest to note that in a comparison of thirty different ingot tests, all came within a surprisingly narrow range around the standard of tungsten and carbon aimed at. After the bars have been reduced to their final dimensions, the ends of each bar are cropped or broken off, as shown in Fig. 9, the resulting fracture is carefully examined, and the surface of the bars is inspected closely for seams. Defective bars are thus quickly detected and thrown out, while the good ones go to the finishing room, where they are labeled and packed for shipment.

An important use to which reclaimed steel is put is in the manufacture of the tool bits which the company markets. Fig. 4 shows the final, and a most important, step in the manufacture of tool bits. This is the hardening operation, and at this plant the tool bits are hardened singly. The illustration shows how the hardener feeds the tool bits into the furnace and withdraws them one at a time with special tongs. These tongs, incidentally, are worthy of notice because, by means of a telescoping finger, they can be operated with one hand. By putting the tool bits through the hardening operation singly instead of in lots, each tool receives the proper heat and no sacrifice in quality for the sake of quantity is made.

Very little has been done, up to the present, in reclaiming high-speed steel scrap, considering the fact that hundreds of tons of high-speed steel are manufactured every year. For this reason, the reclamation process should prove of great value to the mechanical world.

Fig. 11. Grinding Ingot before rough-forging

THE MACHINIST IN RELATION TO MODERN MANUFACTURING

BY H. W. JOHNSON [1]

There seems to be considerable apprehension regarding the ultimate result of the thinning out of the ranks of all-around machinists. It is true that in the average modern shop doing mass production the all-around machinist does not appear in any considerable numbers, but the writer does not believe that this condition is wholly bad. The old order, in which general machinists manned practically all the machines in a shop, was only one stage in the development of machine-shop management. Jobs were quite likely to be given to individual workmen to be completed in all operations. This scheme worked well at the time and is still likely to be used on repair work, although much of this can also be profitably subdivided.

When parts came to be made in such large lots that machines ran for days on one operation, the all-around man was the first one to become tired of running the same thing day in and day out. Handy-men were found to be better adapted to this sort of thing, and as they had no experience in governing speeds and feeds, scientific adjustment of output was easy. The proposition is sound from every viewpoint. The firm gets a big output, the man gets far more money than he earned as a laborer, and the machinist gets a raise and becomes a gang boss. When functional foremanship is in use, men with some, but not all, of the qualifications of successful military foremen are capable of giving satisfactory service. In other words, not only has machine operation been simplified, but also supervision.

It has been pointed out by some that the average man in the building trades approaches more nearly to all-around proficiency than does his brother in the machine shop. This is so, but it does not necessarily mean that a desirable state of affairs exists in the building trades. It simply indicates that the building trades are just about where the machine business was before the Taylor system was evolved. Some progress has been made in bricklaying, but it has not reached every mason contractor. It is only reasonable to look for as large a saving through scientific building as has been made in scientific manufacturing. Meanwhile the consumer (property owner) pays the bill. Neither do we believe that the larger unit pay in the building trades is attracting young men who might have become machinist apprentices. In the past six years the writer has employed in machine-shop work men from practically all the building trades. They were in the machine shop because they could average more per month than at their trade, this being due to absence of interference from bad weather and to the ability of the shop to make stock in advance of orders, which is seldom possible in house building. The machine shop provided steady work.

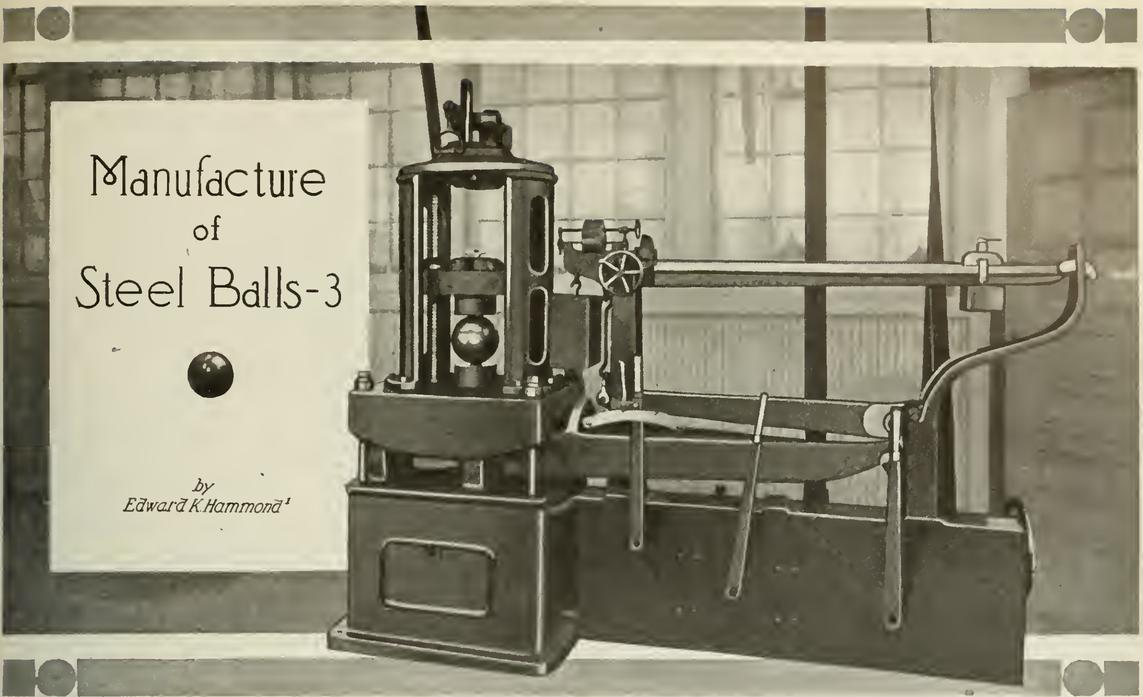
It is better not to try to sweep back the tide with a broom. Specialized manufacturing is here to stay because it is giving us better manufactured goods for less money than the old scheme could. With this system have come the specialist operator and the functional foreman. Just now we are using all-around machinists for gang bosses because they are available, but it will not be necessary to continue this practice, for gang bosses as well as machine operators can be trained to proficiency in their particular lines. Some positions will call for technical graduates. Maintenance work and some jobbing and toolmaking will call for all-around men, and it is fortunate that maintenance and tool departments and jobbing shops are the very places in which general machinists can be made. The supply can be fitted to the needs.

However, the writer does not belittle the importance of the various apprentice schemes now being advanced, for it is a peculiarity of the machinist's trade that it fits him for more positions, both in and out of the business, than any other line except politics. Nor is the money spent on a boy necessarily lost if he later takes up some other line of work. He is quite likely to send business to the old shop, if his memories of that shop are of fair treatment in a plant making a meritorious article.

[1] Address: 42 Maple St., Poughkeepsie, N. Y.

Manufacture of Steel Balls-3

by Edward K. Hammond[1]



A DESCRIPTION of the work of the inspection department which was published at the end of the preceding installment of this article explains the great care which is taken in examining the finished product of the Hoover Steel Ball Co. in order to be sure of eliminating all balls that are in any way defective. It is obvious that in the tonnage manufacture of a product that must meet such exact requirements as balls for use in high-grade annular bearings, the greatest care must be taken in the selection of raw material and in conducting each step in the process of manufacture in order to produce balls that will pass the inspection department. In addition to the requirements of high-grade balls that were referred to in the description of various examinations that are conducted by the inspectors, it is absolutely necessary for the balls to be of uniform hardness right to the center, because this is the only way of being sure that all balls will possess uniform durability and elasticity.

Assurance must be obtained that the steel received at the factory is of a suitable grade to produce balls that will fulfill the specifications before manufacturing operations are started, because if the balls were finished before it was found that they were defective, the raw material and the labor involved in converting this material into finished balls would be lost. Data showing that the steel fulfills these specifications are obtained from the results of tests conducted in the laboratory which is equipped with all the necessary apparatus for making physical and chemical tests upon the raw material. In addition, the laboratory is referred to by heads of the various manufacturing departments when any case of trouble arises, such as failure of the balls to harden properly, the production of more than the usual number of balls with cracks, and other troubles of this kind. Some exceptionally interesting results have been brought to light as the result of work conducted in the laboratory, and the present installment of the article will deal with the methods used by the metallurgists of the Hoover Steel Ball Co. in conducting tests on the raw material and the finished product; and reference will be made to some of the information that has been brought to light as a result of these tests.

Testing Raw Material

There are sidings from the Ann Arbor Railroad entering the plant so that cars may be run directly to the building in which the raw material is received and to the building where the finished balls are packed for shipment. The method of procedure in testing raw material is the same for both straight bars and stock which comes in coils; it consists of selecting six bars or coils of every size of stock received at the plant, from the end of each of which is cut a sample eighteen inches in length. From the inner end of this sample is cut a piece two inches long, which is boiled in 20 per cent hydrochloric acid for fifteen minutes to remove the outer scale. After this has been done, the surface of the metal is carefully examined to see that it is free from cracks or seams In addition to removing the outer scale, the acid tends to accentuate any surface defects that may be present, so that those that might be invisible in the bar as it comes to the plant can be quite easily seen after the treatment. In ball manufacture it is highly important for the stock to have a smooth surface, because any slight defects are carried right through the process of manufacture and are likely to become accentuated, with the result that balls produced from this stock will be rejected by the inspectors.

The regular routine tests of the raw material inspected in the laboratory also include a chemical analysis of the steel—especially as regards its carbon and chromium content—and a Brinell hardness test. The latter is especially important in the case of "wire" under 11/16 inch in diameter that is converted into ball blanks by the cold-heading process, because excessive hardness of this material is likely to give trouble through the breakage of the cut-off knives or the dies used on the cold-headers. In order to give the best possible results, stock for the cold-heading machine should have a Brinell hardness of 170, but material of slightly greater hardness could be worked without undue trouble. When the preliminary tests made in the laboratory show that the steel is not up to standard, further examinations are made to determine possible defects produced by the mechanical treatment at the rolling mills. This is done by polishing one end of the test sample and examining the surface under a microscope to determine defective conditions resulting from segregation or the formation of a pipe at the center of the bar. In cases where laboratory tests do not show that the stock is defective, an "unloading ticket" is made out and sent to the stock-room, authorizing the material to be taken from the cars and placed in storage, ready to be drawn out on requisition by the manufacturing department.

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Tests of Seamy Cold-drawn Wire

In describing the inspecting of balls, reference was made to the rejection of those with what are known as fire cracks. These exist almost entirely in balls up to and including 5/8 inch in diameter, the blanks for which are made by the cold-heading process; it seldom happens that fire-cracked balls are found in sizes over 5/8 inch, blanks for which are made by the process of hot-forging. A study of this subject reveals the fact that after cold-heading, ball blanks almost invariably have some sort of crack, and in a great many cases these cracks are quite deep. At first it was thought that this was due to a large percentage of chromium in the steel, which has a tendency to make the metal brittle, but subsequent investigation showed that this is not the case.

Study of Seams in Steel Bars and Wire

Defects revealed by boiling the metal in hydrochloric acid run lengthwise of the bar; sometimes these extend for the entire length of the coil, while in other cases only one end is found to be defective. For want of a better name, the laboratory has called these defects "seams," and it has been proved that wire with seams will in all cases be split to some extent during the process of cold-heading, while that without seams will produce perfect balls in the cold-heading machines. In some cases the cracks opened up in the balls while cold-heading are not so deep that they cannot be eliminated during the subsequent treatment to which the blanks are subjected; but in other cases it may happen that these splits in the blanks are so deep that they reach below the surface of the finished balls, in which case the balls will be rejected by the inspectors because they contain what are commonly known as "fire cracks."

The investigations conducted in the laboratory relative to troubles resulting from stock having seams or scratches have developed the following information: (1) Cold-drawn wire on which the surface is apparently quite smooth, and on which no seams are visible, is found to possess minute laps or seams after being etched with hydrochloric acid. (2) Although these seams may not be deep on the original wire, they are accentuated by the stretch which the surface of the wire undergoes during the cold-heading operation. (3) Such cracks are likely to be still further accentuated in hardening, and in many cases they will cause the ball to split in half.

In making a study of the effect of seams and scratches on the steel, it is the practice, as previously mentioned, to etch the stock with 20 per cent hydrochloric acid for fifteen minutes. After this has been done, it is passed across a grinding wheel having a face width of only 1/16 inch, care being taken to impart a combination rotary and transverse motion to the stock so that a helix is described on the surface, as shown in Fig. 32. This is preferable to passing the wire across the wheel without etching, because the action of the acid first lays open any surface defects which may be closed so tightly by the pressure of the cold-drawing operation that they will be invisible to the eye unless subjected to the acid treatment. The acid also makes the cracks black, and subsequent grinding exposes the white surface of the adjacent metal so that the crack is brought into as great prominence as possible.

Testing for Seams in Stock by Application of Pressure

Recently another test for revealing these seams has been developed, which consists of upsetting short blanks cut from the bars. These test blanks are 7/16 inch high and are ordinarily subjected to a pressure of 20,000 pounds, which results in flattening them out to a height of 3/16 inch, or to a pressure of 50,000 pounds, which flattens them out to a height of 3/32 inch. In all cases where there are seams in the wire, these test samples are split open by this pressure, while a perfect wire without any seams is not damaged by the treatment. At *A* in Fig. 33 are shown a sample cut from wire containing a seam and the same blank partially and fully upset; it will be noticed that, although the seam in the wire is small, it has been widened out considerably by the upsetting. At *B* in the same illustration is shown a similar set from perfect wire, comprising a blank and partially and fully upset samples, and it will be seen that the upset sample does not show any tendency to split.

In order to give some idea of the extent to which the seam at *A* was deepened by the upsetting treatment, section a–b through the blank and section c–d through the flat disk were polished, and photomicrographs of these are shown in Fig. 34. At *A* in Fig. 34 the seam in the original wire was about 0.010 inch in depth, while at *B* the depth of the seam after the blank has been upset has been increased to approximately 0.050 inch. From this it will be apparent that seams in the wire that do not appear to be of sufficient depth to give trouble may become very objectionable because of the tendency to deepen during the conversion of the stock into ball blanks. Upset disk *B*

Fig. 30. General View in Physical Laboratory. Attention is called to Brinell Hardness Testing Machine, Shore Scleroscope and Camera for taking Photomicrographs

Fig. 31. General View in Chemical Laboratory, showing Apparatus for making Analyses of Steel, and Electric Furnace used in conducting Special Heat-treating Operations

is of about the same diameter as a ball blank made from this wire by the cold-heading process, so that it has been subjected to about the same amount of stretch in upsetting that would ordinarily take place in making a ball blank by the cold-heading process. To show how trouble may develop in this way, a ball 0.375 inch in diameter is produced from a blank 0.400 inch in diameter, so that the blank is reduced 0.025 inch on the diameter, or approximately 0.013 inch on the radius. This leaves 0.050 minus 0.013, or 0.037 inch of the split extending below the surface of the finished ball, which will certainly lead to its rejection by the inspectors.

It appears that hardness of the wire does not cause splitting of the upset blank. Tests conducted with a view to establishing this fact have shown that blanks made from seamless steel with a high Brinell hardness number did not split under the most severe conditions of upsetting, while blanks of metal with a low Brinell hardness number, but with seams on their surfaces, were frequently split during the process of cold-heading. Specifications under which steel is purchased for the production of ball blanks in cold-heading machines call for metal with a hardness number not exceeding 170 as determined by the Brinell method, but slightly harder stock is capable of being worked with fairly satisfactory results.

How Seamy Stock Acts in Cold-heading Machine

In order to confirm the accuracy of the conclusions reached in regard to the action of seamy stock when worked up into ball blanks in the cold-heading machines, tests were conducted by placing coils that had bad seams in them on the cold-headers and observing the kind of ball blanks that were produced. In every case it was found that the blanks produced from such stock showed bad cracks, as shown at *A* in Fig. 35. In the inspection department, cracks found in finished balls are commonly referred to as "fire cracks" on the assumption that they were developed during the process of heat-treatment, but they should really be designated as "header cracks." In this illustration attention is called to the fact that at the top and bottom of each ball blank there is a small projection formed by pressing the metal into the knock-out pin hole in the header dies. These have been termed "poles," and it will be noted that the poles lie on the axis of the wire. Midway between the two poles there is a band or "fin" caused by the metal being forced out between the two header dies; and this fin has been termed the "equator" of the ball.

It will be noted at *A* in Fig. 35 that the header cracks run from pole to pole. At *B* in the same illustration are shown some finished balls with the same kind of cracks, and it has always been found that cracks in the finished balls have been lengthened to a considerable extent, the ends of these cracks terminating in very fine lines. This is due to the fact that a small crack or fine sharp tool mark on a piece to be hardened causes a weak spot which in many cases will result in splitting the piece during the process of heat-treatment. At *A* in Fig. 36 are shown some balls that were picked out in the inspection department because they had fire cracks; these were sent to the laboratory and fractured to reveal the grain of the metal. It will be noticed—particularly in the third ball of the third line—that at the extreme left of the fracture there is a dark spot near the surface, which is the mark left by the original crack produced during the cold-heading operation. Then to the extreme right there is a fresh fracture which represents all the metal that the ball had to hold it together after being hardened.

Attention is called to the fact that the middle of the ball is black and oily; this is the hardening crack into which the oil and abrasive have found their way during the oil-rolling and grinding operations. It is believed that the crack produced in cold-heading was undoubtedly the cause of a further cracking of the ball during the process of heat-treatment. At *B* in Fig. 36 are shown some finished balls that were rejected by the inspectors because of cracks. Before being photographed these balls were etched with hydrochloric acid, and it will be noticed that the cracks run from pole to pole, and in some cases there are also secondary cracks following the line of the equator. The way in which these equatorial cracks are produced can best be explained by reference to a longitudinal section of the wire shown at *A* in Fig. 37, which has been etched with hydrochloric acid to reveal the structure of the metal.

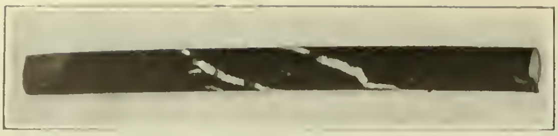


Fig. 32. Sample of Steel "Wire" etched and ground to show Seam

Attention is called to the lamellar structure, which is characteristic of any steel and is no reflection upon its quality. These laminations run lengthwise of the coil. At *B* is shown a section of a headed ball blank made from a piece of this wire and etched with acid to bring up the structure of the metal. Here it will be seen that the laminations have arranged themselves in a manner similar to magnetic lines of force running from pole to pole.

At *D* and *E* are shown header-cracked ball blanks, and it will be noticed that blank *E* shows an unusually large fin on one side. Blank *D* shows the split on one side and also a portion of the split extending into the fin. Blank *F* is properly headed and shows no crack or excessively large fins. Referring to the view shown at *C*, which is a cross-section of blank *D*, it will be seen that the split extends into the fin, and it will also be noted that the crack extends below the surface of the ball, although it comes to the surface at each end at points near the poles. This is due to the fact that the split does not penetrate the ball at right angles to the surface, but runs on a slant. Instead of compressing and filling up the open space in the ball, material has been pressed outward and

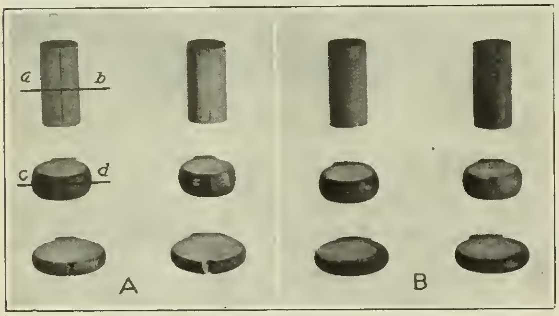


Fig. 33. (A) Samples cut from Steel with Seam in Surface, and Same Samples partially and fully upset, indicating how Seam opens up through Application of Pressure; (B) Similar Samples from Steel without Seam, which show No Tendency to split

made a large fin; when this fin is ground away, the crack is quite evident. At *G* and *H* are shown finished balls that have been etched with acid to show the grain at the equator and at the poles, respectively.

Referring again to the sectional view of the wire shown at *A* in Fig. 37, and also to the cross-section of a ball blank made from this wire shown at *B*, it will be seen that the structure of the steel has been greatly disturbed during the process of cold-heading to produce the ball blank. In Fig. 38 is shown diagrammatically the way in which this disturbance takes place. It will be seen that the ends of the fibers come to the surface at the poles and at both sides of the equatorial fin; and when the ball is etched the steel is attacked more rapidly at these points. The peculiar marks shown at *G* and *H* in Fig. 37 are the result of this disturbance of structure. The conclusion has been reached that when a ball with so-called "fire cracks" is etched with acid and shows two end poles and two equatorial marks with a wide crack running from pole to pole and a secondary crack running between the two equators, this crack is a header crack which is caused by a seam or lap in the steel from which the ball was made.

A number of these balls with header cracks were heated in an electric furnace in the laboratory and quenched in water at 1500 degrees F.; every ball was further cracked by this treatment, and several of them fell in half or were easily broken by a light hammer blow. Another lot of balls with no header crack was heated in the electric furnace and quenched in water at 1600 degrees F., and not a ball was cracked in

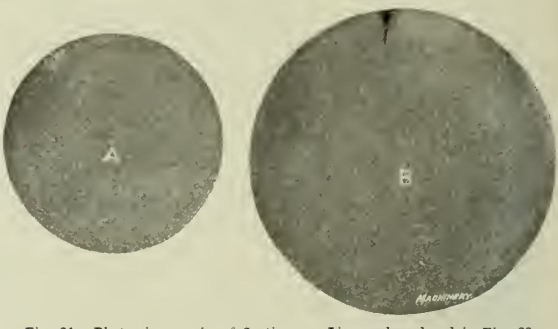


Fig. 34. Photomicrographs of Sections on Lines a–b and c–d in Fig. 33, indicating Increase in Size of Seam through stretching of Metal Surface in upsetting

hardening. Balls quenched in water at 1500 degrees F. that broke during the process of heat-treatment are shown at *A* in Fig. 39, while the balls quenched in water at 1600 degrees F., without damage are shown at *B* in the same illustration. At this excessive temperature the grain of the metal was coarsened, but no hardening cracks were produced and it required considerable force to break the balls. Several finished balls were next selected in the inspection department that showed very slight header cracks. These balls were hardened at 1500 degrees F. and cracked in the process of hardening exactly as before. The characteristic black mark left by the original header crack is shown at one side of the balls at *C* in Fig. 39. Another lot of finished balls showing no header cracks was hardened at 1600 degrees F. and none of the balls was cracked, views of the fractured surfaces of these balls being shown at *D* in Fig. 39. This confirmed the accuracy of previous tests, and from these data the following conclusions were drawn: (1) The header crack forms a weak spot, so that when the ball is hardened, even at the proper temperature, what the inspectors call a "fire crack" is likely to be produced. (2) A ball with no header cracks can be hardened at an excessively high temperature without producing a fire crack.

Another hardening test was made with four samples of wire, two pieces of which showed seams, and two pieces that did not. The seamy pieces of wire were quenched at a temperature of about 1500 degrees F. in water and hardening cracks developed along the seams. The two pieces without seams were quenched in water at a temperature of 1600 degrees F. and no cracks

Fig. 35. (A) Cold-header Ball Blanks, showing Splits running from Pole to Pole; (B) Finished Balls produced from Blanks split during Cold-heading Operation

Fig. 36. (A) Fractures of Balls shown at (B) in Fig. 35, showing Original Header Crack, Fire Crack and Fracture of Uncracked Metal; (B) Etched Balls, showing Crack from Pole to Pole and Crack on Equator

developed. All these tests show that with small blanks without any header cracks, it is practically impossible to produce fire cracks in the automatic hardening furnaces; when cracks are produced they are started in cold-heading and not through the process of heat-treatment. The shape of the ball is in its favor, as it insures uniform quenching and a minimum of internal strain. Application of too high a temperature would tend to increase the size of the grain in the steel and make it brittle, but it would not produce hardening cracks.

Effect of Hardness of Wire

When the wire used in making ball blanks on cold-headers is too hard, there is a tendency for it to break off instead of shearing as it should. When trouble of this sort is encountered, it is likely to be accentuated by the fact that the blank is often carried to the heading die in a sidewise position, which results in the development of abnormal pressure in the die. Working hard stock of this kind is likely to result in breaking the cut-off knife or the dies on the cold-heading machine. This condition of excessive hardness does not usually exist for the entire length of the coil; wire may shear off and head nicely for some time, when suddenly a hard spot will be reached

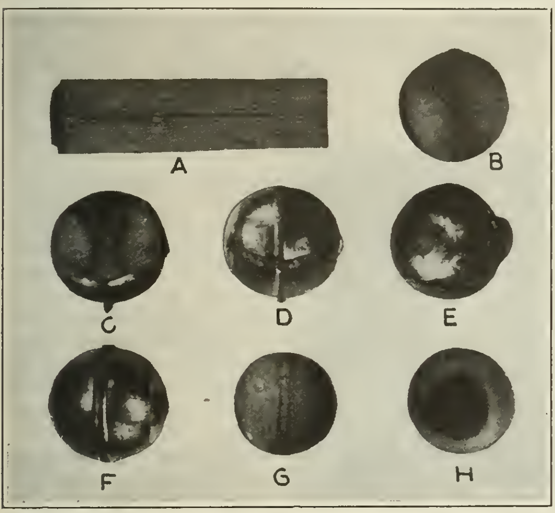


Fig. 37. (A) Section of Steel Stock, showing Lamellar Structure; (B) Cross-section of Cold-header Ball Blank, showing Distortion of Steel Structure; (C) Cross-section of Header Cracked Ball Blank; (D) Ball Blank shown in Cross-section at (C); (E) Cold-header Ball Blank with Large Fin; (F) Perfect Cold-header Ball Blank; (G) Etched Ball, showing End Grain of Steel at Equator; (H) Etched Ball, showing End Grain of Steel at Pole

and then the dies or the cut-off knife is likely to suffer. After this hard spot has been passed, the wire may be all right for another period of considerable duration. With the view of showing the relative condition of hard and soft spots in the wire, slugs of metal were selected at a point where trouble was encountered from this cause, and again at a point where the operation of the cold-header was entirely satisfactory. These were tested by the Brinell method and it was found that the hard slugs had a Brinell hardness number of 215, while the soft slugs only showed a Brinell hardness number of 190. The latter is really higher than it should be, as 170 is specified for steel to be used in cold-heading machines.

Fig. 39. (A) Fractures of Header Cracked Balls that broke when re-heat-treated in Laboratory at 1500 Degrees F.; (B) Fractures of Perfect Balls that did not break when re-heat-treated at 1600 Degrees F.; (C) Fractures of Balls with Slight Cracks which broke when re-heat-treated at 1500 Degrees F.; (D) Fractures of Perfect Balls that did not break when re-heat-treated at 1600 Degrees F.

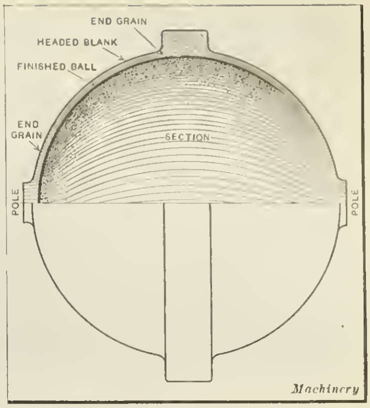


Fig. 38. Diagram illustrating Distortion of Steel Structure in Cold-header Ball Blank similar to that shown at (B) in Fig. 37

At *A* in Fig. 40 is shown the fresh fracture of a slug of hard metal, and attention is called to the coarse grain as compared with the finer grain of the normal steel shown at *B*. The hard specimen was very brittle and easy to break, while the normal steel was tough and capable of bending considerably before being broken. Specimens of these two steels were next polished and etched, with the results shown at *C* and *D*, respectively. These are transverse sections cut through the wire, and attention is called to the coarse grain of the steel shown at *C*; the ring at the surface is a band of decarbonized steel produced by the application of too high an annealing temperature. The normal steel shown at *D* has a fine grain and there is no indication of decarbonization, although what appears to be a band at one side of this section is in reality a thin oxidation film caused by the etching reagent.

At *A* in Fig. 41 is shown the decarbonized band of steel surrounding section *C* in Fig. 40, which is magnified to 62 diameters, instead of 5.25 diameters, as in the case of the previous illustration. It will be noted that the extreme edge of this photomicrograph is somewhat indistinct, owing to the slightly rounded edge formed while polishing the specimen. The decarbonized surface of this stock would not be entirely removed in the process of grinding, and would result in the production of either soft balls or balls with soft spots. At *B*, Fig. 41, we have the condition where there is practically no loss of carbon at the surface, with a proportional increase in the size of grains, although this is not enough to cause trouble. At *A* and *B* in Fig. 42 is seen a decided contrast between the structure of the slug of hard metal and that taken from the normal wire. At *A* there is a pronounced pearlitic structure with distinct cell boundaries of excess cementite, which also indicates the application of too high an annealing temperature. At *B* the structure is fine grained, which is the condition produced by employing the proper annealing temperature. Where lack of uniformity is discovered in the hardness of the wire, it is probably due to application of too high an annealing temperature.

Cause of Soft Spots on Balls

Some valuable discoveries have been made in the laboratory as a result of work that was started with some other object in view. For instance, an investigation that was started with the view of determining the effect of slight seams found in a certain shipment of steel at the time of the preliminary tests. These seams were not considered serious enough to justify rejection of the steel, but after the first lot of blanks had been finish dry ground, tests

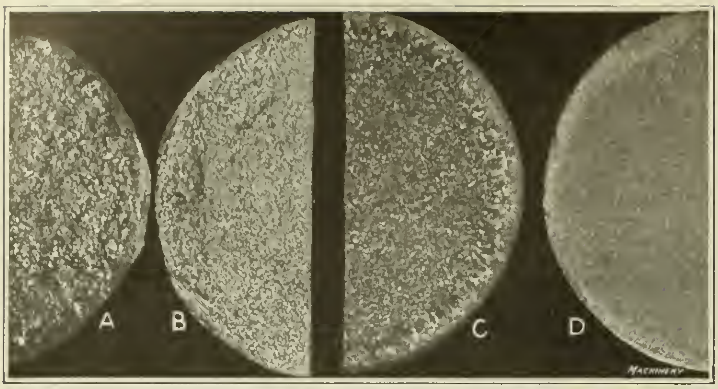


Fig. 40. (A) Fracture of Hard Metal Slug; (B) Fracture of Normal Metal Slug; (C) Etched Surface of Hard Steel magnified 5.25 Diameters—Attention is called to Decarbonization at Circumference; (D) Etched Surface of Normal Steel with No Decarbonization at Circumference

were made. This was done by etching a number of balls in hydrochloric acid, to see if the seams had been removed in grinding. The balls were immersed in the solution until they assumed its temperature, and after being etched for fifteen or twenty minutes they were removed, washed in water and brushed.

When treated in this way, the balls are usually a light gray color over their entire surface, but the particular lot of balls referred to could not be uniformly etched. At first it was thought that a film of grease or some other foreign matter was interfering with the action of the acid, but a second trial resulted in the same mottled appearance of the etched balls. Part of the surface was light gray, while other parts were dark gray and almost black. Balls with these spots are shown in Fig. 43, and no matter how often they were re-etched, the same spots always appeared and they were of the same outline as those developed by the previous etching. Some of the unetched samples were examined, and it was found that a considerable quantity of black scale was left on the balls, *i. e.*, the forging had not been cleaned up properly after the finish dry-grinding. At this stage the ball consistently measured 1.135 inch, *i. e.*, within 0.010 inch of the finished size—1⅛ inch.

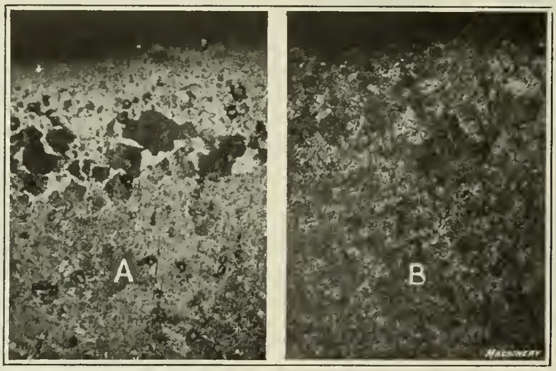


Fig. 41. (A) Decarbonized Surface shown at (C) in Fig. 40 magnified to Sixty-two Diameters; (B) Same Magnification as at (A), showing Condition of Practically No Decarbonization

Thus far results seemed to indicate that the forging blanks were under size, so five samples were selected at random and measured. The measurements of these five blanks are given in Table 4, reference to which will show that dimension A across the poles and dimension B near the poles were of ample size; and the surfaces at or close to the poles were also smooth and well filled out. However, these conditions did not exist around the equator, where it will be seen that dimension C was scant in many balls, and additional trouble was caused by the fact that the surface was very rough and covered with "hills" and "valleys." In making these equatorial measurements with a micrometer, the distance is taken across the tops of the "hills," while the dimensions in the "valleys" will obviously be considerably less. It is doubtful, therefore, whether three out of five of these samples would clean up in the rough dry-grinding. A re-examination of the etched dry-ground balls showed that the peculiar black spots did not appear at the poles as frequently as they did at the equator; and when a new file was applied to the black spots shown in Fig. 43, it was found that they were dead soft, while the light gray spots were very hard. The scleroscope hardness of ten of these balls was taken and averaged as follows: black spots, 48; gray spots, 70.

The reason for these spots will be understood from the photomicrographs presented at A and B in Fig. 44, which are taken from polished surfaces at the extreme outer surface of the black and white spots on the balls. These surfaces were prepared and photographed in exactly the same way; instead of polishing a flat on the ball, the spherical surface was polished, because a flat surface having any width whatever would also be at a considerable depth below the surface of the ball, and would not reveal conditions that it was desired to investigate. Difficulty was experienced in polishing this spherical surface, and so the photographs reproduced in Fig. 44 show polish marks rather too distinctly, but these have no bearing upon the accuracy of the results obtained in the investigation. At A is shown a large percentage of free ferrite, indicating a hypo-eutectoid structure of about 0.30 to 0.40 per cent carbon; in other words, the metal is similar to a mild steel. On the other hand, the condition revealed at B is practically a pure eutectoid structure of pearlite, this steel having from 0.85 to 0.90 per cent carbon. Specifications under which the steel is purchased call for from 0.85 to 0.95 per cent of carbon, so that in this regard it fulfills requirements. At B in Fig. 44 is illustrated steel of the original carbon content, while A illustrates the decarbonized steel.

A further test was conducted by preparing flat surfaces on the balls and examining these under the microscope; and in both cases it was found that photomicrographs obtained in this way indicated metal containing its full percentage of carbon. Hardness tests show that the metal directly under a decarbonized spot is soft and indicate not only that the decarbonized surface fails to harden, but that it also forms a sort of insulator and retards the proper hardening of the eutectoid steel beneath it. Therefore, the decarbonization plus its effects means a soft area of decided depth, so deep, in fact, that when the ball is finished the soft spot still appears.

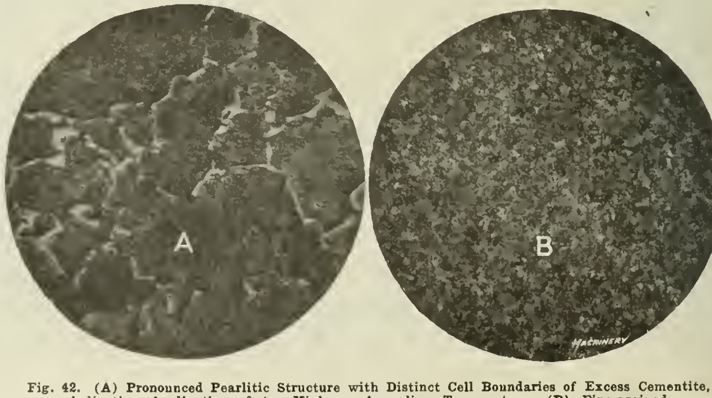


Fig. 42. (A) Pronounced Pearlitic Structure with Distinct Cell Boundaries of Excess Cementite, indicating Application of too High an Annealing Temperature; (B) Fine-grained Structure, showing Condition obtained with Proper Annealing Temperature. Both Samples magnified to 225 Diameters

Fig. 43. Finish Dry-ground Balls after being etched with Hydrochloric Acid, showing Mottled Appearance due to Soft Spots produced by Decarbonization of Steel

Having reached this conclusion, specimens of the raw material were prepared by cutting sections transversely from the bar, and these were prepared and photographed, Fig. 45 illustrating the conditions that were revealed in this way. It will be noted that the steel shown at *A* is decarbonized to a depth of 0.010 inch — 0.020 inch on the diameter of the ball—while in the sample shown at *B* there is no decarbonization. It was this steel with the decarbonized surface that produced balls showing soft spots in the tests.

Fifty of these balls showing soft spots were taken to the laboratory, where they were again heat-treated, and the result was that the balls came out hard. It was not considered, however, that this indicated defective heat-treatment in the process of manufacture, because it might have happened that the operation of finish dry-grinding removed enough metal from the surface so that the balls would harden properly, although they were prevented from doing so at the time of the original treatment by the decarbonized steel that covered the surface of the balls. Because of the oval shape of the forgings, the depth of decarbonization varies at different spots on the rough-ground surface of the balls; for example, at the poles there is little or no decarbonization, while around the equator the decarbonization is quite deep. When a ball is reduced to the finished size, the following conditions will be found: (1) decarbonized areas where the original decarbonization on the rough ball was deep; (2) soft areas where the original decarbonization on the rough ball was shallow; (3) hard areas where there was little or no decarbonization on the rough ball. In cases (2) and (3) the steel has its full percentage of carbon, and when the balls are rehardened some of the soft spots disappear, while the spots devoid of carbon still remain soft. It would be possible to reduce these balls to a smaller size and reclaim them by rehardening, but this subsequent heat-treatment makes the balls shrink and also has a tendency to roughen their surface slightly, which necessitates subsequent grinding operations that would probably reduce the diameter from 0.015 to 0.020 inch, so that allowance must be made for this reduction in size.

To overcome trouble from the use of stock that is decarbonized at the surface, special forging dies were made which produce oversize ball blanks, so that the diameter at the equator measures from 0.060 to 0.080 inch more than that of the standard finished balls. The same stock forged in a regular die would make a blank 0.025 inch to 0.035 inch larger than the finished size. In the present case it is found that these would not clean up, but left soft and decarbonized spots on the surface of the finished ball. For this reason, the special forging dies were produced. This practice was adopted because, owing to the slow deliveries made by the steel mills, it was desired not to reject any steel that could possibly be used.

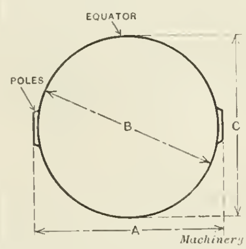
Development of a Device for Separating Hard and Soft Balls

Owing to shipment to the factory of a large quantity of low-carbon steel through an error made at the steel mills, about seven tons of this material was converted into ball blanks before it was attempted to harden them. This was due to the fact that a large supply of blanks of the same sizes had accumulated, and these were naturally sent through the heat-treating department ahead of blanks made from this shipment of steel. When the blanks had been heat-treated, they were tested in order to determine the nature of the results obtained, and while a number of balls broke with a fine-grained fracture and showed a hardness that was all that could be desired, almost 10 per cent of the balls were found to be dead soft. When these balls were subjected to pressure they flattened out instead of breaking in the usual way. A peculiar mottled effect was noted on the balls found to be file hard, while the soft balls were a dull black color; but this difference in appearance was not sufficiently marked to enable the balls to be separated, and even had this been possible, the length of time required to eliminate defective balls by this method would have been prohibitive.

With a view to overcoming this difficulty, a device was developed which is shown in diagrammatic form in Fig. 46. Its principle of operation is based on the fact that when balls are dropped on a hardened steel anvil there is considerable difference in the height of the rebound of hard and soft balls

TABLE 4. MEASUREMENTS OF BALLS ACROSS POLES, NEAR POLES AND AT EQUATOR

Sample	A	B	C			
1	1.169	1.167	1.166	1.161	1.160	1.166
2	1.166	1.165	1.161	1.157	1.163	1.162
3	1.168	1.155	1.151	1.145	1.145	1.150
4	1.169	1.175	1.175	1.172	1.170	1.159
5	1.170	1.168	1.152	1.170	1.158	1.167



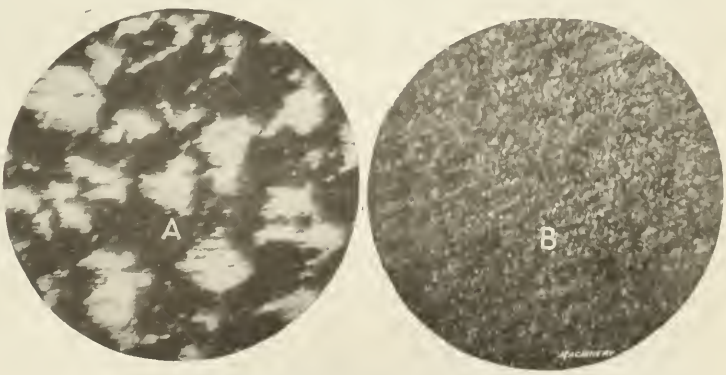


Fig. 44. (A) Photomicrograph of Black Soft Spots on Balls shown in Fig. 43, showing Large Percentage of Free Ferrite and Hypo-eutectoid Structure; (B) Photomicrograph of Hard White Spots on Balls shown in Fig. 43, indicating the Desired Eutectoid Structure

The balls to be tested roll down an inclined plane and drop upon a hardened steel block, from which they rebound; the hard balls rise high enough to pass over a "hurdle" into a box, while the soft balls do not reach this height and are deposited in a second box. To test the efficiency of this device, 119 balls taken from one of the tote pans in the shop were run through the drop test; 79 dropped into the "hard bin" and 40 into the "soft bin." These balls were once more thoroughly mixed and again run through the apparatus with the same result as in the previous case. Additional trials confirmed the accuracy of the apparatus. This method of separation proved so satisfactory that a regular equipment is now being built for use in the dry-grinding room, where it will be used for separating hard and soft balls.

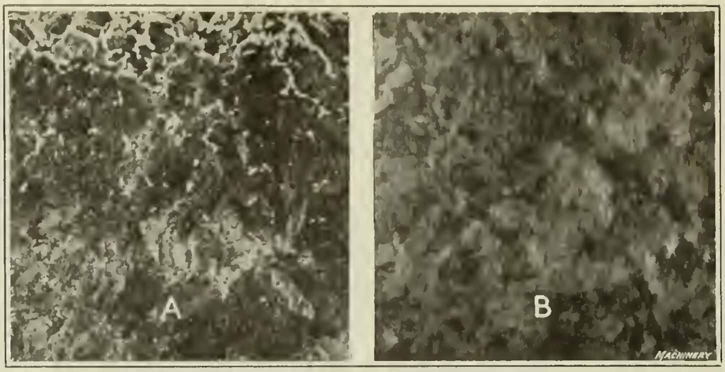


Fig. 45. (A) Photomicrograph of Transverse Section of Decarbonized Edge of Steel—Magnification, 125 Diameters; (B) Photomicrograph of Transverse Section of Steel showing No Decarbonization—Magnification, 125 Diameters

Conclusion

Many of the cases of trouble to which reference has been made are of rare occurrence, but it is obvious that they exert a powerful influence on the quality of the product turned out in the factory. Also, the conditions brought to light by these investigations are exceptionally interesting. It was on this account that they were selected for discussion in the present article, in connection with the regular work of the laboratory, and not because they really belong to a description of routine work of testing the raw material and product of a factory engaged in the manufacture of steel balls.

* * *

MAKING PISTON RINGS

BY B. T. HAWLEY[1]

I was required to make some snap piston rings to fit an air-compressor cylinder 8 1/32 inches in diameter, the piston-ring groove being ½ inch wide. Wishing to profit by the experience of others, I sought data on piston-ring design, but found nothing that would help, so I made the ring as follows: A hard gray-iron casting was obtained from a pattern that had an inside diameter of 7 7/8 inches, an outside diameter of 8 3/8 inches and a length of 4 inches. The inside of the casting was not machined, so that the scale might be left for spring. The casting was chucked in a lathe 1/16 inch off center, giving a run out of 1/8 inch, and the outside diameter was turned to 8 1/4 inches. The rings were then carefully cut off 0.01 inch longer than the finished dimension with a parting tool, and ground on a surface grinder to a close fit in the piston-ring grooves. Next, a slot 3/8 inch wide was milled through the thinnest part of the piston-ring at an angle of 45 degrees with the face. A simple fixture was then made for finishing the outside diameter by chucking, in a lathe, a cast-iron disk 8 inches in diameter. This was permitted to protrude from the chuck 1 inch, and a shoulder 7.315 inches in diameter and 3/8 inch long was turned on its end. A clamp washer, the outside diameter of which was 7 7/8 inches, was fitted to this disk and drawn on with four cap-screws. The cut rings were placed on this shoulder and the ring ends drawn together with a rawhide belt lace. Then, while each ring was held so that its thickest part hugged the turned diameter of the fixture, it was turned with a scraped finish to the exact diameter of the cylinder, and finished except for a few thousandths of an inch, which was filed off the ends of the rings when they were being fitted to the cylinder.

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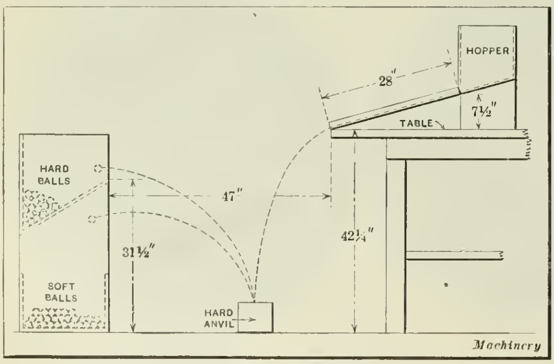

Fig. 46. Diagram Illustrating Principle of Apparatus developed for Automatic Separation of ¾-inch Hard and Soft Balls

Fig. 47. Highly Magnified Surface of Polished Ball, showing that under Best Conditions Surface is covered with Multitude of Scratches

* * *

MACHINERY IN WARFARE

The European war is characterized by the use of machinery on a larger scale than has ever before been experienced in warfare. The so-called "tanks" used by the British in the operations on the Somme are the latest developments of machinery applied to destruction. These tanks are armored caterpillar tractors, which by reason of their design are able to traverse areas impossible to negotiate by ordinary wheel vehicles. H. G. Wells, the well-known British writer, predicts that if the war continues tanks will be developed to enormous size and power, and will be the most terrible agents of destruction ever known. He visualizes monsters weighing many hundreds of tons, driven by engines of enormous power and tracking many yards in width. These gigantic land battleships would be practically irresistible in their onward march. They would level and crush fortifications, buildings, forests, and other obstacles, and the very land itself would be so cut to pieces as to be worthless for agricultural purposes or other uses for years to come. What this war will bring forth in the way of destructive agencies it is hard to say, but the heavy gun of mobile type seems to be the most effective weapon.

USE OF DIAGRAMS IN MACHINE DESIGN[1]

VALUE OF ANALYSIS OF MECHANICAL MOVEMENTS IN LAYING OUT AUTOMATIC MACHINES

BY J. W. WUNSCH[2]

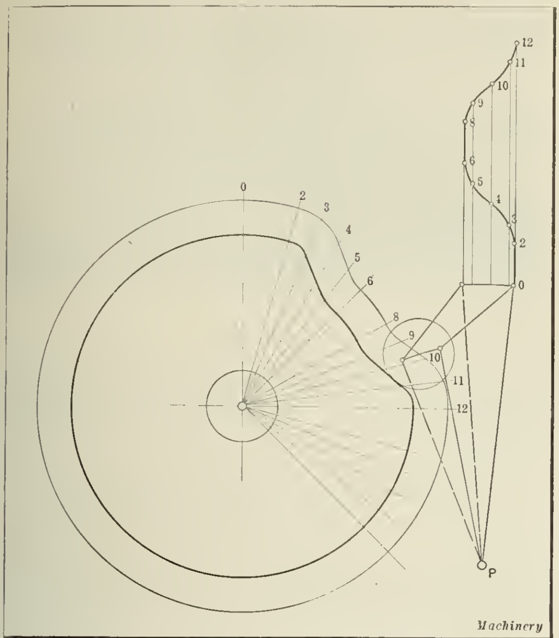

Fig. 1. Analysis of Movement of Simple Cam

A DIAGRAM, in machine design, is the graphical representation of one or more movements or functions of a mechanism through a complete cycle or any part of one. A diagrammatic analysis of the movement of a simple cam is shown in Fig. 1. There is nothing new about such a chart, yet if it were used more universally in designing, cams that are right the first time would be the rule rather than the exception. The cam lever is centered at *P*, and the chart clearly shows the character of the movement imparted to it.

A diagram illustrating the functions of a mechanism through a complete cycle is shown in Fig. 2. The device is employed in a blood-pump for the transfusing of blood from one person to another. It is practically a two-phase valve, as shown at *A*; at *B* its operation is illustrated schematically. In one position it transfuses blood from the donor to the recipient and in the other it transfuses the saline solution to the donor. The latter position is the one illustrated.

A diagram of every function and movement for a sheet-feeding device is shown in Fig. 3. A few of the most interesting movements will be analyzed and the reader can easily figure out the others for himself. The beginning of the feeding action is similar to the manual turning of a leaf in a book. The feed fingers, one of which is shown in Fig. 4, come down on the sheet and feed it forward, then are lifted from the table and return for the next sheet. Curve *A*, Fig. 3, illustrates the forward and backward motions and curve *B* the

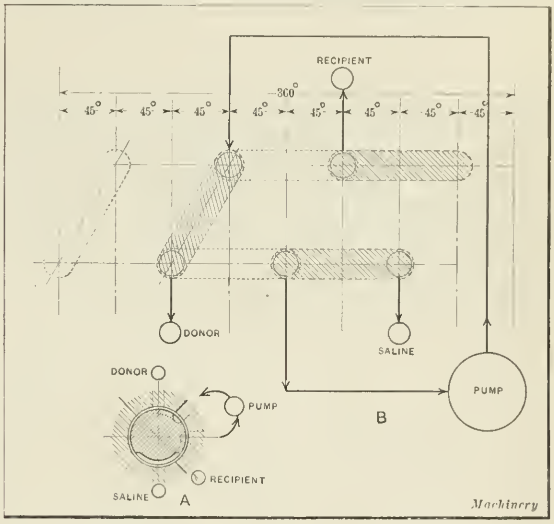

Fig. 2. Illustration of Operation of a Blood Pump

[1] See also "Design of Automatic Machinery," in MACHINERY, August, 1916.
[2] Address: 1581 Lincoln Place, Brooklyn, N. Y.

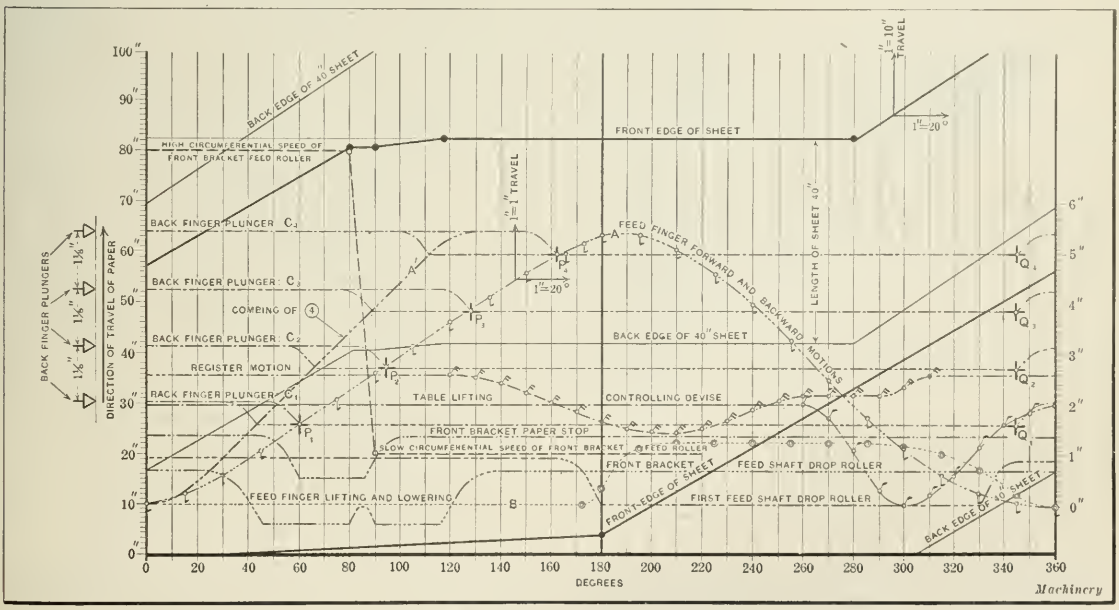

Fig. 3. Diagram of Movements of a Sheet-feeding Device

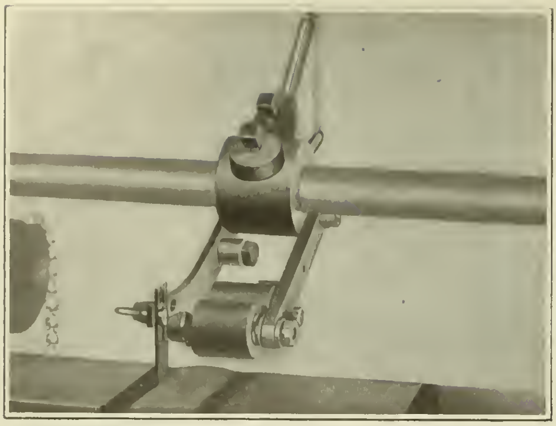

Fig. 4. Feed Finger of Sheet-feeding Device

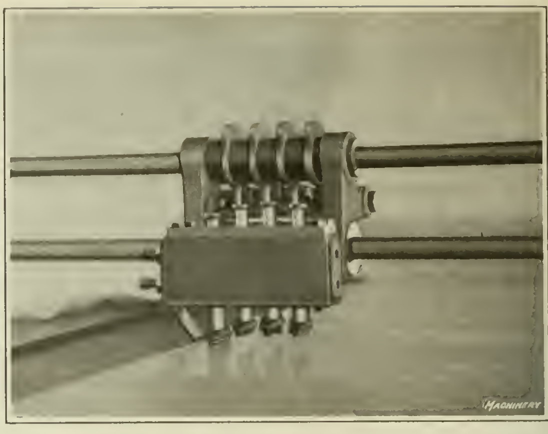

Fig. 5. Back-fingers of Sheet-feeding Device

lifting and lowering. It is interesting to note in curve *B* that the feed rollers leave the paper very quickly (about 35 degrees) and descend on the next sheet, moving forward very gradually, that is using about 80 degrees of the cycle. The function of the back-finger plungers shown in Fig. 5 is to insure that only one sheet is fed at a time. These fingers are actuated by cams, and drop successively on the table. The curve C_1, Fig. 3, shows the movement of the first back-finger plunger, C_2, the second, and so on. It will be noticed that the first finger drops on the sheet after one-sixth of the cycle is completed, the second finger somewhat ahead of it, the third finger ahead of the second, and so on. These positions are indicated at P_1, P_2, P_3, and P_4. All back-finger plungers rise simultaneously a little before the feed fingers descend to feed the sheet; these positions are indicated at Q_1, Q_2, Q_3, and Q_4.

Fig. 3 also illustrates one reason for charting curves on one diagram; that is, it shows the degree of adjustability. There seems to be no good reason why cams on special machinery should have to be "doctored" to perform properly, as they invariably must be. This may be entirely prevented by proper

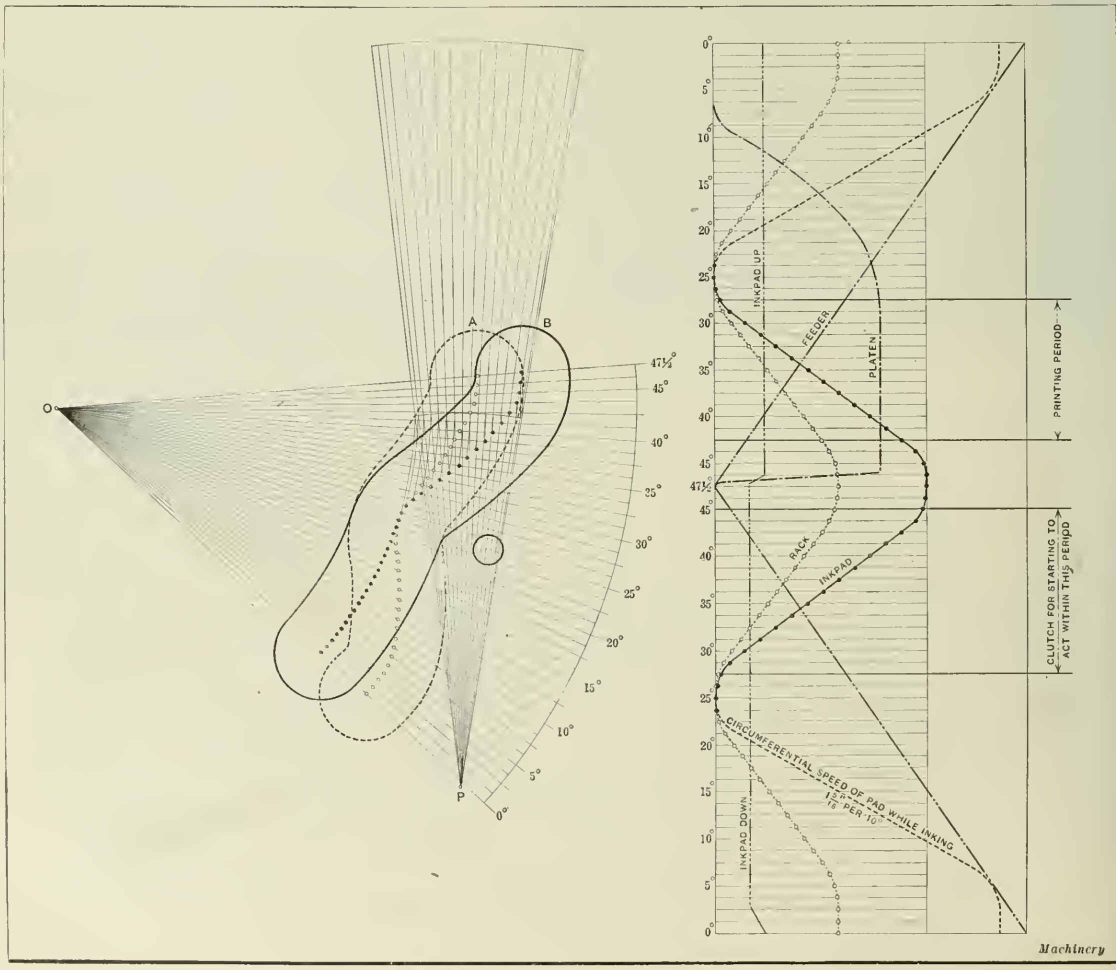

Fig. 6. Diagrammatic Analysis of a Reciprocating Mechanism

diagrammatic investigations before the cams are made. However, related movements should, whenever possible, be obtained with a certain degree of adjustability to compensate for any changes that may be required, due to unexpected behavior of the articles handled. It will be noted that, from such a diagram as that shown in Fig. 3, the limits of adjustability of any movement may be discerned at a glance. For example, suppose it is desired to lift the back-finger plungers from the table later in the cycle; it will be seen from curves A and C_1, C_2, C_3, and C_4 that there is about 18 degrees of adjustability in this direction. Obviously it would not do to make this movement later than 18 degrees, since the feed fingers will have already dropped on the table and will be moving the sheet forward.

A reciprocating mechanism operating within 47½ degrees is illustrated in Fig. 6. It consists of two groove cams A and B, which are centered at O and actuate cam levers pivoted at P. The function of cam A is to operate a rack in a special printing machine. Cam B operates an ink-pad in the same device. In this illustration these movements are also analyzed diagrammatically, together with several other related functions. It will be noted that since these movements are charted with relation to the fulcrum O, the entire operation takes place in 47½ degrees forward and 47½ degrees return; yet this mechanism has completed its cycle in this interval.

* * *

MACHINING A SPRINKLER HEAD

BY JOHN J. BORKENHAGEN[1]

The method of machining a sprinkler head described in the September, 1916, number of MACHINERY seems to the writer to be too long. Further, the use of the nut and washer to hold the head in the second setting would be likely to cause a burr to be raised on the seat which would result in a leak in the head when assembled. Some time ago the writer machined 36,000 heads by the following method at an average production of 700 per day. Out of lots of 1000 that were tested at 500 pounds water pressure, less than one per cent was scrapped. A two-jaw chuck was used, with openings in the sides for the chips to drop through. The work was done as follows:

First Setting

Operation 1—In the first operation the head is turned, faced to length, the hole roughed out and the end of the head chamfered. The hole is roughed out and the head faced by a flat counterbore-drill A held by set-screw C in a cast-iron box-tool B. Another set-screw D prevents the drill from sliding backward. The hardened bushing E is provided for guiding the end of the sprinkler head as it enters the box-tool. The turning tool F is set in the box-tool at an angle, resting in a milled slot and a set-screw prevents it moving. The chamfering tool is held in the opposite side of the box-tool in a similar manner.

Operation 2—In this operation the hole is reamed to the two diameters by a four-lip combination reamer H and the hole is drilled at the other end of the sprinkler head by drill G. The center of the combination reamer is drilled out to take the drill G, which is held in place by a set-screw.

Operation 3—This operation consists of back-facing the inner surface by a special tool. The hook tool J is located eccentrically with the body of the tool K. The shank of the hook tool extends into the body of the holder for a considerable distance and a handle L is inserted in it. The tool body is milled away, providing a slot to rotate the handle L 180 degrees, thus revolving the hook tool to a position where the entire device may be removed from the hole in the work. The shank of the tool and the handle are fitted snugly to the holder K to prevent chattering. The hook tool J is turned and milled, and the cutting edge roughed out. After the roughing of this cutting surface, a hollow mill is used which accurately governs its shape. By keeping the edge of the hook tool sharp, which is necessary to prevent a leak when the head is in use, the writer completed, on an average, from 3000 to 4000 pieces in the life of each of the hook tools. A suitable stop was used on the carriage of the machine in which this job was performed to limit the backward movement of the hook tool, thereby governing the amount of material removed from the seat.

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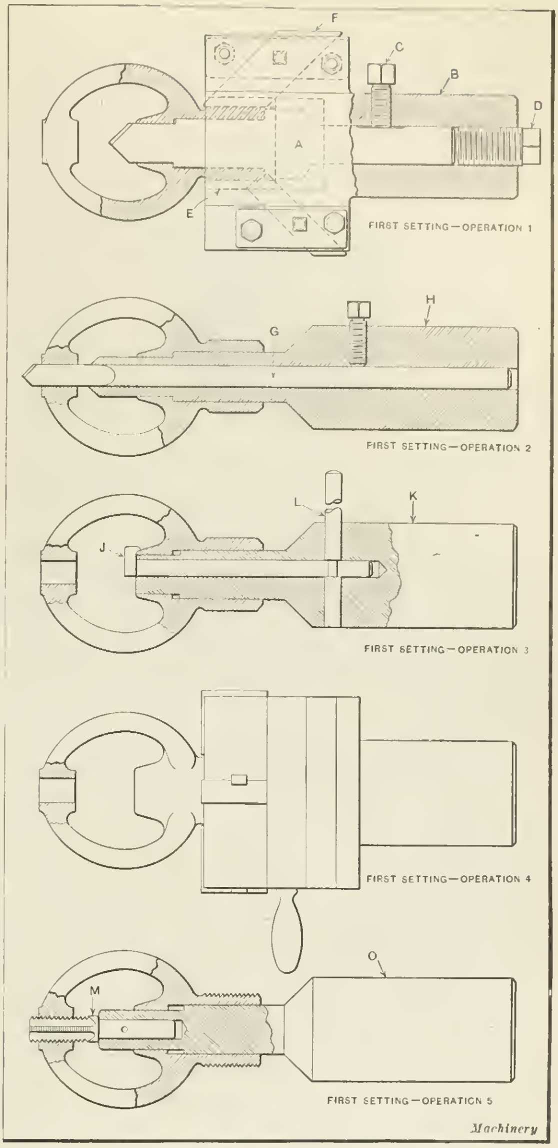

Operations in First Setting of Sprinkler Head

Operation 4—In this operation the thread is cut on the outside of the sprinkler head by means of an ordinary self-opening die-head. By turning the die-head upside down in the carriage and leaving the handle low enough to hit the carriage when revolving the turret, the closing of the die is accomplished automatically.

Operation 5—This operation consists of tapping the small hole in the farthest end of the sprinkler head. A simple brass tap-holder O fits the previously reamed hole and guides the tap M, which is soldered to it.

Second Setting

In the second setting, the top of the casting may be faced in a drill press by a four-lipped facing tool, thus completing the machining of the sprinkler head.

* * *

The number of motor and passenger vehicles exported from the United States during the last fiscal year was 77,496. The number exported in 1915 was 37,876; in 1914, 29,090; and in 1911, 11,803.

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NOTCHED HAMMER HANDLES

A well-known manufacturing firm in the Middle West had hired a number of men to work in its blacksmith shop, and while making his rounds shortly after this addition to the force, the superintendent stopped to speak to one of the new employes. During the course of their conversation, he inquired the reason why the hammers in this man's kit of tools were notched in a peculiar way; and with a directness which was commendably frank, but somewhat lacking in diplomacy, the new blacksmith replied:

"I have used those hammers for a good many years, and the notches on each handle are what I call my 'pay gage.' When I get thirty-two and a half cents an hour I hold the hammer at the notch nearest the head; for thirty-five cents an hour I hold the handle one notch nearer the end; for thirty-seven and a half cents an hour I take hold still one notch farther from the hammer head; and when I get forty cents an hour I take hold at the end of the handle."

It happened that the superintendent of this plant was a man who made quick decisions, and as his firm was badly in need of blacksmiths and hampered by the impossibility of getting forgings as rapidly as they were required, he decided to try an experiment with this new blacksmith. Having reached this decision, he said:

"As you were holding your hammer handle somewhere around the third notch at the time I came along, I judge your present rate of pay is about thirty-seven and a half cents an hour. Now I have decided to try you out on a different scale of wages. You take hold at the end of that hammer handle, and if you can earn the money, at the end of the week your pay envelope will be filled at the rate of forty-five cents an hour."

Every man who is familiar with conditions in American manufacturing plants knows that efficiency is being greatly hampered because a large percentage of the employes are using hammers with notched handles. This is due to a variety of causes, and an important one is that many employers of labor make a practice of basing wages upon general experience with men hired for doing a given class of work, rather than upon results of a study of the quantity and quality of work produced by individual employes. Men are hired as milling machine operators, lathe hands, blacksmiths, etc., and are given a specified rate of pay upon which they are likely to continue, because that is the rate that has always been paid for the job on which they are engaged.

If the turning out of more work and work of a better quality than that ordinarily done were the means of securing higher wages, there would be more ambition among mechanics to stand high in the regard of their employers; and they would progress more rapidly toward positions of responsibility. That success followed the experiment of the superintendent is attested by the fact that his new blacksmith is still working at the rate of forty-five cents an hour.

* * *

USE OF PORTABLE TOOLS IN MANUFACTURING

Portable tools, except pneumatic hammers and electric drills, which have a recognized field of use in erecting bridges, buildings and other structures, are generally regarded as makeshift means for doing repair work on parts that cannot be conveniently taken down and carried to stationary machine tools. But this conception is not altogether sound, as portable tools are being used successfully for the manufacture of machinery. A few months ago a new concern organized in the West for building a line of machine tools was confronted by the practical impossibility of obtaining regular equipment in time to build the machines it had agreed to furnish, and its general manager was forced to develop new means and methods for machining the castings, the result being the production of a number of portable machines that have been used with entire satisfaction.

In building machine tools especially, it is feasible to do machining operations following planing with comparatively small and inexpensive portable machines supported on the planed surfaces. Then holes bored with fixtures supported on the planed surfaces may be used for locating and holding the tools for subsequent operations. Portable tools offer several advantages, among which are the following:

The frame is machined in its working position and not lying down, thereby eliminating flexure; a portable tool can be set up on the casting in less time than the casting can be set up on a machine tool; the actual machining is done in less time, as the tools are set ready for work; and the shop capacity is greatly increased at moderate outlay, as the portable tools generally take the place of large expensive tools. Another important advantage is that often two or three different operations can be performed simultaneously on the same lathe bed or other machine frame.

The principal disadvantage of portable tools is that they require operators who must be skilled mechanics. Machine operators having had experience on repetitive work only are not suited to this work without special training. The men must be experienced, have good judgment and be adaptable. Of course if manufacturing along these lines were highly specialized and the quantity of work to be done were large, it would be feasible to train operators to do certain jobs as effectively, probably, as on stationary machine tools. There is a field for highly developed and accurate portable tools not generally seen by the average machine builder.

* * *

AN INTELLIGENTLY SELFISH EMPLOYER

Once upon a time a liberal minded general manager said, when making a yearly settlement with his traveling representative, "John, I wish this check that I am handing you for commission accrued over and above your weekly drawing account was more." The check was a large one—to some managers it would have seemed entirely too large—but this manager's attitude was intelligently selfish. If the traveling representative had earned more, *his* profit would have been more. Too few employers of labor recognize the great truth that the more their men earn, the greater their profits will be, if the business is properly managed. The employer who fixes an unchangeable day rate of pay for his employes is short-sighted and may generally be regarded as a poor manager. He does not recognize the fact that his employes are properly co-operators and not servants.

DEFECTIVE MACHINERY

BY CHESLA C. SHERLOCK [1]

The general rule of law is that a manufacturer or vendor is not liable to third parties, who have no contractual relations with him, for negligence in the construction, manufacture, or sale of articles which he handles. This rule has been supported for generations by the courts and the decisions on the point would cover many volumes. The theory that no man has a right to sue another upon a contract or an implied contract, unless there is a contractual relation between them, is a relic of the old English common law.

The advent of our present age of industrialism presented situations to our courts which were never contemplated by the common law. It was found that in many instances manufacturers could produce a product of inferior quality, both in material and workmanship, sell it to wholesalers and jobbers, and escape all liability for any injury resulting from its inferiority. The courts justly came to the conclusion that exceptions to the general rule were in order, so that during the last ten or twelve years we have had some new laws on this subject which is of vital importance to all who are engaged in the manufacture or sale of machinery. These exceptions, as generally recognized by the courts, are limited to three. The first is where the manufactured product itself is imminently dangerous to human life. A manufacturer engaged in the business of producing a machine or a product that, in itself, is dangerous to human life is bound to use the best material and the utmost care in workmanship, if he would escape liability to any third party who may purchase or use his product. The courts have not been content to let the matter rest at this point. They have gone further and said that if a machine, itself, was not imminently dangerous to human life, but that if, through inferior material or unskilled workmanship, it is rendered dangerous to human life, the same liability will attach to the manufacturer.

The second exception to the general rule is where the manufacturer invites or induces the injured party to use the defective product or represents it to be safe and sound. Of course, this does not mean that the manufacturer personally must make the representations. It means that either he or his selling force or agents may make the false representations so as to hold him for the injury done.

The third exception to the rule is where the manufacturer knows that defective material or workmanship is being used, but takes steps to conceal such defects by the use of paint, putty, or other means so that they cannot be discovered.

In any one of these exceptions, the manufacturer of machinery will be liable to third parties for injuries sustained, regardless of whether there is privity of contract between them or not. Deceit is an important element in this new line of decisions. The New York Supreme Court did much to blaze the way when it said:

> A manufacturer has a right to sell a defective machine if he gives notice of the defect to the purchaser, who, in turn, has the same right. Neither has the right, however, with furtive intent, to completely conceal the defect and sell the machine as sound and safe, intending it to be used as such by anyone into whose possession it might lawfully come, when the natural result would be the infliction of any injury upon any person who used it. By giving currency to the implement as safe, with intent to deceive not only the purchaser but any user, and yet so covering up the defect as to entirely conceal it, the defendant (a manufacturer) was guilty of an actionable wrong.

The real distinction between cases where the manufacturer is liable and where he is not liable seems to rest upon the character of the manufactured article itself. In general terms, it can be said that if the machine itself is dangerous to human life the manufacturer will be liable for any defect; if it is not of itself dangerous to human life, he will not be liable, in the absence of knowledge of its defective condition. It should be remembered, however, that the courts are leaning even farther and have come to the conclusion that even though the machine itself is not ordinarily dangerous, if the inferior materials used or unskilled workmanship renders it dangerous to life, the same liability will attach.

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LARGE RETURNS FROM SMALL TOOLS

BY J. W. T.

The writer recently spent several days inspecting the tool-room and tool cribs of a shop employing over 1500 men, of whom probably fifty were toolmakers. Some of the things he saw in this shop, which is credited with being strictly up to date, should be interesting and instructive to many readers of MACHINERY. This article is confined to the tool-room and tool cribs, but the methods of handling tools and men in this department will apply to the machine shop as well, and the conditions existing in this shop will be found in a large percentage of the shops in the country. The foreman of the tool-room, who has two assistants, complained that he had great difficulty in getting good men; that men came to him with first-class references, and started in as if they knew their business, only to fall down in a few days; or after working a day or so decided they did not want to stay. The result of the writer's inspection has given the foreman cause for reflection if nothing more.

Much care and money had been given to this department. Sheet-metal boxes and drawers, conveniently arranged and indexed, provided for a ready distribution of tools. But, and here is the first fly in the ointment, these tool cribs were handled by boys who were totally ignorant of the use of the tools; therefore, they were unable to give the tools the necessary care while in the cribs. To illustrate, there were forty-eight boxes provided for reamers, of which a large stock is carried. When these tools were received or given out, they were chucked into the boxes as if they were scrap. Careful inspection of over one hundred reamers failed to find one that was not nicked, with, in most cases, a burr projecting; and these reamers were expected to make polished bores. It was the same way with taps. Thirty or forty were thrown indiscriminately into a sheet-iron box without any thought being given to protecting the cutting edges; there was not one first-class tap in the crib, although a large proportion were new. Small milling cutters suffered to the same extent. Corners of teeth were broken off and dull cutters were placed with good tools. End-mills weighing over a pound were dropped over a foot into a sheet-iron box on top of others.

While these tools appeared to be ready for use, they really were not. Reamers had to be stoned before using and the toolmaker who overlooked this fact would spoil a hole in a piece on which he might possibly have spent a day or more. Or, if he did stone up the reamer, it cut just enough small to require an hour or two for lapping to size. A tap, which appeared to be new, would have the point of a tooth nicked off just enough to make it "hog" in when used on tool steel. Often the only milling cutter of a given size left in the crib had to be ground, and the man who was to use it had to wait the convenience of the cutter grinder. All these things cost money and are hard on the temper of many good workers; and foremen are paid high salaries to keep men in good humor. Now all these tools are received in a package that will stand severe shipment and can be stored in the cribs, in many instances at least, in the original package without taking up much more room. They may be kept in these packages when not in actual use. The foreman agreed with the writer that at least 50 per cent of the wear and tear on these three classes of tools can be saved in the tool crib.

In the tool-room, bolts, washers, and clamps for planers and millers were in bad shape. The bolts were without nuts and the clamps were distorted and not of proper design. A ten-minute milling job often required a half hour or more to get bolts and clamps. Collars on arbors were bruised and out of truth. Arbor-center adjusting screws were not oiled and stuck so that a wrench was necessary to move them. There were no wrenches to fit the nuts, except such as were kept in lockers by the older hands and considered private property. All these things made it extremely difficult for a new man to get started on work which, under proper conditions, would be very simple to do.

On lathes, the head centers were often found to be lower than the tail centers, making it practically impossible to ream a bore with the reamer held on centers. A lathe hand, on

being hired, was told that the shop furnished all the tools necessary and was given a patent tool-holder and two or three pieces of tool steel with which to do possibly a dozen different operations, each requiring only a minute to do; but five to ten minutes had to be consumed each time in grinding a tool from one shape to another. And there are some lathe operations in which such tools cannot be ground to do the work. End-mill sockets did not fit the spindles and draw-bolts would not fit, as the threads were worn off and the bolts were too short to cut new threads. Mills would work loose and dig into the work. Often, when this occurred, work which had taken over an hour to set up had to be moved in order to tighten the mill, and then reset and the cut picked up. It is often difficult to pick up a cut, and then a file must be used to get the required dimension and finish. This is disheartening to a new man. Belts were of improper size and dry. When a machine was pushed up to anywhere near its reasonable limit, the belt ran off. Then the operator had to send for the belt man and his ladder and wait until he arrived.

These conditions, which the writer feels safe in saying obtain in many of our shops, can be remedied at little or no cost. The resultant saving will boost dividends to a surprising extent. Many good workmen, who are now considered inferior, would prove money makers and the amount of spoiled work would be greatly reduced. Most shops are fairly well equipped with large tools, but many are far from being properly fitted with small tools and facilities for keeping them in serviceable condition. A tool not in condition to be used should never go into the crib. In 1901, the late Frederick W. Taylor, at a meeting of the board of directors of one of the shops of the Allis-Chalmers Corporation, said that in his opinion the three most important elements entering into shop production were equipment, labor, and supervision. Of these, he attached the greatest importance to equipment; and having worked under Mr. Taylor's direction several years, the writer knows he placed such equipment as that discussed in the first rank in importance. This small-tool equipment is the penny that grows to a dollar every six months, and strict attention to these details will make good workmen out of poor ones and superintendents out of foremen.

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MACHINE TOOL REPAIRS

BY W. G.

The interpreting of orders for repair parts for machinery is a matter with which the writer has had considerable to do, and he has often asked himself: "When people require repairs, and particularly when they request immediate shipment, why do they not take sufficient interest in their own business to state what they want?" The writer encounters many cases of lack of adequate information. For instance, in today's mail is received an order from a large concern calling for "one compound rest for lathe." How the customer expects the manufacturer who receives the order to determine what is wanted is a question. Upon receipt of the order the question at once arose, "What lathe is it for?"; and next, "What part of the lathe does this customer call the 'compound rest'?" Of course, if the order clerk should hazard a guess, and not guess correctly, he would have to explain the reason for the guess. It is necessary, therefore, to take up the matter with the customer. In this case the reply was received without undue delay, which disclosed that two parts of the lathe carriage were wanted; but the other question as to what lathe the parts were for was ignored, though the customer emphasized his request for prompt shipment.

In the same mail, an order from one of the largest companies in this country read: "One each parts Figs. Nos. 4, 7, 11, and 13, as per blueprint No. 123,456." But the blueprint did not accompany the order, although the order stated that the material was wanted at the customer's works on the same day that the manufacturer received the order. Another order in that mail said: "One carriage for 36-inch lathe serial number 40,000. Don't need apron for gears." Investigation disclosed that the manufacturer's No. 40,000 was not for any part of a 36-inch lathe; hence an illustration was sent to the customer for the manufacturer's shop number of the lathe, and he was requested to indicate on the illustration what part he called the "carriage." In due time the illustration was returned, and, notwithstanding the fact that the customer was three thousand miles away, he only indicated what part he called the "carriage," which proved to be what the manufacturer calls the "tool-slide." Consequently, another letter had to be sent, and three weeks more was lost in an effort to learn what was required to fill the order.

Again, a firm may purchase a machine from a second-hand dealer, of which transaction the manufacturer has no record, and later may find a gear with some teeth missing. The probability is that the purchaser will write to the manufacturer, supposing that the machine is a metal planing machine, "Please express at once gear for our planer," with probably some description of what the gear is, but without any dimensions, number of teeth, or other information to aid in determining what the gear is or what machine it is for, and the customer fully expects the gear to be shipped as ordered. In the case of a metal planing machine with, say, four heads, it often happens that a part of one of the heads is broken. It is the exception rather than the rule, however, for the order for repairs to state for which head the parts are desired. Is it not reasonable to suppose that the shop engineer or any one else whose duty it is to specify for these repairs should know that the parts wanted are not common to any of the other heads, and should designate to his purchasing department for which head parts were needed?

These instances could be enumerated indefinitely. The point to which the writer wishes to draw the attention of the shop people is the great waste of time caused by the present system. In many cases it has taken from one to two months to have the customer supply the information necessary to fill his order, during which time the machine is out of commission, in addition to the time it then takes to fill the order; and it is possible that the use of this machine is worth from ten to one hundred dollars a day, depending on its size. This is an item to be considered when the machine is idle for weeks for the simple reason that definite, intelligent information is not furnished in the beginning, say, from the shop to the purchasing department.

The foregoing examples are ordinary cases, being handled by the writer daily. They lead to the conclusion that some purchasing agents word their orders according to the wording of the requisitions sent them. A description of the article or articles wanted is often misleading from the point of view of the receiver, because of the localism in the wording, but if the description were supplemented by a rough sketch, with the principal approximate dimensions, it would usually be possible for the manufacturer to determine exactly what is wanted and fill the order promptly. A sketch generally gives more information than lines of description. If the purchasing agent would insist upon the shop supplying, with its requisition, a sketch of the parts wanted, many of the present delays would be avoided and the machine would be placed in service much sooner. In most cases, when repairs are needed they are needed at once, in view of which fact it would seem as though the customer would take unusual pains to make clear to the manufacturer what was wanted.

Some years ago there was published an article that showed the lack of uniformity in the names of lathe parts; a piece is called by one name in one section, by another in another section, and so on, which makes a description indefinite and misleading. When definite information is furnished with an order for repairs, the manufacturer can enter the order for execution in less time than it would take to write for further information, aside from waiting for a reply, and enable shipment to be made much more quickly, and thus place the idle machine in operation making its daily profit. It should not take a mind reader of the Sherlock Holmes variety to determine what an order is meant to cover, nor should the manufacturer be expected to guess.

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Although the tungsten deposits in California were discovered in 1913, they were not worked to any extent until the early part of 1916. Since then they have yielded large quantities of the mineral.

Portable Tools for Lathe Manufacture

By Edward K. Hammond[1]

Many experienced machine tool builders and most engineers who have made a study of the methods employed in this line of manufacture, regard it as work which requires the shops to be fully equipped with planers, boring mills, milling machines, shapers and a variety of other standard machine tools. The nature of the work handled in machine tool building factories also makes it necessary to have tools of ample capacity, because the castings for the beds, headstocks, aprons and many other parts are of considerable size and weight. To those readers of Machinery who have grown accustomed to standard practice in machine tool building, it will come as a surprise to learn that the Phoenix Mfg. Co., Eau Claire, Wis., has been securing very satisfactory results in machining bed castings for Conradson engine lathes without using anything but small portable tools after the ways on the bed have been planed. It is the purpose of this article to describe the portable tools used for this purpose, and the economic conditions which made it necessary to adopt this method of machining. The special tool equipment was designed by C. M. Conradson of Eau Claire, Wis., and shows what gratifying results can sometimes be obtained by discarding generally established methods of machining in favor of individual methods especially developed to meet existing requirements.

Conditions which Led to Development of Special Tools

At the time that the Phoenix Mfg. Co. was preparing to engage in the manufacture of Conradson lathes, the demand for machine tools for use in manufacturing munitions was so urgent that it was a matter of extreme difficulty to obtain any sort of reasonable deliveries. Reference to the accompanying illustrations will show that the Conradson lathe is designed with the headstock cast integral with the bed of the machine, and the gearing in the head is carried in a cylindrical case or barrel that may be rotated in the cross-bore of the headstock to engage either a worm and wheel or a spiral gear drive to the spindle. Ordinary practice would be to bore the holes for the spindle bearings and for this gear-case on a horizontal boring machine, but a tool of this kind was not included in the equipment of the Phoenix shops. Inquiry among manufacturers of boring mills revealed the fact that they had booked orders so far ahead of their delivery dates that it would be at least eight months before a boring mill could be placed on the floor of the Phoenix shop in Eau Claire. This made it necessary either to develop some special means of machining or fail to take advantage of the great demand that existed for engine lathes, and after giving the subject some study, Mr. Conradson developed the portable boring-bars shown in Figs. 1 and 2.

This was the starting point in the development of portable tools for machining the lathe beds, and as it was subsequently found that builders of radial drilling machines and other machine tools, which would ordinarily have been purchased to equip the factory for lathe manufacture, were as badly off in regard to deliveries as the boring mill builders to whom application was first made, Mr. Conradson proceeded to develop a complete equipment of portable tools for conducting machining operations on the lathe beds and tailstocks. The following description outlines the different machining operations in the order in which they are conducted, and in each case a description of the special portable tool will be given with an explanation of the work for which it is used.

Boring Holes for Taper Bronze Spindle Bearing Boxes

It has already been mentioned that at the time work is started on the lathe bed castings with these portable tools, the ways have been planed, and these are used as reference points from which to locate the tools for subsequent machining operations. The first step is to rough-bore the taper holes for the bronze spindle bushings, which is done with a portable boring-bar shown in operation in Fig. 1. This outfit is used to bore the holes and face the inside and outside ends of the boss surrounding each bearing. Two rough-boring cuts are first taken in the holes, then a roughing and finishing cut are taken on the face surrounding the inside and outside ends of each spindle bearing, after which finishing cuts are taken through the bearing holes. The order in which these facing cuts are taken is as follows: First take roughing and finishing cuts on the inside of the rear bearing, and from this finished surface—after the roughing cut has been taken—gage across the open space in the headstock with a pin gage in order to finish the inside of the front bearing to the required position. Next take roughing and finishing cuts on the outside end of the rear and front spindle bearings, using snap gages to provide for taking the finish cuts to reduce these bearings to the required length. After facing the surfaces at each end of the spindle bearings, these bearings are finish-bored. The reason this finishing cut is taken after facing is because of the taper form of the holes to be bored, which obviously makes

[1] Associate Editor of Machinery.

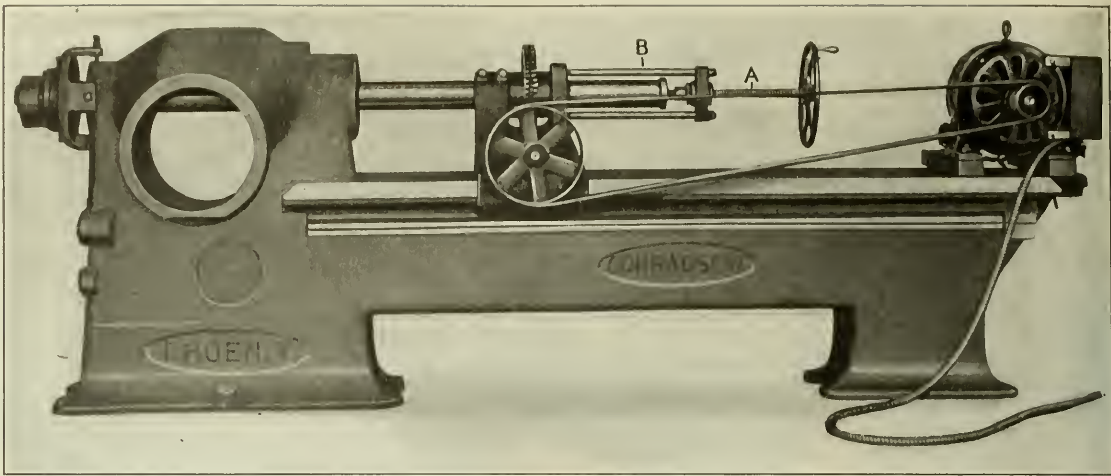

Fig. 1. Portable Boring-bar Equipment for boring and facing Spindle Bearings in Headstock

it necessary to have them properly located in relation to the finished faces.

The equipment with which these boring and facing operations are performed is shown in operation in Fig. 1, and it will be seen to consist of a carriage mounted on the planed ways of the lathe bed, which receives power from an individual motor drive. The boring-bar is driven by means of the worm-wheel shown, and feeding of the bar into the work is accomplished by means of screw *A*. Secured to the boring-bar carriage is a yoke *B*, through the end of which runs the feed-screw, although this screw is not threaded into the end of the yoke. It will be seen that the feed-screw is splined, and a sliding lock fitting into this spline provides for securing the feed-nut to the end of yoke *B*. In this way, power feed is obtained, and when it is desired to use hand feed the lock is disengaged so that feed-screw *A* can be turned by means of the handwheel carried at the end of this screw.

Construction of Boring-bar

A sectional view of the boring-bar used for machining the tapered holes for the bronze spindle bearing bushings is illustrated in Fig. 2, where it will be seen that two cutters *A* and *B* are provided to bore the two bearings simultaneously. These cutters are revolved by the bar in the usual way, and in order to obtain the desired taper for the bored holes, the effective radius of each cutter is varied as the cutters are fed through the work, by means of wedges *C* and *D* which run under clips that carry the boring cutters. The way in which this mechanism operates may be briefly described as follows: A spline groove cut in the boring-bar receives wedges *C* and *D*, and the remainder of the spline groove is occupied by filler strips *E*. In setting up the portable boring tool for operation, a collar *F* is mounted at the end of the headstock casting; this collar is held by clamps *G*, which fit into an annular groove, so that collar *F* is free to revolve with the boring-bar. Wedges *C* and *D* are free in the spline groove, but are prevented from moving longitudinally as the boring-bar is fed through the work by the combined action of collar *F* and filler strips *E*. The result is that cutters *A* and *B* run over tapered wedges *C* and *D*, and in this way the effective radius of the cutters is varied so that the holes are bored to the desired taper. It will be obvious that a bar of this kind could easily be constructed with wedges of any desired taper to meet the requirements of different boring operations. Facing of the inner and outer ends of the bearings is accomplished by means of facing cutters substituted in the bar in place of the boring cutters, but in this case wedges *C* and *D* are not required.

Boring and Facing Tailstock Bearing

For boring and facing the tailstock bearing hole, the same portable outfit is used, but for this operation a boring-bar of smaller diameter is employed. The method of performing this operation is illustrated in Fig. 3, where it will be seen that the tailstock casting is placed on the bed of the lathe between the boring-bar carriage and the headstock. The bar is then passed through the cored hole in the tailstock casting and piloted in a bushing in the spindle bearing of the headstock. When this has been done, two rough-boring cuts are taken through the bearing hole, after which the front and rear ends are faced off to reduce the bearing to the required length, which is determined with a snap gage. The illustration shows the facing head in operation, and attention is called to the fact that this is the same form of head that is employed on the bar for facing the ends of the headstock spindle bearings. For performing this operation, the connection with screw *A*

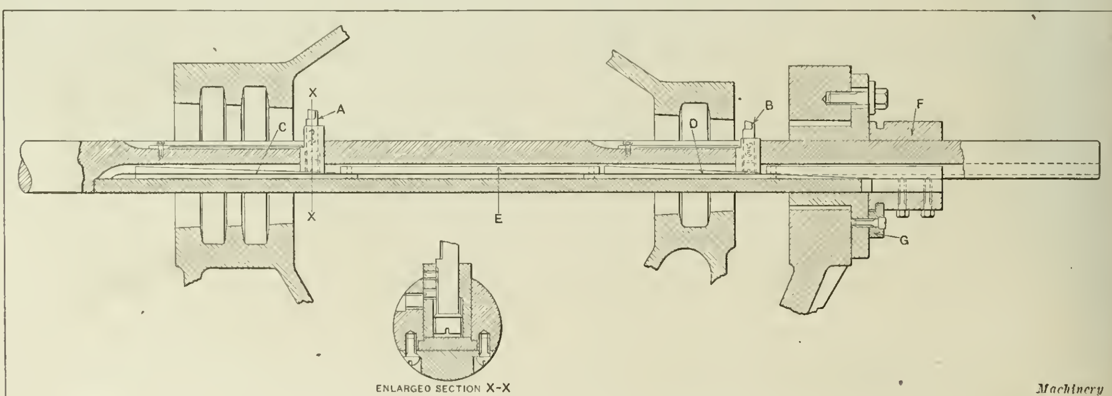

Fig. 2. Sectional View of Boring-bar for Taper Holes, shown in Operation in Fig. 1

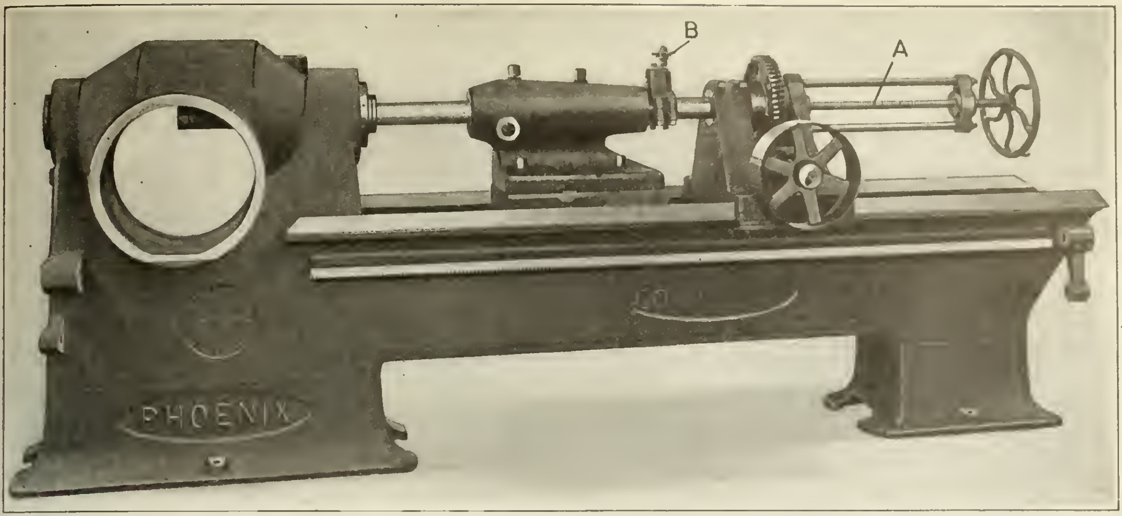

Fig. 3. Equipment for boring and facing Tailstock Spindle Bearing—Illustration shows Performance of Facing Operation

is disengaged and the facing cutter is fed to the work by means of a star-feed *B* on the head that engages a dog clamped at the rear of the lathe bed. After taking the finish-facing cuts, the facing head is removed from the bar and a finishing cut is taken through the spindle bearing, as in machining the headstocks.

Boring and Facing Gear-case Bearings

Next in the order of operations performed on the lathe bed comes the boring and facing of bearings for the gear-case in the headstock. Figs. 4, 5 and 6 show the portable tool developed for this purpose, which is driven by the same motor secured to the end of the lathe bed that was employed for driving the spindle boring fixture. A point of particular interest in the case of this cross-boring outfit is that provision has been made for performing simultaneously the boring and facing operations on the bearings at the front and back of the headstock. In order to explain the operation of this boring-bar, attention is directed to Fig. 6, which shows in detail the arrangement of the cutter-heads. The tool is supported in the lathe headstock by a bushing *A*, through which a bar is slipped, passing through the finished headstock spindle bearings.

It has been explained how the spindle bearings are bored with a tool that locates itself from the finished ways on the lathe bed, and as the supporting bar fitting into bushing *A* is carefully machined to fit accurately in the spindle bearings and in bushing *A*, it will be apparent that this location will result in boring and facing the gear-case bearings accurately in relation to both the ways and spindle bearings. The fixture is driven by means of planetary gears, which are arranged as follows: Pinion *B* is cut in a bushing keyed to the shaft on which the driving pulley is mounted, and this pinion drives a gear and pinion *C*, which will be seen to mesh with gear *D*. Gear *D* is secured to the casting of which bushing *A* is a part, so that it cannot rotate. As a result, the planetary gearing causes rotation of the cutter-heads for boring and facing the bearings at each side of the lathe headstock, these heads being mounted on the bar that extends right through the fixture. In each of these heads there is one boring and one facing cutter, the boring cutter in one head being shown at *E*, and the facing cutter in the opposite head at *F*. These cutters are mounted on slides so that the feeds may be obtained through screws actuated by star-feeds, the star-feeds *G* for the facing cutters being operated by dogs mounted on the ways of the lathe bed, while star-feeds *H* for the boring cutters are operated by dogs supported on stands placed on the floor at each side of the lathe bed.

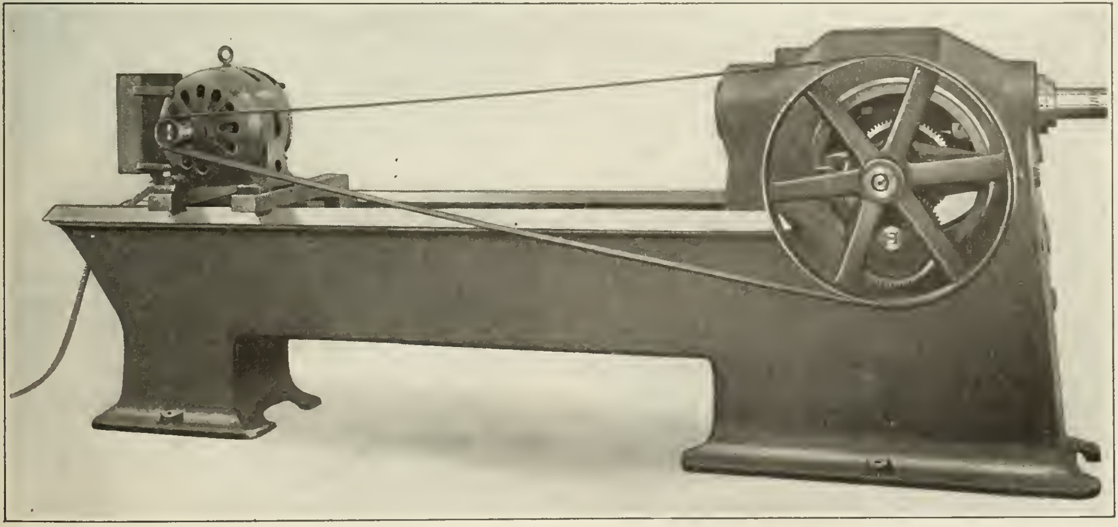

Fig. 4. Portable Tool for boring and facing Bearings for Case containing Speed Change-gears—Bearings at Opposite Side of Head are bored and faced simultaneously

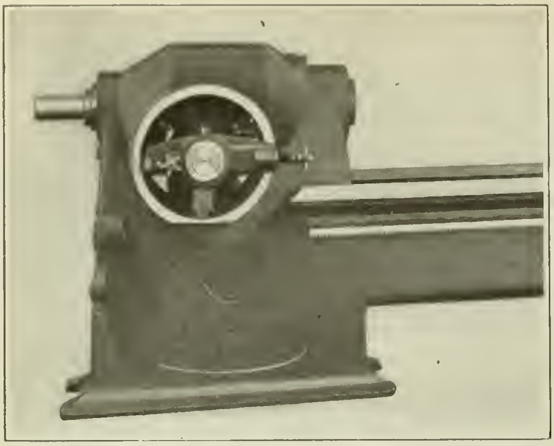

Fig. 5. Opposite Side of Boring Equipment shown in Fig. 4—Attention is directed to Star-feeds for Boring and Facing Tools

Radial Drilling Attachment for Drilling and Facing Operations on Headstock

The next step is to drill two holes at the top of each spindle bearing, which are required for the oil cups and for the screws used to secure the wedges that are employed for adjusting the tapered spindle-bearing bushings. For the performance of these drilling operations, a portable radial drilling machine is employed, which is shown in operation in Fig. 7. For mounting this tool, it will be seen that use is made of the same bar through the spindle bearings that was employed for supporting the cross-boring fixture shown in Figs. 4, 5 and 6. This bar locates the frame that rests across the ways on the lathe bed, so that location is obtained from both the ways and the spindle bearings. It will be seen that a jig plate *A* is used for locating the two holes that are to be drilled at the front end of the headstock. After drilling these holes, the radial arm of the drill is lifted off and transferred to post *B* at the opposite end, which is furnished with a jig plate *C* for locating the holes at this end of the work.

A brief description of this radial drilling machine will not be out of place. It will be seen that the drive is furnished from an individual motor, on the armature spindle of which there is a sprocket that transmits power by a chain drive having a ratio of 1 to 3. From this point, power is transmitted through a pair of spur gears having a ratio of 1 to 3, and thence through a spiral gear drive contained in case *D*, which also has a ratio of 1 to 3. In this way, the power is stepped up three times, making it possible for a 1/2-horsepower motor to perform all drilling and spot-facing operations on the headstock, which include drilling a 2½-inch cored hole. It will, of course, be apparent that the radial position of the head on the arm is adjusted by means of lever *E*, and that driving rod *F* that transmits power from the spur gears to the spiral gears in case *D* is splined to provide for making this adjustment. The drill is fed to the work by hand by means of crank *G* that turns the feed-screw.

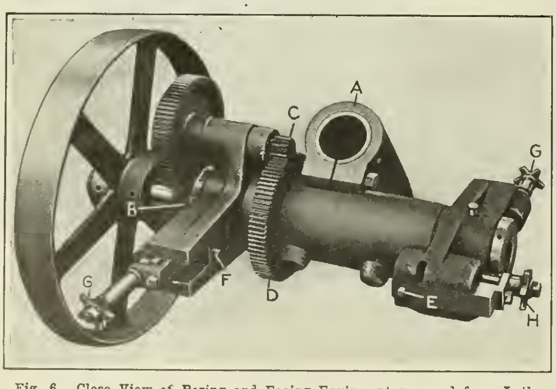

Fig. 6. Close View of Boring and Facing Equipment removed from Lathe Head to show Features of Design

Spot-facing Bosses for Feed-box and Brackets for Feed-screw and Lead-rod

After completing the drilling operations referred to, the jig plates and posts for supporting the radial arm are removed, and the radial arm is next set up on the rod extending through the spindle bearings, the radial arm being interchangeable between this rod and the posts shown in the preceding illustration. With the arm in this position, a spot-facing cutter is mounted in the spindle, and the four bosses for securing the feed-box in place and the two brackets for the feed-screw and lead-rod are spot-faced. Having completed this operation, a jig plate *A*, Fig. 8, is set up on the bar through the spindle bearings, and the holes in the bosses and brackets previously referred to are drilled and reamed. It is obviously important to have these holes properly located in relation to the ways in order that they will line up with the carriage and apron which are supported by the ways. This is done by placing a finished carriage on the ways, and slipping through the machined lead-rod bearing a master bar, the end of which extends through the lead-rod drill bushing hole in jig plate *A*. When this has been done, the jig is properly located and it is secured in this position by tightening screws *B* at each side

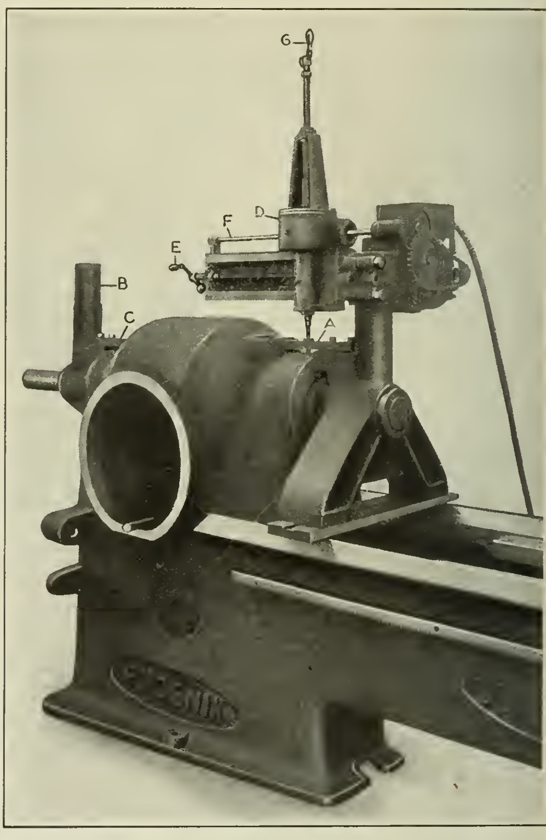

Fig. 7. Portable Radial Drilling Machine engaged in drilling Holes for Oil Cups and Wedge Clamping Screws

of the headstock. Then the master bar is withdrawn and the operator is ready to proceed with the drilling and reaming of the required holes. It will be apparent that in performing these drilling operations, location is obtained from the carefully fitted bar in the spindle bearings and from the ways on the bed and lead-rod bearing in the carriage, so that these drilling operations are conducted in a way that insures the desired alignment. The equipment for spot-facing is the same as that shown for drilling in Fig. 8, except that jig plate *A* is not necessary. This illustration shows the drilling of a 2½-inch cored hole with a tool driven by a 1/2-horsepower motor and a ½-inch splined shaft, which shows what can be done in the way of economizing power consumption if equipment is designed with that idea in view.

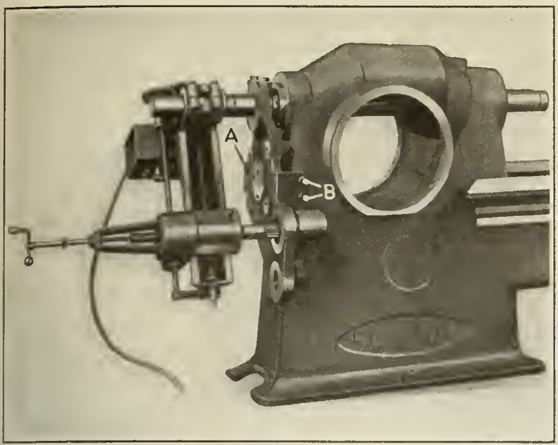

Fig. 8. Radial Drilling Machine set up for drilling Holes for Feed-screw, Lead-rod, and Screws for securing Feed-box to Bed

Drilling Operations at Tailstock End of Bed

The machining operations at the headstock end of the lathe bed have now been completed, and those operations which must be performed at the tailstock end will now be taken up. For this work, a fixture is placed on the vees, as shown in Fig. 9, and the first step is to secure to this fixture a jig plate for locating and drilling the two holes required for screws *A* that secure to the lathe bed a bracket for supporting the feed-screw and lead-rod. After this has been done, the fixture is slid along the ways, and at specified intervals screw holes are drilled to provide for securing the feed rack in place. These holes are drilled through the same jig plate used for locating and drilling the holes for screws *A*; and the points at which these holes are to be drilled are determined by having the feed rack clamped to the lathe bed, so that the holes in the casting may be drilled through the holes which have already been machined in the finished rack.

Drilling Lead-rod and Feed-screw Bracket

The final operation consists of drilling the holes in the bracket that supports the lead-rod and feed-screw; and for this purpose the jig plate is taken off the fixture shown in Fig. 9, and at the end of this fixture is substituted a jig plate for drilling the required holes in the bracket. It will be seen that this jig plate is furnished with a bushing to support a post on which is mounted the arm of the radial drill. Having set the equipment up in this way, the bracket is bolted in place on the lathe bed, and the holes are drilled in the manner shown in Fig. 10. After completing these two drilling operations, the lathe bed is ready for all parts to be assembled.

Conclusion

The way in which the location is obtained for various machining operations has been fully explained, and it will be evident to the reader who makes a careful study of conditions under which the work is done that, with reasonable care exercised by the operator, no trouble would be experienced in obtaining the desired degree of accuracy. These special tools were developed to meet the demand for equipment required for machining the beds of Conradson lathes—a demand that could not be filled by builders of standard machine tools, owing to the large amount of business standing on their books for deferred delivery. As a matter of fact, the portable tools meet all requirements, and aside from the benefit obtained through securing equipment at the time when it was required, these tools, produced at a nominal cost, are doing the work of standard machine tool equipment that would have involved the outlay of many thousands of dollars.

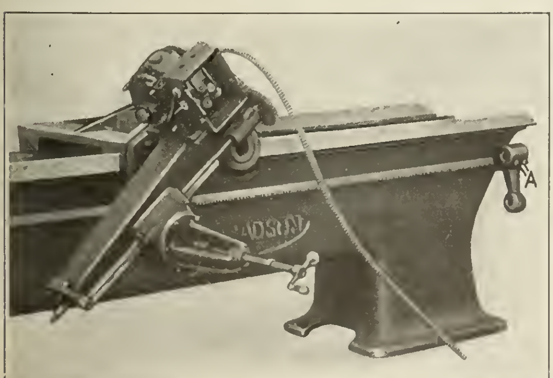

Fig. 9. Radial Drilling Machine drilling Holes for Screws used to secure Feed Rack to Bed

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MAKING CUTTING TOOLS TO GAGES

BY ERIC LEE[1]

Some time ago the writer filed a number of forged cutting tools to gages. They were made of "Novo" high-speed steel and included lathe and planer tools—diamond points and round-nose cutting-off tools, right-hand and left-hand side tools and boring tools. When these tools were filed and hardened they were ground to gages made of sheet steel about 1/16 inch thick and showing the angles of rake and clearance that a series of experiments had proved were the best. Different gages were made for tools for machining tool steel, soft steel and brass. Afterward all cutting tools were milled to gage, hardened and ground by the tool-room assistant. No workman was allowed to grind his cutting tool; if the tool did not suit, it was exchanged, without comment, at the tool crib.

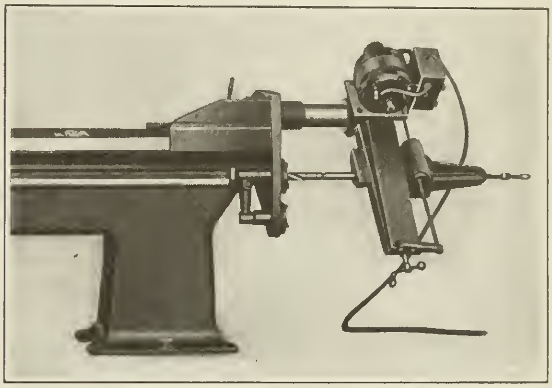

Fig. 10. Drilling Holes in Feed-screw and Lead-rod Bracket at Tailstock End of Bed

After a careful study, this method was found to be satisfactory. Men were not constantly running to the grinder to grind tools to any old angle they thought necessary. Besides, when one man was employed grinding the tools, he used goggles, whereas the other workmen would not stop to put on glasses and the number of accidents reported "foreign matter in the eyes" was greatly reduced. Although to mechanics who have been at the business many years it is often second nature to grind their tools so as to get the proper rake and clearance, many men have not had this experience, and it is a sad sight to see the grinding wheel worn away and steel wasted by some inexperienced workman trying to make a tool cut to advantage.

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At a meeting of the executive committee of the National Advisory Committee for Aeronautics held in Washington, D. C., in December, the committee adopted the metric system as a standard so far as the work of the committee is concerned. Recommendations have been sent to the various departments of the government that this system be adopted in connection with all matters pertaining to aeronautics. The War Department will put the change into effect in its aviation section, using the metric and English systems on drawings.

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SIMPLIFIED CHANGE-GEAR CALCULATIONS

SOLVING CHANGE-GEAR PROBLEMS BY USE OF LOGARITHMS—LOGARITHMS OF CHANGE-GEAR RATIOS, 16 TO 120 TEETH—USING TABLE FOR FOUR-GEAR TRAINS

BY GEORGE M. MEYNCKE [1]

The calculation of change-gears is troublesome to many mechanics because the terms of the ratios are indefinite; in the case of simple ratios they may often be expressed in many pairs of tooth numbers, all within the range of an ordinary change-gear set, and it is necessary to select a suitable multiplier for one side of the ratio before the other can be known; hence the difficulty of the inexperienced in choosing gears, especially in compound trains. Change-gear problems often present serious difficulties also to those who are expert in mathematics, when the ratios cannot be exactly expressed in whole numbers within the range of ordinary gearing. The logarithmic method of finding the numbers of teeth required for a pair of change-gears in any ratio is simple and well within average comprehension. This article briefly describes the use of logarithms in change-gear calculations, and is accompanied by a table giving the logs of all the ratios from 1.0084 + : 1 to 7½ : 1, inclusive, in a gear set of 16 to 120 teeth. This table greatly simplifies the finding of pairs of change-gears, and makes the selection of gears for four-gear and six-gear sets easy.

Most shop calculations made by draftsmen, foremen or toolmakers involve the selection of gears to obtain certain ratios. When an odd thread is to be cut or it is necessary to obtain a milling-machine lead of greater accuracy than those given in the table supplied with the machine, a long and tedious calculation is usually required; and often the results are not sufficiently accurate. Numerous examples of change-gear calculations to cut unusual leads on the lathe have been given from time to time in MACHINERY, and have been kept on file by many readers because of their suggestive value. This is an indication of the general need of these data.

The slide-rule is useful in selecting gears to satisfy any ratio, but as the inaccuracy of the eye and graduations will not permit a ten-inch slide-rule to be read beyond the third figure, an unavoidable source of error is encountered; when four or six gears must be used, there is a multiplication of errors and the results become less accurate. A ten-foot slide-rule would greatly reduce this inaccuracy, but this size rule has not come into common use; few drawing-rooms possess it, and for the man in the shop it is out of the question. Also, the use of a slide-rule requires skill that comes only through frequent use.

A simple and accurate method of calculation that will enable the shop man to solve change-gear problems without a slide-rule has long been desired. Such calculations as odd threads or leads for the lathe or milling machine, change-gears for gear hobbing for the gear planer or gear shaper, and change-gears for relieving spiral-fluted hobs or cutters are among the problems most commonly encountered. The solution of these problems is the calculation of gears to obtain a certain ratio between the driving and the driven gears. An example will serve to make this clear:

Suppose that two gears must run in the ratio of 3 to 1. To find the required number of teeth in the gears, it is only necessary to multiply both terms in the ratio by the same number. As 16 is the smallest gear that can be used in most cases, multiplying both terms of the ratio by 16 gives 48 : 16. Therefore, a 48- and a 16-tooth gear may be used. Other gears that can be used are 54 : 18, obtained by multiplying both terms of the ratio 3 : 1 by 18; 60 : 20, obtained by multiplying both terms by 20; and 72 : 24, obtained by multiplying by 24. If instead of 3 to 1 the gear ratio is 3.423 to 1, the same system may be followed. A multiplier is found by trial that will give a whole, or nearly a whole number in the products; for example:

$$\begin{array}{rr} 3.423 : & 1 \\ 16 & 16 \\ \hline 54.768 : & 16 \end{array} \qquad \begin{array}{rr} 3.423 : & 1 \\ 18 & 18 \\ \hline 61.614 : & 18 \end{array} \qquad \begin{array}{rr} 3.423 : & 1 \\ 20 & 20 \\ \hline 68.460 : & 20 \end{array}$$

In each of these cases the product obtained for the 3.423 side of the ratio leaves a large fractional tooth. Taking the one with the smallest fractional tooth, 68 : 20 = 3.4 : 1, there is an error of 0.023 in the ratio.

Another and better way of obtaining the correct gears is by the cancellation method, changing 3.423 to $\frac{3423}{1000}$ to clear of decimals, and then as 3423 will not cancel small enough to obtain ordinary size gears, changing it to 3420;

$$\frac{3420}{1000} = \frac{342}{100} = \frac{3 \times 2 \times 57}{2 \times 50} = \frac{3 \times 57}{1 \times 50}$$

Then, multiplying $\frac{3}{1}$ by some number, say, 24, we have

$$\frac{72}{24} \times \frac{57}{50} = \frac{4104}{1200} = \frac{3.42}{1},$$ in which there is an error of 0.003.

When the ratios are simple or when they cancel freely, the cancellation method is not difficult and is frequently used; but by the use of the logarithm method here described more accurate results are possible in most cases. The accompanying table contains the six-place logarithms of all gear combinations between 16 and 120, inclusive, excepting 1 : 1 ratios, of course; that is, all pairs of gears from 16 to 120 teeth, inclusive, are given, excepting the pairs with the same number of teeth. These logarithms were derived in the following manner: 72 : 41 equals $\frac{72}{41}$, or 72 divided by 41. To divide, find the logarithms, and subtract the logarithm of one number from the logarithm of the other, thus:

$$\begin{aligned} \log 72 &= 1.857333 \\ \log 41 &= 1.612784 \\ \hline \text{ratio } \log &= 0.244549 \end{aligned}$$

The ratio logarithms of the combinations between 16 and 120 have been arranged in numerical order in the accompanying table. In a number of cases, more than one combination gives the same logarithm, so that the different gears that equal the logarithm have been repeated. In some simple cases, however, the ratio only has been given in order to shorten the table; for instance, all the gear combinations that equal a 2 to 1 ratio have been omitted and the ratio only is given.

To show how the table is to be used, suppose that gears having the ratio 3.423 : 1 are desired. Log 3.423 = 0.534407. From the table, log 89 : 26 = 0.534417; therefore, the gears having 89 and 26 teeth are the nearest to the ratio 3.423 to 1, and as 89 ÷ 26 = 3.423077, the ratio error is only 0.000077. The error by the cancellation method, using four gears, was 0.003. This can be reduced after a number of changes have been made in the ratio 3423 : 1000. However, there is no way of determining if the error has been reduced to the lowest possible figure; but with the gear ratio logarithms this can be discovered at once by an inspection of the table.

There are nearly 5000 different ratios represented in the gear tables between the extremes 1.0084 + to 1 (120 : 119) and 7½ to 1 (120 to 16). As the sum of any two two-gear logarithms equals a four-gear logarithm, the tables represent over 12,000,000 four-gear combinations; and by using three pairs of gears in a train, there are over 20,000,000,000 six-gear combinations available.

When solving gear problems the ratio always should be reduced to terms of 1. For example, what two gears will drive two shafts at a ratio of 7.182 to 3.902? $\frac{7.182}{3.902} = \frac{1.84059}{1}$; the log of 1.84059 is 0.264957. From the table, 81 : 44 = log 0.265032. As 81 ÷ 44 = 1.84091, the table error is only 0.00032. The advantage of reducing to terms of 1 is that it checks all work, including the taking out of the logarithms.

Caution—Extraordinary care has been taken to eliminate errors in the accompanying table of change-gear logarithms, but the difficulty of securing perfect accuracy in the first presentation of a table containing nearly 5000 items is enormous, and it is too much to expect that there are no mistakes. Users are cautioned, therefore, to check all data taken for their computations, by finding the logs of each pair of tooth numbers in a six-place table, and subtracting one from the other; the remainder is the log of the ratio, and should agree with that given in the accompanying table, if both are correct.—EDITOR.

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A more rapid solution of the same problem, which may be used by those familiar with logarithms, is:

$$\log 7.182 = 0.856245$$
$$\log 3.902 = 0.591287$$
$$\text{ratio log} = 0.264958$$

From the table, log 81 : 44 = 0.265032. To find the error, proceed thus:

$$\log 0.265032$$
$$\log 0.264958$$
$$\text{log of ratio error } 0.000074$$

Finding Four-gear Ratios

When four gears must be used, the gear logarithms* permit of more accurate results being obtained than any other method. For example, suppose it is desired to find four gears that will yield a ratio of 2.105399 to 1. Log 2.105399 = 0.323334. To keep the reduction about equal in each pair of gears, it is necessary to select from the table that set of gears the logarithm of which is equal to about one-half the ratio logarithm, as log 57 : 37 = 0.187673. By subtracting this from log 0.323334, the other logarithm is found to be 0.135661. From

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—1

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
120:16	0.875061	118:21	.749663	89:18	0.694118	103:23	.651109	99:24	0.615424	107:28	.582226	111:31	0.553961	91:27	.527678
119:16	.871427	101:18	.749049	84:17	.693830	94:21	.650909	66:16	.615424	84:22	.581857	68:19	.553755	64:19	.527426
118:16	.867762	112:20	.748188	79:16	.693507	85:19	.650665	103:25	.614897	103:27	.581473	93:26	.553504	101:30	.527200
117:16	.864065	95:17	.747275	118:24	.691671	76:17	.650365	70:17	.614649	61:16	.581210	118:33	.553368	111:33	.526809
116:16	.860338	106:19	.746552	113:23	.691351	116:26	.649485	107:26	.614411	80:21	.580871	100:28	.552842	74:22	.526809
115:16	.856578	117:21	0.745967	108:22	.691001	107:24	0.649173	111:27	.613959	99:26	0.580662	75:21	.552842	84:25	0.526339
114:16	.852785	89:16	.745270	103:21	.690618	98:22	.648803	74:18	.613959	118:31	.580520	107:30	.552263	94:28	.525970
113:16	.848958	100:18	.744728	98:20	.690196	89:20	.648360	115:28	.613540	114:30	.579784	82:23	.552086	104:31	.525672
120:17	.848732	111:20	.744293	93:19	.689729	80:18	.647818	78:19	.613341	95:25	.579784	114:32	.551755	114:34	.525426
119:17	.845098	94:17	.742680	88:18	.689210	120:27	.647817	119:29	.613149	76:20	.579784	89:25	.551450	67:20	.525045
112:16	0.845098	105:19	.742436	83:17	0.688629	111:25	.647383	82:20	0.612784	110:29	.578995	96:27	0.550907	77:23	.524763
118:17	.841433	116:21	.742239	117:24	.687975	71:16	.647138	86:21	.612279	91:24	.578830	64:18	.550907	87:26	.524546
111:16	.841203	110:20	.740363	78:16	.687975	102:23	.646872	90:22	.611820	72:19	.578579	103:29	.550439	97:29	.524374
117.17	.837737	99:18	.740363	112:23	.687490	93:21	.646264	94:23	.611400	106:28	.578148	71:20	.550228	107:32	.524234
110:16	.837272	88:16	.740363	107:22	.686961	115:26	.645725	98:24	.611015	87:23	.577792	110:31	.550031	117:35	.524118
116:17	.834009	115:21	0.738479	102:21	.686381	84:19	0.645526	102:25	.610660	102:27	0.577236	117:33	.549672	120:36	0.522879
109:16	.833307	104:19	.738280	97:20	.685742	106:24	.645095	106:26	.610333	68:18	.577236	78:22	.549672	110:33	.522879
115:17	.830249	93:17	.738034	92:19	.685034	75:17	.644612	110:27	.610029	117:31	.576824	85:24	.549208	100:30	.522879
108:16	.829304	120:22	.736759	116:24	.684247	97:22	.644349	114:28	.609747	83:22	.576655	92:26	.548815	90:27	.522879
114:17	.826456	109:20	.736397	87:18	.684247	119:27	.644183	112:29	.609484	98:26	.576253	99:28	.548477	80:24	.522879
107:16	0.825264	98:18	.735954	111:23	0.683595	110:25	.643453	65:16	0.608793	113:30	.575957	106:30	0.548185	70:21	.522879
120:18	.823909	87:16	.735400	82:17	.683365	88:20	.643453	69:17	.608400	64:17	.575731	113:32	.547928	60:18	.522879
113:17	.822629	114:21	.734686	106:22	.682883	101:23	.642594	73:18	.608050	79:21	.575408	120:34	.547702	113:34	.521600
106:16	.821186	103:19	.734084	77:16	.682371	79:18	.642355	77:19	.607737	94:25	.575188	67:19	.547321	103:31	.521476
119:18	.820275	92:17	.733339	101:21	.682102	114:26	.641932	81:20	.607455	109:29	.575029	74:21	.547012	93:28	.521325
112:17	.818769	119:22	0.733124	120:25	.681241	92:21	0.641569	85:21	.607200	120:32	0.574031	81:23	.546757	83:25	0.521138
105:16	.817069	108:20	.732394	96:20	.681241	105:24	.640978	89:22	.606967	105:28	.574031	88:25	.546543	73:22	.520900
118:18	.816609	97:18	.731499	115:24	.680487	70:16	.640978	93:23	.606755	90:24	.574031	95:27	.546360	63:19	.520587
111:17	.814874	113:21	.730859	91:19	.680288	118:27	.640518	97:24	.606561	75:20	.574031	102:29	.546202	116:35	.520390
117:18	.812913	86:16	.730379	110:23	.679665	83:19	.640324	101:25	.606381	60:16	.574031	109:31	.546065	106:32	.520156
104:16	0.812913	102:19	.729847	86:18	0.679226	96:22	.639849	105:26	0.606216	116:31	.573096	119:34	0.544068	96:29	.519873
110:17	.810944	118:22	.729459	105:22	.678767	109:25	.639487	109:27	.606063	86:23	.572770	112:32	.544068	86:26	.519525
116:18	.809186	91:17	.728593	81:17	.678036	74:17	.638783	113:28	.605920	71:19	.572505	105:30	.544068	119:36	.519245
103:16	.808717	107:20	.728354	100:21	.677781	87:20	.638489	117:29	.605788	112:30	.572097	98:28	.544068	76:23	.519086
109:17	.806978	112:21	.726999	119:25	.677607	100:23	.638272	116:23	.602730	97:26	.571798	91:26	.544068	109:33	.518913
115:18	.805425	96:18	0.726999	114:24	.676694	113:26	0.638105	64:16		82:22	0.571391	84:24	.544068	99:30	0.518514
102:16	.804480	117:22	.725763	95:20	.676694	117:27	.636822	or		108:29	.571026	77:22	.544068	89:27	.518026
108:17	.802975	101:19	.725568	76:16	.676694	104:24	.636822	any	.602060	67.18	.570802	70:20	.544068	112:34	.517739
114:18	.801632	85:16	.725299	109:23	.675699	91:21	.636822	4 to 1		93:25	.570543	63:18	.544068	79:24	.517416
120:19	.800428	106:20	.724276	90:19	.675489	78:18	.636822	ratio		119:32	.570397	56:16	.544068	102:31	.517239
101:16	0.800201	90:17	.723794	104:22	0.674611	108:25	.635484	119:30	0.598426	104:28	.569875	115:33	0.542184	115:35	.516630
107:17	.798936	111:21	.723104	85:18	.674146	95:22	.635301	115:29	.598300	78:21	.569875	108:31	.542062	69:21	.516630
113:18	.797806	95:18	.722451	118:25	.673942	82:19	.635060	111:28	.598165	115:31	.569336	101:29	.541923	92:28	.516629
119:19	.796793	116:22	.722035	99:21	.673416	69:16	.634729	107:27	.598020	89:24	.569179	87:25	.541579	105:32	.516039
100:16	.795880	100:19	.721246	113:24	.672867	112:26	.634245	103:26	.597864	63:17	.568892	80:23	.541362	82:25	.515874
106:17	.794857	105:20	0.720159	80:17	.672641	99:23	0.633907	99:25	.597695	100:27	0.568636	73:21	.541104	118:36	0.515580
112:18	.793946	84:16	.720159	94:20	.672098	86:20	.633469	95:24	.597512	111:30	.568202	66:19	.540790	95:29	.515326
118:19	.793128	110:21	.719173	108:23	.671696	116:27	.633094	91:23	.597314	74:20	.568202	118:34	.540403	108:33	.514910
99:16	.791515	89:17	.718941	75:16	.670941	73:17	.632874	87:22	.597097	85:23	.567691	111:32	.540173	77:22	.514910
105:17	.790740	115:22	.718275	89:19	.670636	103:24	.632626	83:21	.596859	96:26	.567298	104:30	.539912	85:26	.514446
111:18	0.790051	94:18	.717855	103:22	0.670415	120:28	.632023	79:20	0.596597	107:29	.566986	97:28	0.539614	98:30	.514105
98:16	.787106	120:23	.717453	117:25	.670246	90:21	.632023	75:19	.596308	118:32	.566732	90:26	.539269	111:34	.513844
104:17	.786584	99:19	.716882	112:24	.669007	107:25	.631444	71:18	.595986	70:19	.566344	83:24	.538867	62:19	.513638
110:18	.786120	109:21	.715207	98:21	.669007	77:18	.631218	67:17	.595626	81:22	.566062	114:33	.538391	75:23	.513334
116:19	.785704	83:16	.714958	84:18	.669007	94:22	.630705	63:16	.595221	92:25	.565848	76:22	.538391	88:27	.513119
97:16	.782652	114:22	0.714482	107:23	.667656	111:26	0.630350	118:30	.594761	103:28	0.565679	107:31	.538022	101:31	0.512960
103:17	.782388	88:17	.714034	93:20	.667453	81:19	.629731	114:29	.594507	114:31	.565543	69:20	.537819	114:35	.512837
109:18	.782154	119:23	.713819	79:17	.667178	98:23	.629498	110:28	.594235	88:24	.564272	100:29	.537602	117:36	.511883
115:19	.781944	93:18	.713210	116:25	.666518	115:27	.629334	106:27	.593942	110:30	.564271	93:27	.537119	104:32	.511883
114:19	.778151	98:19	.712473	102:22	.666178	119:28	.628389	102:26	.593627	99:27	.564271	62:18	.537119	91:28	.511883
108:18	0.778151	103:20	.711807	88:19	0.665730	85:20	.628389	98:25	0.593286	77:21	.564271	117:34	0.536707	65:20	.511883
102:17	.778151	108:21	.711205	111:24	.665112	68:16	.628389	94:24	.592917	66:18	.564271	86:25	.536559	120:37	.510980
96:16	.778151	113:22	.710656	74:16	.665112	106:25	.627366	90:23	.592515	117:32	.563036	110:32	.536243	107:33	.510870
119:20	.774517	118:23	.710154	97:21	.664552	89:21	.627171	86:22	.592076	106:29	.562908	55:16	.536243	94:29	.510730
113:19	.774325	82:16	.709694	120:26	.664208	72:17	.626884	82:21	.591595	73:20	.562293	79:23	.535899	81:25	.510545
107:18	.774111	87:17	0.709070	83:18	.663806	110:26	0.626419	117:30	.591065	95:26	0.562750	103:30	.535716	68:21	0.510290
101:17	.773873	92:18	.708515	106:23	.663578	93:22	.626060	78:20	.591065	84:23	.562552	120:35	.535113	110:34	.509914
95:16	.773604	97:19	.708018	115:25	.662758	114:27	.625541	113:29	.590680	62:17	.561943	96:28	.535113	97:30	.509650
112:19	.770464	102:20	.707570	92:20	.662758	76:18	.625541	74:19	.590478	113:31	.561717	72:21	.535113	84:26	.509306
106:18	.770033	107:21	.707165	101:22	.661899	97:23	.625044	109:28	.590269	102:28	.561442	113:33	.534565	113:35	.509010
100:17	0.769551	112:22	.706795	78:17	0.661645	118:28	.624724	105:27	0.589826	91:25	.561101	89:26	0.534417	71:22	.508836
94:16	.769008	117:23	.706458	110:24	.661182	80:19	.624336	70:18	.589826	120:33	.560667	65:19	.534160	100:31	.508638
117:20	.767156	81:16	.704365	87:19	.660766	101:24	.624110	101:26	.589348	80:22	.560667	106:31	.533944	116:36	.508156
111:19	.766570	86:17	.704050	119:26	.660574	105:25	.623249	66:17	.589105	109:30	.560305	82:24	.533603	87:27	.508156
105:18	.765917	91:18	.703769	96:21	.660052	84:20	.623249	97:25	.588832	69:19	.560096	99:29	.533237	103:32	.507687
99:17	.765186	96:19	0.703518	105:23	.659462	109:26	0.622453	62:16	.588272	98:27	0.559862	116:34	.532980	74:23	0.507504
93:16	.764363	101:20	.703291	73:16	.659203	88:21	.622263	120:31	.587820	116:32	.559308	75:22	.532639	119:37	.507345
116:20	.763429	106:21	.703087	114:25	.658965	67:16	.621955	89:23	.587662	87:24	.559308	92:27	.532424	90:28	.507085
110:19	.762639	111:22	.702900	82:18	.658541	113:27	.621715	116:30	.587337	105:29	.558791	109:32	.532277	106:33	.506792
104:18	.761761	116:23	.702730	91:20	.658011	92:22	.621365	85:22	.586996	76:21	.558594	119:35	.531479	61:19	.506576
98:17	0.760777	120:24	.698970	100:22	0.657577	117:28	.621028	112:29	0.586820	94:26	.558155	102:30	0.531479	77:24	.506280
115:20	.759668	115:23	.698970	109:24	.657215	71:17	.620809	108:28	.586266	112:31	.557856	85:25	.531479	93:29	.506085
92:16	.759668	110:22	.698970	118:26	.656909	96:23	.620543	81:21	.586266	65:18	.557641	68:20	.531479	109:34	.505948
109:19	.758673	105:21	.698970	77:17	.656042	100:24	.619789	104:27	.585670	83:23	.557350	112:33	.530704	112:35	.505150
103:18	.757565	100:20	.698970	86:19	.655745	75:18	.619789	77:20	.585461	101:28	.557163	95:28	.530566	96:30	.505150
120:21	.756962	95:19	0.698970	95:21	.655504	104:25	0.619093	100:26	.585027	119:33	0.557033	78:23	.530367	80:25	0.505150
114:20	.755875	90:18	.698970	104:23	.655306	79:19	.618874	73:19	.584569	108:30	.556303	61:18	.530057	64:20	.505150
91:16	.754921	85:17	.698970	113:25	.655138	108:26	.618451	96:25	.584331	90:25	.556303	105:31	.529828	115:36	.504395
108:19	.754670	80:16	.698970	117:26	.653213	83:20	.618048	119:31	.584185	72:20	.556303	88:26	.529509	99:31	.504274
119:21	.753328	119:24	.695336	108:24	.653213	112:27	.617854	115:30	.583577	115:32	.555548	115:34	.529219	83:26	.504105
102:18	0.753328	114:23	.695171	99:22	0.653213	116:28	.617300	92:24	0.583577	97:27	.555408	71:21	0.529039	67:21	.503856
113:20	.752048	109:22	.695004	90:20	.653213	87:21	.617300	69:18	.583577	79:22	.555204	98:29	.528828	118:37	.503680
96:17	.751822	104:21	.694814	81:18	.653213	120:29	.616783	111:29	.582925	61:17	.554881	108:32	.528274	102.32	.503450
107:19	.750630	99:20	.694605	72:16	.653213	91:22	.616619	88:23	.582755	104:29	.554635	81:24	.528274	86:27	.503135
90:16	.750123	94:19	.694374	112:25	.651278	95:23	.615996	65:17	.582465	86:24	.554287	118:35	.527814	105:33	.502675

Machinery

the table, log 41 : 30 = 0.135663, so the error is log 0.000002. Thus this result is obtained:

$$\frac{57}{37} \times \frac{41}{30} = \frac{2337}{1110} = 2.105405$$

As the ratio of the gears is 2.105405 and the desired ratio is 2.105399, the error in the ratio is 0.000006. It should be noted that in this case the gearing does not overlap; that is, the two largest gears will be drivers or driven, whichever the case may be.

In case no combination can be found that nearly equals the logarithm of the ratio, a suitable four-gear combination may be found by reversing the second ratio selected from the table. For example, what gears will drive two shafts at a ratio of 595 to 594? Taking the logs from a six-place table, we have:

$$\begin{aligned} \log 595 &= 2.774517 \\ \log 594 &= 2.773786 \\ \hline \log \text{ratio} &= 0.000731 \end{aligned}$$

From the accompanying table select any ratio, say log 72 : 70 = 0.012235, and add the logarithm of the ratio 595 : 594,

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—2

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
70:22	0.502675	119:40	.473487	119:42	.452298	100:37	.431798	111:43	.411855	96:39	.391207	90:38	.374459	107:47	.357286
89:28	.502232	116:39	.473393	102:36	0.452298	108:40	.431364	80:31	.411728	64:26	.391207	116:49	.374262	66:29	0.357146
108:34	.501945	113:38	.473295	85:30	.452298	81:30	.431364	98:38	.411443	91:37	.390840	71:30	.374137	91:40	.356981
73:23	.501595	110:37	.473191	68:24	.452298	54:20	.431364	67:26	0.411102	59:24	.390641	97:41	.373988	116:51	.356888
92:29	.501390	107:36	.473081	116:41	.451674	116:43	.430990	116:45	.411246	86:35	.390431	78:33	.373581	75:33	.356547
111:35	.501255	104:35	0.472965	99:35	.451567	89:33	.430876	85:33	.410905	113:46	.390321	52:22	0.373581	50:22	.356547
95:30	.500602	101:34	.472843	82:29	.451416	62:23	.430664	103:40	.410777	108:44	.389971	111:47	.373225	100:44	.356547
76:24	.500602	98:33	.472712	65:23	.451186	97:36	0.430469	90:35	.410175	81:33	.389971	85:36	.373116	109:48	.356185
117:37	.499984	95:32	.472574	113:40	.451018	105:39	.430125	72:28	.410175	54:22	.389971	59:25	.372912	84:37	.356078
98:31	.499864	92:31	.472426	96:34	.450792	70:26	.430125	54:21	.410175	103:42	0.389588	92:39	.372723	59:26	.355879
79:25	0.499687	89:30	.472269	79:28	.450469	113:42	.429829	113:44	.409626	76:31	.389452	66:28	.372386	93:41	.355699
120:38	.499398	86:29	.472101	110:39	0.450328	78:29	.429697	95:37	.409522	98:40	.389166	99:42	.372386	102:45	0.355388
101:32	.499171	83:28	.471920	93:33	.449969	86:32	.429349	77:30	.409369	49:20	.389166	106:45	.372093	68:30	.355388
82:26	.498841	80:27	.471726	62:22	.449970	94:35	.429060	59:23	0.409124	120:49	.388985	73:31	.371961	111:49	.355127
104:33	.498519	77:26	.471517	107:38	.449600	102:38	.428817	100:39	.408935	71:29	.388860	113:48	.371837	77:34	.355012
63:20	.498311	74:25	0.471291	76:27	.449450	110:41	.428609	82:32	.408664	93:38	.388699	120:51	0.371611	120:53	.354905
85:27	.498055	71:24	.471047	90:32	.449092	59:22	.428429	105:41	.408405	115:47	.388600	80:34	.371611	86:38	.354715
107:34	.497905	68:23	.470781	104:37	.448832	67:25	0.428135	64:25	.408240	110:45	.388180	87:37	.371318	95:42	.354474
110:35	.497325	65:22	.470491	118:42	.448633	75:28	.427903	87:34	.408040	88:36	.388180	94:40	.371068	52:23	.354276
88:28	.497325	62:21	.470172	73:26	.448350	83:31	.427716	110:43	.407924	66:27	0.388180	47:20	.371068	113:50	.354108
113:36	0.496776	118:40	.469822	87:31	.448158	91:34	.427563	115:45	.407485	105:43	.387721	101:43	.370853	61:27	.353966
91:29	.496643	115:39	.469633	101:36	0.448019	99:37	.427434	92:36	.407485	83:34	.387599	54:23	.370666	70:31	0.353736
69:22	.496426	112:38	.469434	115:41	.447914	107:40	.427324	69:27	.407485	61:25	.387390	115:49	.370502	79:35	.353559
116:37	.496256	109:37	.469225	98:35	.447158	115:43	.427229	120:47	0.407083	100:41	.387216	61:26	.370357	88:39	.353418
94:30	.496007	106:36	.469003	84:30	.447158	120:45	.425969	97:38	.406988	117:48	.386945	68:29	.370111	97:43	.353303
119:38	.495763	103:35	0.468769	112:40	.447159	112:42	.425969	74:29	.406834	78:32	.386945	75:32	0.369911	106:47	.353208
72:23	.495605	100:34	.468521	70:25	.447159	104:39	.425969	51:20	.406540	95:39	.386659	82:35	.369746	115:51	.353128
97:31	.495410	97:33	.468258	109:39	.446362	96:36	0.425969	79:31	.406265	112:46	.386460	89:38	.369606	117:52	.352183
100:32	.494850	94:32	.467978	95:34	.446245	88:33	.425969	107:42	.406135	56:23	.386460	96:41	.369487	108:48	.352183
75:24	.494850	91:31	.467680	81:29	.446087	80:30	.425969	84:33	.405765	73:30	0.386202	103:44	.369385	99:44	.352183
103:33	0.494323	88:30	.467361	67:24	.445864	72:27	.425969	56:22	.405765	90:37	.386041	110:47	.369295	90:40	.352183
78:25	.494155	85:29	.467021	120:43	0.445713	64:24	.425969	117:46	.405428	107:44	.385931	117:50	.369216	81:36	0.352183
106:34	.493827	82:28	.466656	106:38	.445522	56:21	.425969	89:35	.405322	102:42	.385351	119:51	.367977	72:32	.352183
81:26	.493511	120:41	.466397	92:33	.445274	117:44	.424733	61:24	0.405119	119:49	.385351	105:45	.367977	63:28	.352183
109:35	.493359	79:27	.466263	117:42	.444937	109:41	.424643	94:37	.404926	85:35	.385351	98:42	.367977	45:20	.352183
112:36	.492916	117:40	0.466126	78:28	.444937	101:38	.424538	99:39	.404571	68:28	.385351	91:39	0.367977	119:53	.351271
84:27	.492916	114:39	.465840	103:37	.444636	93:35	.424415	66:26	.404571	51:21	.385351	84:36	.367977	110:49	.351197
115:37	.492496	76:26	.465840	64:23	.444452	85:32	0.424269	104:41	.404249	114:47	.384807	77:33	.367977	101:45	.251109
87:28	.492361	111:38	.465539	89:32	.444240	77:29	.424093	71:28	.404100	97:40	.384712	70:30	.367977	92:41	.351004
118:38	.492098	73:25	.465383	114:41	.444121	69:26	.423876	109:43	.403958	80:33	0.384576	63:27	.367977	83:37	.350876
90:29	0.491845	108:37	.465222	100:36	.443698	61:23	.423602	114:45	.403692	63:26	.384367	56:24	.367977	74:33	.350718
93:30	.491362	70:24	.464887	75:27	0.443698	114:43	.423436	76:30	.403692	109:45	.384214	49:21	.367977	65:29	0.350515
62:20	.491362	102:35	.464532	111:40	.443263	106:40	.423246	119:47	.403449	92:38	.384004	114:49	.366709	56:25	.350248
96:31	.490910	67:23	.464347	86:31	.443137	98:37	.423024	81:32	0.403335	75:31	.383700	107:46	.366626	103:46	.350079
65:21	.490694	99:34	.464156	61:22	.442907	90:34	.422764	86:34	.403020	104:43	.383565	100:43	.366532	94:42	.349879
99:32	.490485	96:33	0.463757	97:35	.442704	82:31	.422452	91:36	.402739	87:36	.383217	93:40	0.366423	85:38	.349635
102:33	.490086	64:22	.463757	72:26	.442359	119:45	.422335	96:38	.402488	58:24	.383217	86:37	.366297	114:51	.349335
68:22	.490086	93:32	.463333	108:39	.442360	111:42	0.422074	101:40	.402261	99:41	.382851	79:34	.366148	76:34	.349335
105:34	.489710	90:31	.462881	119:43	.442079	74:28	.422074	53:21	.402057	70:29	.382700	72:31	.365971	105:47	.349091
71:23	.489531	61:21	.463111	83:30	.441957	103:39	.421773	111:44	.401870	111:46	0.382565	65:28	.365755	67:30	.348954
108:35	0.489356	119:41	.462763	94:34	.441649	95:36	.421421	58:23	.401700	82:34	.382335	58:25	.365488	96:43	.348803
111:36	.489021	116:40	.462398	105:38	0.441406	87:33	.421005	63:25	.401401	94:39	.382063	109:47	.365329	87:39	0.348455
74:24	.489021	87:30	.462398	58:21	.441209	58:22	.421005	68:27	.401145	53:22	.381853	102:44	.365148	58:26	.348455
114:37	.488703	58:20	.462398	80:29	.440692	108:41	.420640	73:29	0.400925	118:49	.381686	95:41	.364940	107:48	.348143
77:25	.488551	84:29	.461881	91:33	.440528	79:30	.420506	78:31	.400733	65:27	.381550	88:38	.364700	78:35	.348027
117:38	.488402	110:38	0.461609	102:37	.440399	100:38	.420216	83:33	.400564	77:32	.381341	81:35	0.364417	98:44	.347773
120:39	.488117	81:28	.461327	113:41	.440295	71:27	.419895	88:35	.400415	89:37	.381188	118:51	.364312	49:22	.347773
80:26	.488117	107:37	.461182	110:40	.439333	92:35	0.419720	93:37	.400281	101:42	.381072	111:48	.364083	118:53	.347606
83:27	.487714	69:25	.460909	99:36	.439333	113:43	.419610	98:39	.400162	113:47	.380981	74:32	.364082	69:31	.347487
86:28	.487341	104:36	.460731	88:32	.439333	105:40	.419130	103:41	.400053	120:50	0.380211	104:45	.363821	89:40	.347330
89:29	0.486992	78:27	.460731	77:28	.439333	63:24	.419130	108:43	.399955	108:45	.380211	67:29	.363677	109:49	.347230
92:30	.486667	101:35	.460253	118:43	0.438414	84:32	.419129	113:45	.399866	96:40	.380211	90:39	.363178	100:45	0.346788
95:31	.486362	75:26	.460088	107:39	.438319	118:45	.418670	118:47	.399784	84:35	.380211	60:26	.363178	80:36	.346788
98:32	.486076	98:34	.459747	96:35	.438203	97:37	.418570	40:16		72:30	.380211	113:49	.362882	60:27	.346788
101:33	.485808	72:25	.459393	85:31	.438057	76:29	.418416	or any	0.397940	60:25	.380211	53:23	.362548	111:50	.346353
104:34	.485554	95:33	0.459210	74:27	.437868	55:21	.418143	2½ to 1		48:20	.380211	76:33	0.362300	91:41	.346258
107:35	.485316	118:41	.459098	63:23	.437613	89:34	.417911	ratio		115:48	.379457	99:43	.362167	51:23	.345842
110:36	.485090	115:40	.458638	115:42	.437449	102:39	0.417536	117:47	.396088	103:43	.379369	115:50	.361728	113:51	.345508
113:37	.484877	92:32	.458638	104:38	.437250	68:26	.417536	112:45	.396006	91:38	.379258	92:40	.361728	93:42	.345234
116:38	.484674	69:24	.458638	93:34	.437004	115:44	.417245	107:43	.395915	79:33	0.379113	69:30	.361728	62:28	.345234
119:39	0.484482	112:39	.458153	82:30	.436693	81:31	.417123	102:41	.395816	67:28	.378916	46:20	.361728	104:47	.344935
61:20	.484300	89:31	.458028	112:41	0.436434	94:36	.416825	97:39	.395707	55:23	.378635	108:47	.361326	73:33	0.344809
64:21	.483961	66:23	.457816	71:26	.436285	107:41	.416600	92:37	.395586	98:41	.378442	85:37	.361217	115:52	.344695
67:22	.483652	109:38	.457643	101:37	.436120	60:23	.416424	87:35	0.395451	86:36	.378196	62:27	.361028	84:38	.344496
70:23	.483370	86:30	.457377	90:33	.435729	73:28	.416165	82:33	.395300	117:49	.377990	101:44	.360869	95:43	.344255
73:24	.483112	106:37	0.457104	60:22	.435729	86:33	.415985	77:31	.395129	74:31	.377870	117:51	0.360616	53:24	.344065
76:25	.482874	63:22	.456918	109:40	.435367	99:38	.415852	72:29	.394935	105:44	.377737	78:34	.360616	117:53	.343910
79:26	.482654	83:29	.456680	79:29	.435229	112:43	0.415750	67:27	.394711	93:39	.377418	94:41	.360344	64:29	.343782
82:27	.482450	103:36	.456535	98:36	.434924	117:45	.414973	62:25	.394452	62:26	.377418	55:24	.360152	75:34	.343582
85:28	.482261	120:42	.455932	117:43	.434717	91:35	.414973	119:48	.394306	112:47	0.377120	71:31	.359897	86:39	.343434
88:29	0.482085	100:35	.455932	68:25	.434569	78:30	.414973	57:23	.394147	81:34	.377006	87:38	.359736	97:44	.343319
91:30	.481920	80:28	.455932	87:32	0.434369	52:20	.414973	109:44	.393974	100:42	.376751	103:45	.359625	108:49	0.343228
94:31	.481736	60:21	.455932	106:39	.434241	109:42	.414177	52:21	.393784	50:21	.376751	119:52	.359544	119:54	.343153
97:32	.481622	117:41	.455402	114:42	.433656	96:37	.414070	99:40	0.393575	119:50	.376577	112:49	.359022	99:45	.342423
100:33	.481486	97:34	.455293	95:35	.433656	83:32	.413928	94:38	.393344	69:29	.376451	96:42	.359022	88:40	.342423
103:34	.481358	77:27	0.455127	76:28	.433656	70:27	.413734	89:36	.393088	88:37	.376281	80:35	0.359022	77:35	.342423
106:35	.481237	114:40	.454845	57:21	.433656	57:22	.413452	84:34	.392800	107:45	.376171	64:28	.359022	66:30	.342423
109:36	.481124	94:33	.454614	103:38	.433054	101:39	0.413257	79:32	.392477	95:40	.375664	48:21	.359022	55:25	.342423
112:37	.481016	111:39	.454258	84:31	.432918	88:34	.413004	116:47	.392360	76:32	.375664	105:46	.358432	112:51	.341648
115:38	.480914	74:26	.454258	65:24	.432702	119:46	.412789	111:45	.392111	57:24	0.375664	89:39	.358325	101:46	.341564
118:39	0.480817	91:32	.453891	111:41	.432539	75:29	.412663	74:30	.392110	102:43	.375132	73:32	.358173	90:41	.341459
48:16		71:25	.453318	92:34	0.432309	106:41	.412522	106:43	.391837	83:35	.375010	57:25	.357935	79:36	0.341325
or any	.477121	88:31	.453121	119:44	.432094	62:24	.412181	69:28	.391691	64:27	.374816	98:43	.357758	57:26	.340902
3 to 1		105:37	.452988	73:27	.431959	93:36	.412180	101:41	0.391538	109:46	.374669	82:36	.357511	103:47	.340739
ratio															

Machinery

or 0.000731; the sum is 0.012966. Select the logarithm nearest the sum from the table; this is found to be log 68 : 66 = 0.012965. Now by reversing this pair the difference of the ratios, or 594 : 595, will be obtained. Reversing 68 : 66 gives 66 : 68; therefore, the gears required are $\frac{72}{70} \times \frac{66}{68}$. The proof of this is: $\frac{72}{70} \times \frac{66}{68} = \frac{4752}{4760} = \frac{594}{595}$.

It is evident that overlapping is necessary only when the ratio is nearly 1 to 1. Care should be taken in overlapping to avoid interference on the machine. The best rule is to keep the gears as near the same size as possible.

Driver and Driven Gears

Gears for the ratio 7.32 : 4.17 are selected in the same manner as gears for the ratio 4.17 : 7.32. The logarithm of the smaller number is subtracted from the logarithm of the larger, giving the logarithm of the ratio. There may be some difficulty in determining which gears are the drivers and which the driven. The first figure of a gear ratio is usually considered to be the driver. For example, if two shafts are to

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—3

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
92:42	.340539	74:35	.325164	92:45	.0310575	96:49	.292075	89:47	.277292	77:42	.263241	80:45	.249878	76:44	0.237361
46:21	.340539	93:44	.325030	94:46	.310370	94:48	.291887	53:28	.277118	66:36	.263241	64:36	.249878	57:33	.237361
81:37	.340283	112.53	.324942	96:47	.310173	92:47	.291690	87:46	0.276762	55:30	.263241	119:67	.249472	38:22	.237361
116:53	.340182	95:45	0.324511	98:48	.309985	90:46	.291485	104:55	.276671	119:65	.262634	103:58	.249409	107:62	.236992
105:48	.339948	76:36	.324511	100:49	.309804	88:45	.291270	119:63	.276207	108:59	.262572	87:49	0.249323	88:51	.236913
70:32	.339948	57:27	.324511	102:50	.309630	86:44	.291046	85:45	.276207	97:53	.262496	71:40	.249198	69:40	.236789
93:43	.339659	116:55	.324095	51:25	.309630	84:43	0.290811	68:36	.276206	86:47	.262401	110:62	.249001	119:69	.236698
118:54	0.339488	97:46	.324014	104:51	.309463	82:42	.290565	117:62	.275794	75:41	.262277	55:31	.249001	100:58	.236572
59:27	.339488	78:37	.323893	53:26	.309303	41:21	.290565	100:53	.275724	64:35	0.262112	94:53	.248852	50:29	.236572
83:38	.339295	59:28	.323694	108:53	.309148	80:41	.290306	83:44	.275625	53:29	.261878	117:66	.248642	81:47	.236387
107:49	.339188	99:47	.323537	55:27	0.308999	119.61	.290217	66:35	.275476	95:52	.261720	78:44	.248642	112:65	0.236305
120:55	.338819	120:57	.323306	112:55	.308855	78:40	.290035	115:61	.275368	84:46	.261522	101:57	.248447	62:36	.236089
96:44	.338819	80:38	.323306	57:28	.308717	39:20	.290035	98:52	0.275223	115:63	.261357	62:35	.248324	93:54	.236089
72:33	.338819	101:48	0.323080	116:57	.308583	115:59	.289846	81:43	.275017	73:40	.261262	85:48	.248178	105:61	.235860
48:22	.338819	61:29	.322932	59:29	.308454	76:39	.289749	113:60	.274927	104:57	.261158	108:61	0.248094	74:43	.235763
109:50	.338457	82:39	.322749	120:59	.308329	113:58	.289650	96:51	.274701	62:34	.260913	115:65	.247785	117:68	.235677
85:39	.338354	103:49	.322641	61:30	.308209	111:57	0.289448	64:34	.274701	93:51	.260912	92:52	.247785	86:50	.235529
61:28	0.338172	105:50	.322219	63:31	.307979	74:38	.289448	111:59	.274471	113:62	.260687	69:39	.247785	98:57	.235351
98:45	.338014	84:40	.322219	65:32	.307763	109:56	.289239	79:42	.274378	82:45	0.260601	99:56	.247447	110:64	.235213
111:51	.337753	63:30	.322219	67:33	.307561	72:37	.289131	94:50	.274158	51:28	.260412	76:43	.247345	55:32	.235213
74:34	.337753	42:20	.322219	118:58	0.307454	107:55	.289021	109:58	.273999	71:39	.260194	106:60	.247155	67:39	0.235010
87:40	.337459	107:51	.321814	69:34	.307370	70:36	.288796	62:33	.273878	91:50	.260071	53:30	.247155	79:46	.234869
100:46	.337242	86:41	.321715	71:35	.307190	103:53	.288561	77:41	0.273707	111:61	.259993	83:47	.246980	91:53	.234766
113:52	.337075	65:31	0.321552	73:36	.307020	68:35	.288441	92:49	.273592	100:55	.259637	113:64	.246898	103:60	.234686
63:29	.336943	109:52	.321423	75:37	.306860	101:52	.288318	107:57	.273509	80:44	.259637	120:68	0.246672	115:67	.234623
76:35	.336746	88:42	.321233	77:38	.306707	66:34	.288065	120:64	.273001	40:22	.259637	90:51	.246672	96:56	.234083
89:41	.336606	44:21	.321233	79:39	.306563	99:51	0.288065	105:56	.273001	109:60	.259275	60:34	.246672	84:49	.234083
102:47	0.336502	111:53	.321047	81:40	.306425	97:50	.287802	90:48	.273001	89:49	.259194	97:55	.246409	72:42	.234083
115:53	.336412	67:32	.320925	83:41	.306294	64:33	.287666	75:40	.273001	69:38	0.259066	67:38	.246291	60:35	.234083
117:54	.335792	90:43	.320774	85:42	.306170	95:49	.287528	60:32	.273001	118:65	.258969	104:59	.246181	113:66	.233535
91:42	.335792	113:54	.320685	87:43	0.306051	93:48	.287242	118:63	.272542	98:54	.258832	111:63	.245982	101:59	0.233469
78:36	.335792	115:55	.320335	89:44	.305937	62:32	.287242	103:55	.272475	78:43	.258626	74:42	.245982	89:52	.233388
65:30	.335792	92:44	.320335	91:45	.305829	91:47	.286944	88:47	0.272385	107:59	.258532	37:21	.245982	77:45	.233278
52:24	.335792	69:33	0.320335	93:46	.305725	120:62	.286790	73:39	.272258	116:64	.258278	118:67	.245807	65:38	.233130
119:55	.335184	46:22	.320335	95:47	.305626	89:46	.286632	58:31	.272066	87:48	.258278	81:46	0.245727	118:69	.233033
106:49	.335110	117:56	.319998	97:48	.305531	118:61	.286552	101:54	.271928	58:32	.258278	88:50	.245513	53:31	.232914
93:43	.335014	71:34	.319779	99:49	.305439	116:60	0.286307	86:46	.271741	96:53	.257995	95:54	.245330	94:55	.232765
80:37	0.334888	119:57	.319672	101:50	.305351	56:30	.286307	114:61	.271575	67:37	.257873	51:29	.245172	82:48	.232573
67:31	.334713	96:46	.319513	103:51	.305267	114:59	.286053	99:53	.271360	105:58	0.257761	109:62	.245035	111:65	.232410
54:25	.334454	73:35	.319255	105:52	.305186	85:44	.285966	112:60	.271067	38:21	.257564	58:33	.244914	70:41	.232314
95:44	.334271	98:47	.319128	107:53	0.305108	56:29	.285790	84:45	.271067	76:42	.257564	65:37	.244712	87:51	0.231949
82:38	.334030	100:48	.318759	109:54	.305033	83:43	.285610	56:30	.271067	85:47	.257321	72:41	.244549	58:34	.231949
110:51	.333823	75:36	.318759	111:55	.304960	110:57	.285518	97:52	0.270768	94:52	.257125	79:45	.244415	104:61	.231704
69:32	.333699	102:49	0.318404	113:56	.304890	81:42	.285236	69:37	.270647	103:57	.256962	86:49	.244302	75:44	.231608
97:45	.333559	77:37	.318289	115:57	.304823	54:28	.285235	110:59	.270541	112:62	.256826	93:53	0.244207	92:54	.231394
84:39	.333215	52:25	.318063	117:58	.304758	106:55	.284943	82:44	.270361	56:31	.256826	100:57	.244125	109:64	.231247
56:26	.333215	79:38	.317844	119:59	.304695	79:41	0.284843	41:22	.270361	65:36	.256611	107:61	.244054	63:37	.231139
99:46	0.332877	106:51	.317736	32:16		52:27	.284640	95:51	.270153	74:41	.256448	114:65	.243992	80:47	.230992
71:33	.332744	81:39	.317420	or		77:40	.284431	54:29	.269996	83:46	0.256320	119:68	.243038	97:57	.230897
114:53	.332629	110:53	.317117	any	0.301030	102:53	.284324	67:36	.269772	92:51	.256218	112:64	.243038	114:67	.230830
86:40	.332439	83:40	.317018	2 to 1		100:52	.283997	80:43	.269622	101:56	.256133	98:56	.243038	85:50	0.230449
43:20	.332439	112:54	.316824	ratio		75:39	.283997	93:50	.269513	110:61	.256063	91:52	.243038	68:40	.230449
101:47	.332224	85:41	.316635	119:60	.297396	98:51	.283656	106:57	0.269431	119:66	.256003	84:48	.243038	51:30	.230449
58:27	.332064	114:55	0.316542	117:59	.297334	73:38	.283540	119:64	.269367	99:55	.255273	77:44	.243038	107:63	.230043
73:34	.331844	87:42	.316270	115:58	.297270	96:50	.283301	117:63	.268845	90:50	.255273	70:40	0.243038	90:53	.229967
88:41	.331699	58:28	.316270	113:57	.297204	119:62	.283155	91:49	.268845	81:45	.255273	63:36	.243038	73:43	.229854
103:48	.331596	118:57	.316007	111:56	.297135	71:37	0.283057	78:42	.268845	72:40	.255273	35:20	.243038	112:66	.229674
118:55	0.331519	89:43	.315922	109:55	.297064	94:49	.282932	65:35	.268845	63:35	.255273	117:67	.242111	56:33	.229674
105:49	.330993	120:58	.315753	107:54	.296990	117:61	.282856	52:28	.268845	54:30	0.255273	110:63	.242052	95:56	.229536
90:42	.330993	60:29	.315753	105:53	.296913	92:48	.282547	39:21	.268845	115:64	.254518	103:59	.241985	117:69	.229337
75:35	.330993	91:44	.315589	103:52	0.296833	69:36	.282547	115:62	.268306	106:59	.254454	96:55	.241909	78:46	0.229337
60:28	.330993	93:45	.315270	101:51	.296751	113:59	.282226	102:55	.268238	97:54	.254378	89:51	.241820	100:59	.229148
45:21	.330993	62:30	.315270	99:50	.296665	90:47	.282145	89:48	0.268149	88:49	.254287	82:47	.241716	61:36	.229027
107:50	.330414	95:46	0.314966	97:49	.296576	67:35	.282007	76:41	.268030	79:44	.254174	75:43	.241593	83:49	.228882
92:43	.330319	64:31	.314818	95:48	.296482	111:58	.281895	63:34	.267862	70:39	.254033	68:39	0.241444	105:62	.228798
77:36	.330188	97:47	.314674	93:47	.296385	88:46	.281725	113:61	.267749	61:34	.253851	61:35	.241262	110:65	.228479
62:29	.329994	99:48	.314394	91:46	.296284	109:57	0.281552	100:54	.267606	113:63	.253738	115:66	.241154	88:52	.228479
109:51	0.329855	66:32	.314394	89:45	.296178	65:34	.281435	87:47	.267421	52:29	.253605	108:62	.241032	66:39	.228479
94:44	.329675	101:49	.314125	87:44	.296067	86:45	.281286	111:60	.267172	95:53	0.253448	54:31	.241032	115:68	.228187
47:22	.329675	68:33	.313995	85:43	.295950	107:56	.281196	74:40	.267172	86:48	.253257	101:58	.240893	93:55	.228120
79:37	.329425	103:50	.313867	83:42	0.295829	84:44	.280827	37:20	.267172	120:67	.253106	94:54	.240734	71:42	0.228009
111:52	.329320	105:51	.313619	81:41	.295701	63:33	.280827	98:53	.266950	77:43	.253022	87:50	.240549	120:71	.227923
96:45	.329059	70:34	.313619	79:40	.295567	103:54	.280443	61:33	0.266816	111:62	.252931	120:69	.240332	98:58	.227798
64:30	.329059	107:52	0.313381	77:39	.295426	82:43	.280345	85:46	.266661	102:57	.252725	80:46	.240332	76:45	.227601
113:53	.328803	72:35	.313265	75:38	.295278	61:32	.280180	109:59	.266575	68:38	.252725	113:65	0.240165	103:61	.227507
81:38	.328701	109:53	.313151	73:37	.295121	101:53	.280046	96:52	.266268	93:52	.252480	73:42	.240074	81:48	.227244
98:46	.328468	74:36	.312929	71:36	.294956	80:42	0.279841	72:39	.266268	118:66	.252338	106:61	.239976	54:32	.227244
115:54	0.328304	111:54	.312929	69:35	.294781	40:21	.279841	107:58	.265956	59:33	.252338	99:57	.239760	113:67	.227004
66:31	.328182	113:55	.312716	67:34	.294596	99:52	.279632	118:64	.265702	84:47	0.252181	66:38	.239760	86:51	.226928
83:39	.328014	76:37	.312612	65:33	.294400	59:31	.279490	59:32	.265702	109:61	.252097	92:53	.239512	59:35	.226784
100:47	.327902	115:56	.312510	63:32	0.294191	78:41	.279311	94:51	.265558	100:56	.251812	59:34	.239373	91:54	0.226648
117:55	.327823	117:57	.312311	61:31	.293968	97:51	.279202	70:38	.265314	75:42	.251812	85:49	.239223	64:38	.226396
119:56	.327359	78:38	.312311	120:61	.293851	116:61	.279128	116:63	0.265118	116:65	.251545	111:64	.239143	96:57	.226396
85:40	.327359	119:58	0.312119	59:30	.293731	95:50	.278754	81:44	.265032	91:51	.251471	78:45	.238882	101:60	.226170
68:32	.327359	80:39	.312025	116:59	.293606	76:40	.278754	92:50	.264818	66:37	.251342	52:30	0.238882	69:41	.226065
51:24	.327359	82:40	.311754	57:29	.293477	57:30	.278754	103:56	.264649	107:60	.251233	97:56	.238584	106:63	.225965
104:49	.326837	41:20	.311754	112:57	.293343	38:20	0.278754	68:37	.264307	82:46	.251056	71:41	.238474	111:66	.225779
87:41	0.326735	84:41	.311495	55:28	.293205	112:59	.278366	79:43	.264159	98:55	.250863	116:67	.238383	74:44	.225779
70:33	.326584	86:42	.311249	108:55	.293061	93:49	.278287	90:49	.264046	57:32	0.250725	90:52	.238239	116:69	.225609
89:42	.326141	43:21	.311249	53:27	.292912	74:39	.278167	101:55	.263959	73:41	.250539	109:63	.238086	79:47	.225529
108:51	.325854	88:43	.311014	104:53	0.292757	55:29	.277965	112:61	.263888	89:50	.250420	64:37	.237978	84:50	0.225309
72:34	.325854	90:44	.310790	51:26	.292597	91:48	.277800	110:60	.263241	105:59	.250337	83:48	.237837	89:53	.225114
91:43	.325573	45:22	.310790	100:51	.292430	108:57	.277549	99:54	0.263241	112:63	.249878	102:59	.237748	94:56	.224940
55:26	.325389			98:50	.292256	72:38	.277549	88:48	.263241	96:54	.249878	95:55	.237361	99:59	.224783

Machinery

run at a ratio of 3 to 1, it is implied that 3 is the driver and the gear with the largest number of teeth will be placed on the driving shaft. In so far as the use of the gear logarithm tables are concerned, it is immaterial which is the driver and which is the driven gear, and by comparing the gears selected with the ratio, no confusion should result.

Applications of Table

The following examples showing the application of the table to ordinary machine-shop work are not intended as a complete explanation of the subject. Knowledge of the construction and application of lathes, milling machines and gear-cutting machinery is taken for granted. The table is useful in the selection of gears (or pulleys) to obtain geometrical speeds, but because of the special nature of this class of work no examples will be given.

Lathe Change-gears

For calculating the change-gears to cut any lead on a lathe, the "constant" of the machine must be known. The constant of a simple change-gear lathe with a single-thread lead-screw may be considered as the number of threads per inch of the

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—4

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
52:31	.224642	62:38	.212608	119:75	.200486	102:66	.189056	74:49	.179036	116:79	.166831	102:71	.157342	90:64	.148063
109:65	.224513	106:65	.212393	92:58	.200360	85:55	.189056	77:51	.178921	69:47	.166751	79:55	.157264	45:32	.148063
114:68	.224396	75:46	0.212304	111:70	.200225	68:44	.189056	80:53	.178811	91:62	.166650	112:78	.157123	97:69	.147923
57:34	.224396	119:73	.212224	65:41	.200130	51:33	0.189056	83:55	.178715	113:77	0.166588	56:39	.157123	104:74	0.147802
119:71	.224289	88:54	.212089	84:53	.200003	34:22	.189056	86:57	.178624	110:75	.166331	89:62	.156998	52:37	.147802
62:37	.224190	101:62	.211930	103:65	.199924	105:68	.188680	89:59	.178538	88:60	.166331	99:69	.156786	111:79	.147696
67:40	0.224015	57:35	.211807	114:72	.199572	88:57	.188608	92:61	.178458	66:45	.166331	66:46	.156786	118:84	.147603
72:43	.223864	70:43	.211630	95:60	.199572	71:46	.188501	95:63	.178383	44:30	.166331	109:76	.156613	66:47	.147446
77:46	.223733	96:59	.211419	76:48	0.199572	54:35	.188326	101:67	0.178257	107:73	.166061	76:53	0.156538	73:52	.147320
82:49	.223618	109:67	.211352	57:36	.199572	91:59	.188190	104:69	.178184	85:58	.165991	119:83	.156469	80:57	.147215
87:52	.223516	117:72	.210853	106:67	.199231	111:72	.187991	107:71	.178126	63:43	.165872	86:60	.156347	87:62	.147128
92:55	.223425	91:56	.210853	87:55	.199157	74:48	.187991	110:73	.178070	104:71	.165775	43:30	.156347	94:67	.147053
97:58	.223344	78:48	0.210853	68:43	.199040	94:61	.187798	113:75	.178017	82:56	.165626	96:67	.156196	101:72	.146989
102:61	.223270	65:40	.210853	117:74	.198954	57:37	0.187673	116:77	.177967	101:69	0.165472	106:74	.156074	108:77	0.146933
107:64	.223204	112:69	.210369	98:62	.198834	77:50	.187521	119:79	.177910	120:82	.165367	53:37	.156074	115:82	.146884
112:67	.223143	99:61	.210305	49:31	.198834	97:63	.187431	24:16		60:41	.165367	116:81	.155973	98:70	.146128
117:70	0.223088	86:53	.210223	79:50	.198657	117:76	.187372	or		79:54	.165233	63:44	.155888	91:65	.146128
100:60	.221849	73:45	.210110	109:69	.198577	100:65	.187087	any	0.176091	98:67	.165151	73:51	.155753	84:60	.146128
95:57	.221849	120:74	.209950	90:57	0.198368	80:52	.187087	3 to 2		117:80	.165096	93:65	0.155570	77:55	.146128
90:54	.221849	60:37	.209950	60:38	.198368	60:39	.187087	ratio		114:78	.164810	103:72	.155505	70:50	.146128
85:51	.221849	107:66	.209840	101:64	.198141	103:67	.186762	118:79	.174255	95:65	.164810	113:79	.155451	63:45	.146128
80:48	.221849	94:58	.209700	71:45	.198046	83:54	.186684	115:77	.174207	76:52	.164810	120:84	.154902	56:40	.146128
75:45	.221849	81:50	0.209515	112:71	.197960	63:41	.186557	112:75	.174157	57:39	.164810	110:77	.154902	49:35	.146128
70:42	.221849	115:71	.209440	82:52	.197811	106:69	0.186457	109:73	.174104	111:76	0.164509	100:70	.154902	42:30	0.146128
65:39	.221849	68:42	.209260	93:59	.197631	86:56	.186311	106:71	.174048	92:63	.164447	90:63	.154902	35:25	.146128
60:36	.221849	34:21	.209260	52:33	.197489	109:71	.186168	103:69	.173988	73:50	.164353	80:56	.154902	116:83	.145380
55:33	0.221849	89:55	.209027	115:73	.197375	66:43	.186075	100:67	.173925	108:74	.164192	70:49	.154902	109:78	.145332
50:30	.221849	55:34	.208884	63:40	.197281	89:58	.185962	97:65	.173858	54:37	.164192	60:42	.154902	102:73	.145277
118:71	.220624	76:47	.208716	74:47	0.197134	112:73	.185895	94:63	0.173787	89:61	.164060	30:21	0.154902	88:63	.145142
113:68	.220570	97:60	.208620	85:54	.197025	115:75	.185637	91:61	.173712	105:72	.163857	117:82	.154372	81:58	.145057
108:65	.220510	118:73	.208559	96:61	.196941	92:60	.185637	88:59	.173631	70:48	.163857	107:75	.154323	74:53	.144956
103:62	.220446	84:52	.208276	107:68	.196875	69:45	.185637	85:57	.173544	86:59	.163647	97:68	.154263	67:48	.144834
98:59	.220374	63:39	0.208276	118:75	.196821	46:30	.185637	82:55	.173451	102:70	.163502	87:61	.154180	120:86	.144683
93:56	.220295	113:70	.207980	110:70	.196295	95:62	0.185332	79:53	.173351	51:35	0.163502	77:54	.154097	60:43	0.144683
88:53	.220207	92:57	.207913	99:63	.196295	72:47	.185235	76:51	.173243	118:81	.163397	67:47	.153977	113:81	.144593
83:50	.220109	71:44	.207806	88:56	.196295	98:64	.185046	73:49	.173127	67:46	.163317	114:80	.153815	106:76	.144492
78:47	0.219997	100:62	.207608	77:49	.196295	49:32	.185046	70:47	.173000	83:57	.163203	57:40	.153815	53:38	.144492
73:44	.219870	50:31	.207608	66:42	.196295	75:49	.184865	67:45	.172862	99:68	.163126	104:73	.153710	99:71	.144377
68:41	.219725	79:49	.207431	55:35	0.196295	101:66	.184778	64:43	0.172712	115:79	.163071	94:66	0.153584	92:66	.144244
63:38	.219557	108:67	.207349	113:72	.195746	104:68	.184524	61:41	.172546	112:77	.162727	47:33	.153584	46:33	.144244
58:35	.219360	87:54	.207126	91:58	.195613	78:51	.184524	119:80	.172457	96:66	.162727	84:59	.153427	85:61	.144089
111:67	.219248	58:36	.207126	102:65	.195607	52:34	.184524	58:39	.172363	80:55	.162727	111:78	.153228	117:84	.143907
53:32	.219126	29:18	0.207126	69:44	.195396	118:77	.184391	113:76	.172265	64:44	.162727	74:52	.153228	78:56	.143907
101:61	.218992	95:59	.206872	58:37	.195226	107:70	0.184286	55:37	.172161	48:33	0.162727	101:71	.153063	110:79	0.143766
96:58	.218843	66:41	.206760	105:67	.195115	81:53	.184209	107:72	.172051	32:22	.162727	64:45	.152968	71:51	.143688
91:55	.218679	103:64	.206651	94:60	.194977	110:72	.184060	104:70	.171935	109:75	.162365	91:64	.152861	103:74	.143606
86:52	0.218495	111:69	.206474	47:30	.194977	55:36	.184060	52:35	.171935	93:64	.162303	118:83	.152804	96:69	.143422
81:49	.218289	74:46	.206474	83:53	.194802	84:55	.183917	101:68	.171813	77:53	.162215	108:76	.152610	64:46	.143422
119:72	.218215	119:74	.206315	119:76	0.194733	113:74	.183847	98:66	0.171682	61:42	.162081	81:57	0.152610	89:64	.143210
76:46	.218056	82:51	.206244	108:69	.194575	116:76	.183644	49:33	.171682	106:73	.161983	54:38	.152610	114:82	.143091
109:66	.217883	90:56	.206055	97:62	.194380	87:57	.183644	95:64	.171544	90:62	.161851	98:69	.152377	57:41	.143091
71:43	.217790	98:61	.205896	61:39	.194265	58:38	.183644	92:62	.171396	45:31	.161851	71:50	.152288	82:59	.142962
104:63	.217693	53:33	0.205762	86:55	.194136	119:78	.183452	46:31	.171396	119:82	.161733	115:81	.152213	107:77	.142893
66:40	.217484	114:71	.205647	111:71	.194065	90:59	0.183391	89:60	.171239	74:51	0.161662	88:62	.152091	100:72	0.142668
94:57	.217253	61:38	.205546	100:64	.193820	61:40	.183270	86:58	.171071	103:71	.161579	44:31	.152091	75:54	.142668
61.37	.217128	69:43	.205380	75:48	.193820	93:61	.183153	83:56	.170890	116:80	.161368	105:74	.151958	50:36	.142668
89:54	0.216996	77:48	.205250	50:32	.193820	96:63	.182931	120:81	.170696	87:60	.161368	61:43	.151861	118:85	.142463
117:71	.216928	85:53	.205143	114:73	.193582	64:42	.182931	80:54	.170696	58:40	.161368	78:55	.151732	93:67	.142408
112:68	.216709	93:58	.205055	89:57	0.193515	32:21	.182931	117:79	0.170559	100:69	.161151	95:67	0.151649	68:49	.142313
84:51	.216709	101:63	.204981	64:41	.193396	99:65	.182722	77:52	.170487	71:49	.161062	112:79	.151591	111:80	.142233
56:34	.216709	109:68	.204918	103:66	.193293	67:44	.182622	114:77	.170414	113:78	.160984	119:84	.151268	86:62	.142107
107:65	.216470	117:73	.204863	117:75	.193125	102:67	.182525	111:75	.170262	84:58	.160851	102:72	.151268	43:31	.142107
79:48	.216386	96:30	0.204120	78:50	.193125	105:69	.182340	74:50	.170262	97:67	.160697	85:60	.151268	104:75	.141972
102:62	.216209	88:55	.204120	92:59	.192936	70:46	0.182340	108:73	.170101	110:76	0.160579	68:48	.151268	61:44	0.141877
51:31	.216209	80:50	.204120	53:34	.192797	108:71	.182166	71:48	.170017	55:38	.160579	51:36	.151268	79:57	.141752
74:45	.216019	72:45	.204120	120:77	.192691	73:48	.182082	105:71	.169931	68:47	.160411	109:77	.150936	97:70	.141674
97:59	0.215920	64:40	.204120	67:43	.192606	111:73	.182000	68:46	.169751	81:56	.160297	92:65	.150874	115:83	.141620
120:73	.215858	56:35	.204120	81:52	.192482	114:75	.181844	99:67	.169560	94:65	.160215	75:53	.150785	108:78	.141829
115:70	.215600	32:20	.204120	95:61	0.192394	76:50	.181844	65:44	0.169461	107:74	.160152	116:82	0.150644	90:65	.141329
92:56	.215600	115:72	.203365	109:70	.192329	117:77	.181695	96:65	.169358	120:83	.160103	58:41	.150644	72:52	.141329
69:42	.215600	107:67	.203309	112:72	.191886	79:52	.181624	93:63	.169142	117:81	.159701	99:70	.150537	54:39	.141329
110:67	.215318	99:62	.203244	98:63	.191886	120:79	.181554	62:42	.169142	104:72	.159701	82:58	.150386	119:86	.141049
87:53	.215243	91:57	0.203167	94:54	.191886	82:54	.181420	31:21	.169142	91:63	.159701	106:75	.150245	101:73	.140999
64:39	.215115	83:52	.203075	70:45	.191886	85:56	0.181231	90:61	.168913	78:54	0.159701	65:46	.150156	83:60	0.140927
105:64	.215009	75:47	.202963	56:36	.191886	88:58	.181055	59:40	.168792	65:45	.159701	89:63	.150050	65:47	.140816
82:50	.214844	67:42	.202826	115:74	.191466	91:60	.180890	118:80	.168792	52:36	.159701	113:80	.149988	112:81	.140733
100:61	0.214670	59:37	.202650	101:65	.191408	94:62	.180736	87:59	.168667	114:79	.159278	120:85	.149762	94:68	.140619
118:72	.214550	110:69	.202544	87:56	.191331	47:31	.180736	115:78	.168603	101:70	.159223	96:68	.149762	47:34	.140619
59:36	.214550	51:32	.202420	73:47	0.191225	97:64	.180592	112:76	0.168404	88:61	.159153	72:51	0.149762	76:55	.140451
77:47	.214393	94:59	.202276	59:38	.191068	100:66	.180456	84:57	.168404	75:52	.159058	48:34	.149762	105:76	.140376
95:58	.214296	86:54	.202105	104:67	.190959	50:33	.180456	56:38	.168404	62:43	.158923	103:73	.149514	116:84	.140179
113:69	.214229	78:49	.201899	90:58	.190815	103:68	.180328	109:74	.168196	111:77	.158832	79:56	.149439	87:63	.140179
90:55	.213878	113:71	0.201820	76:49	.190618	106:70	.180208	81:55	.168122	98:68	.158717	110:78	.149298	58:42	.140179
72:44	.213878	116:73	.201645	107:69	.190535	53:35	0.180208	106:72	.167973	49:34	0.158717	55:39	.149298	29:21	0.140179
54:33	.213878	70:44	.201645	93:60	.190332	109:72	.180094	53:36	.167973	85:59	.158567	86:61	.149169	98:71	.139968
36:22	.213878	97:61	.201442	62:40	.190332	112:74	.179986	78:53	.167819	108:75	.158363	117:83	.149108	69:50	.139879
103:63	0.213497	62:39	.201327	110:71	.190134	53:35	.179986	103:70	.167739	72:50	.158363	93:66	.148939	109:79	.139799
67:41	.213291	89:56	.201202	79:51	.190057	115:76	.179884	100:68	.167491	95:66	.158180	62:44	.148939	120:87	.139662
116:71	.213200	116:73	.201135	96:62	0.189880	118:78	.179787	75:51	0.167491	59:41	.158068	31:22	0.148939	80:58	.139662
98:60	.213075	108:68	.200915	113:73	.189756	59:39	.179787	50:34	.167491	82:57	.157939	100:71	.148742	91:66	.139498
49:30	.213075	81:51	.200915	65:42	.189664	102:69	.179751	97:66	.167228	105:73	.157866	69:49	.148653	102:74	.139369
80:49	.212894	54:34	.200915	82:53	.189538	62:41	.179608	72:49	.167136	115:80	.157608	107:76	.148570	51:37	.139369
111:68	.212814	100:63	0.200660	99:64	.189455	65:43	.179445	119:81	.167062	92:64	.157608	114:81	.148420	113:82	.139265
93:57	.212608	73:46	.200565	116:75	.189397	68:45	0.179296	94:64	.166948	69:48	0.157608	76:54	.148420	62:45	0.139179
				119:77	.189056	71:47	.179160	47:32	.166948	46:32	.157608	83:59	.148226	73:53	.139047

Machinery

lead-screw. But modern lathes often contain permanent internal gears, and are arranged with one or two change-gear studs which must be taken into consideration in determining the constant. For any lathe with equal gears, the number of threads per inch that can be cut with equal gears on the change-gear studs is the constant of the lathe; this can usually be determined from an inspection of the index plate. On lathes equipped with quick-change gears, the constant can be easily changed.

For any lathe, $C : L$ = driver : driven gears, in which C = constant of machine and L = lead desired.

For example, what change-gears are required to cut a lead of 1.7345 threads per inch on a lathe having a constant of 4?

$$C : L = 4 : 1.7345$$

$$\log 4 = 0.602060$$
$$\log 1.7345 = 0.239174$$
$$\text{ratio log} = 0.362886$$
$$\text{From the table, } \log 113 : 49 = 0.362882$$
$$\text{log of ratio error} = 0.000004$$

Therefore, the driver has 113 teeth, and the driven gear, 49 teeth.

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH—5

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
84:61	.138950	112:83	.130140	70:53	.120822	118:41	.112841	56:44	.104735	91:73	.095719	60:49	.087955	95:79	.080097
95:69	.138875	85:63	.130078	103:78	.120743	70:54	.112704	42:33	.104735	86:69	.095649	71:58	.087830	107:89	.079994
106:77	.138815	116:86	.129960	99:75	.120574	92:71	.112530	28:22	.104735	81:65	.095572	82:67	.087739	113:94	.079951
117:85	.138767	58:43	0.129960	66:50	.120574	57:44	0.112422	117:92	.104398	76:61	0.095484	93:76	.087669	119:99	0.079912
110:80	.138303	89:66	.129846	95:72	.120391	79:61	.112297	103:81	.104352	71:57	.095383	104:85	.087614	30:25	
99:72	.138303	120:89	.129791	62:47	.120294	101:78	.112227	89:70	.104292	66:53	.095268	115:94	.087570	or	
88:64	.138303	93:69	.129634	91:69	.120192	110:85	.111974	75:59	.104209	61:49	.095134	110:90	.087150	any	.079181
77:56	.138303	62:46	.129634	120:91	.120140	88:68	.111974	61:48	.104089	117:94	.095058	99:81	.087150	6 to 5	
66:48	0.138303	97:72	.129439	116:88	0.119975	44:34	.111974	108:85	0.104005	56:45	.094976	88:72	0.087150	ratio	
55:40	.138303	66:49	.129348	87:66	.119975	66:51	.111974	94:74	.103896	107:86	.094885	77:63	.087150	115:96	.078427
44:32	.138303	101:75	.129260	58:44	.119975	119:92	.111759	47:37	.103896	102:82	.094786	66:54	.087150	109:91	.078385
114:83	.137827	105:78	.129095	29:22	.119975	97:75	.111710	80:63	.103750	51:41	.094786	55:45	.087150	103:86	.078339
103:75	.137776	70:52	.129095	112:85	.119799	75:58	.111633	113:89	.103688	97:78	.094677	44:36	.087150	97:81	.078287
92:67	.137713	109:81	0.128942	83:63	.119738	106:82	0.111492	99:78	.103541	92:74	0.094556	116:95	.086734	91:76	0.078228
81:59	.137633	74:55	.128869	108:82	.119610	53:41	.111492	66:52	.103541	46:37	.094556	105:86	.086691	85:71	.078161
70:51	.137528	113:84	.128799	54:41	.119610	84:65	.111366	118:93	.103399	87:70	.094421	94:77	.086637	79:66	.078083
118:86	.137384	117:87	.128667	79:60	.119476	115:89	.111308	85:67	.103344	82:66	.094270	83:68	.086569	73:61	.077993
59:43	.137384	78:58	.128667	104:79	.119406	93:72	.111151	104:82	.103219	41:33	.094270	72:59	.086481	67:56	.077887
107:78	0.137289	82:61	.128484	100:76	0.119186	62:48	.111151	52.41	0.103219	118:95	.094158	61:50	0.086360	61:51	.077760
96:70	.137173	86:64	.128319	75:57	.119186	102:79	.110973	90:71	.102984	77:62	.094099	111:91	.086282	116:97	.077686
48:35	.137173	43:32	.128319	50:38	.119186	71:55	.110896	109:86	.102928	113:91	.094037	100:82	.086186	55:46	.077605
85:62	.137027	90:67	.128168	96:73	.118948	111:86	.110825	95:75	.102662	108:87	.093905	50:41	.086186	104:87	.077514
111:81	.136838	94:70	.128030	71:54	.118865	120:93	.110698	76:60	.102662	72:58	.093905	89:73	.086067	98:82	.077412
74:54	.136838	47:35	0.128030	117:89	.118796	80:62	0.110698	57:45	.102662	103:83	0.093759	117:96	.085915	49:41	0.077412
100:73	.136677	98:73	.127903	92:70	.118690	40:31	.110698	38:30	.102662	67:54	.093681	78:64	.085915	92:77	.077297
63:46	.136583	102:76	.127787	46:35	.118690	89:69	.110541	119:94	.102419	98:79	.093599	39:32	.085915	86:72	.077166
89:65	.136477	51:38	.127787	113:86	.118580	98:76	.110413	100:79	.102373	93:75	.093422	106:87	.085787	43:36	.077166
115:84	.136419	106:79	.127679	67:51	.118505	49:38	.110413	81:64	.102305	62:50	.093422	67:55	.085712	80:67	.077015
104:76	0.136220	110:82	.127579	88:67	0.118408	107:83	.110306	62:49	0.102196	119:96	.093276	95:78	0.085629	117:98	.076960
78:57	.136220	55:41	.127579	109:83	.118348	116:90	.110216	105:83	.102111	88:71	.093224	112:92	.085430	111:93	.076840
52:38	.136220	114:85	.127486	84:64	.118099	58:45	.110216	86:68	.101990	114:92	.093117	84:69	.085430	74:62	.076840
119:87	.136028	118:88	.127399	63:48	.118099	67:52	.110072	43:34	.101990	57:46	.093117	56:46	.085430	37:31	.076840
93:68	.135974	59:44	.127399	42:32	.118099	76:59	.109962	110:87	.101873	83:67	.093003	28:23	.085430	105:88	.076707
67:49	.135879	63:47	0.127243	101:77	.117831	85:66	0.109875	67:53	.101799	109:88	0.092944	101:83	.085243	68:57	0.076634
108:79	.135797	67:50	.127105	80:61	.117760	94:73	.109805	91:72	.101709	104:84	.092754	118:97	.085110	99:83	.076557
82:60	.135663	71:53	.126982	118:90	.117640	103:80	.109747	115:91	.101656	78:63	.092754	90:74	.085011	93:78	.076388
41:30	.135663	75:56	.126873	59:45	.117640	112:87	.109699	120:95	.101458	52:42	.092754	45:37	.085011	62:52	.076388
97:71	.135513	79:59	.126775	97:74	.117540	117:91	.109145	96:76	.101458	26:21	.092754	107:88	.084901	118:99	.076247
112:82	0.135404	83:62	.126686	114:87	0.117386	108:84	.109145	72:57	0.101458	99:80	.092545	62:51	0.084822	87:73	.076196
56:41	.135404	87:65	.126606	76:58	.117386	99:77	.109145	48:38	.101458	73:59	.092471	79:65	.084714	112:94	.076090
71:52	.135255	91:68	.126533	93:71	.117225	90:70	.109145	101:80	.101231	120:97	.092410	96:79	.084644	56:47	.076090
86:63	.135158	95:71	.126465	110:84	.117113	81:63	.109145	77:61	.101161	94:76	.092314	113:93	.084596	81:68	.075976
101:74	.135090	99:74	.126404	55:42	.117113	72:56	.109145	106:84	.101027	47:38	.092314	119:98	.084321	106:89	.075916
116:85	.135039	103:77	0.126347	105:80	.117099	63:49	0.109145	53:42	.101027	68:55	0.092146	102:84	.084321	100:84	0.075721
105:77	.134699	107:80	.126294	72:55	.116970	54:42	.109145	82:65	.100901	115:93	.092215	85:70	.084321	75:63	.075721
90:66	.134699	111:83	.126245	89:68	.116881	45:35	.109145	111:88	.100840	89:72	.092058	68:56	.084321	50:42	.075721
75:55	.134699	115:86	.126199	106:81	0.116821	27:21	.109145	116:92	.100670	110:89	.092003	51:42	.084321	25:21	.075721
60:44	.134699	119:89	.126157	119:91	.116506	113:88	.108596	87:69	.100670	105:85	.091770	108:89	.084034	119:100	.075547
45:33	0.134699	120:90	.124939	102:78	0.116506	104:81	.108548	58:46	0.100670	84:68	.091770	91:75	0.083980	94:79	.075501
30:22	.134699	112:84	.124939	85:65	.116506	95:74	.108492	29:23	.100670	63:51	.091770	74:61	.083902	69:58	.075421
109:80	.134337	108:81	.124939	68:52	.116506	86:67	.108424	92:73	.100465	42:34	.091770	114:94	.083777	113:95	.075355
94:69	.134279	104:78	.124939	51:39	.116506	77:60	.108339	63:50	.100371	116:94	.091330	57:47	.083777	88:74	.075251
79:58	.134199	88:66	.124939	34:26	.116506	68:53	.108233	97:77	.100281	58:47	.091330	97:80	.083682	44:37	.075251
64:47	.134082	84:63	0.124939	115:88	.116215	118:92	0.108094	102:81	.100115	95:77	0.091233	120:99	.083546	107:90	0.075141
113:83	.134000	64:48	.124939	98:75	.116165	59:46	.108094	68:54	.100115	111:90	.091080	80:66	.083546	63:53	.075065
98:72	.133894	60.45	.124939	81:62	.116093	109:85	.108008	34:27	.100115	74:60	.091080	40:33	.083546	82:69	.074965
49:36	.133894	44:33	.124939	64:49	.115984	100:78	.107905	107:85	.099964	37:30	.091080	103:85	.083418	101:85	.074903
83:61	.133748	40:30	.124939	111:85	.115904	50:39	.107905	73:58	.099894	90:73	.090920	63:52	.083337	114:96	.074634
117:86	0.133687	28:21	.124939	94:72	0.115795	91:71	.107783	112:89	0.099828	106:86	.090807	86:71	0.083240	95:80	.074634
102:75	.133539	117:88	.123703	47:36	.115795	82:64	.107634	78:62	.099703	53:43	.090807	109:90	.083184	76:64	.074634
68:50	.133539	113:85	.123660	77:59	.115639	41:32	.107634	39:31	.099703	69:56	.090661	115:95	.082974	57:48	.074634
87:64	.133339	109:82	.123613	107:82	.115570	114:89	.107515	83:66	.099534	85:69	.090570	92:76	.082974	38:32	.074634
106:78	.133211	105:79	.123562	120:92	.115393	73:57	.107448	88:70	.099385	101:82	.090508	69:57	.082974	108:91	.074382
72:53	.133057	101:76	0.123508	90:69	.115393	105:82	0.107375	44:35	.099385	117:95	0.090462	46:38	.082974	89:75	0.074329
91:67	.132967	97:73	.123449	60:46	.115393	96:75	.107210	93:74	.099251	112:91	.090177	98:81	.082741	70:59	.074246
110:81	.132908	93:70	.123385	30:23	.115393	64:50	.107210	98:78	.099132	96:78	.090177	75:62	.082670	102:86	.074102
114:84	.132626	89:67	.123315	103:79	.115210	119:93	.107064	49:39	.099132	80:65	.090177	52:43	.082535	51:43	.074102
95:70	.132626	85:64	.123238	73:56	.115135	87:68	.107010	103:82	.099023	64:52	.090177	81:67	.082410	83:70	.073980
76:56	0.132626	81:61	.123155	116:89	0.115068	110:86	.106894	108:86	0.098925	48:39	.090177	110:91	0.082351	115:97	.073927
57:42	.132626	77:58	.123063	86:66	.114955	55:43	.106894	54:43	.098925	107:87	.089865	116:96	.082187	96:81	.073786
118:87	.132363	73:55	.122960	43:33	.114955	78:61	.106765	113:90	.098836	91:74	.089810	87:72	.082187	64:54	.073786
99:73	.132312	69:52	.122846	99:76	.114822	101:79	.106694	118:94	.098754	75:61	.089732	58:48	.082187	109:92	.073639
80:59	.132238	65:49	.122717	112:86	.114720	115:90	.106455	59:47	.098754	118:96	.089611	29:24	.082187	77:65	.073577
61:45	.132117	61:46	0.122572	56:43	.114720	92:72	0.106455	64:51	.098610	59:48	0.089611	93:77	.081992	90:76	0.073429
103:76	.132024	118:89	.122492	69:53	.114573	69:54	.106455	69:55	.098486	102:83	.089522	64:53	.081904	45:38	.073429
84:62	.131888	114:86	.122406	82:63	.114473	46:36	.106455	74:59	.098380	86:70	.089401	99:82	.081821	103:87	.073318
42:31	.131888	57:43	.122406	95:73	.114401	106:83	.106228	79:63	.098287	43:35	.089401	105:87	.081670	116:98	.073232
107:79	.131757	110:83	.122315	108:83	.114346	83:65	.106165	84:67	.098205	113:92	.089291	70:58	.081670	58:49	.073232
65:48	0.131672	53:40	.122216	117:90	0.113943	120:94	.106053	89:71	0.098132	70:57	.089223	76:63	0.081473	71:60	.073107
88:65	.131570	106:80	.122216	104:80	.113943	60:47	.106053	94:75	.098067	97:79	.089145	117:97	.081414	84:71	.073021
111:82	.131509	102:77	.122110	91:70	.113943	97:76	.105958	99:79	.098008	108:88	.088941	82:68	.081305	97:82	.072958
115:85	.131279	98:74	.121994	78:60	.113943	111:87	.105804	104:83	.097955	81:66	.088941	41:34	.081305	110:93	.072910
92:68	.131279	49:37	.121994	65:50	.113943	74:58	.105804	109:87	.097907	54:44	.088941	88:73	.081160	117:99	.072551
69:51	.131279	94:71	0.121870	52:40	.113943	88:69	0.105634	114:91	.097864	27:22	0.088941	94:78	.081033	104:88	0.072551
46:34	.131279	90:68	.121734	39:30	.113943	102:80	.105510	119:95	.097823	119:97	.088775	47:39	.081033	91:77	.072551
119:88	.131064	45:34	.121734	26:20	.113943	51:40	.105510	20:16		65:53	.088638	100:83	.080922	78:66	.072551
96:71	.131013	86:65	.121585	113:87	.113559	116:91	.105417	or		103:84	.088558	106:88	.080823	65:55	.072551
73:54	.130929	82:62	.121422	100:77	.113509	65:51	.105343	any	0.096910	114:93	.088422	53:44	.080823	39:33	.072551
100:74	0.130768	41:31	.121422	87:67	0.113445	79:62	.105235	5 to 4		76:62	.088422	118:98	0.080656	52:34	.072551
50:37	.130768	119:90	.121305	74:57	.113357	93:73	.105160	ratio		38:31	.088422	59:48	.080656	111:94	.072195
77:57	.130616	78:59	.121243	61:47	.113232	107:84	.105105	116:93	.095975	87:71	.088261	65:54	.080510	98:83	.072148
104:77	.130543	115:87	.121179	109:84	.113147	112:88	.104735	111:89	.095933	98:80	.088136	71:59	.080406	85:72	.072086
81:60	.130334	111:84	.121044	96:74	.113040	98:77	.104735	106:85	.095887	49:40	.088136	77:64	.080311	72:61	.072003
54:40	.130334	74:56	0.121044	48:37	.113040	84:66	0.104735	101:81	.095836	109:89	0.088037	83:69	.080229	118:100	0.071882
27:20	.130334	107:81	.120899	83:64	.112898	70:55	.104735	96:77	.095781	120:98	.087955	89:74	.080158	59:50	.071882

Machinery

Milling-machine Change-gears

Milling-machine change-gears required for such work as cutting helical or herringbone gears accurately are solved in a similar way to lathe change-gears. The constant of a milling machine is the lead cut with equal gears on the worm and stud. With four threads per inch on the feed-screw and a 40-tooth worm-wheel and single-thread worm (the usual combination on a milling machine), the constant is one-fourth of 40, or 10. For any milling machine, $C : L =$ driver (feed-screw gear) : driven gear (worm-shaft gear), in which C is the constant or lead of the machine, and L, the lead of spiral to be cut.

Hobbing Spiral Gears

In problems of this nature, the gear logarithms are particularly valuable, as two gear ratios must be synchronized. The feed of the hob and the rate of rotation of the blank are interrelated, and gears must be found that will equal the desired feed; this feed also must be calculated in connection with the formula for index gears. The internal gears and arrangement

RATIO LOGS OF CHANGE-GEARS, 16 TO 120 TEETH–6

Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm	Ratio	Logarithm
92:78	.071693	96:83	.063193	51:45	.054358	40:36	0.045758	37:34	.036723	32:30	0.028029	47:45	.018885	44:43	0.009984
46:39	.071693	74:64	.063052	34:30	.054358	111:100	.045323	99:91	.036594	97:91	.027730	71:68	.018749	89:87	.009871
79:67	.071552	37:32	0.063052	111:98	.054097	101:91	.045280	62:57	.036517	81:76	.027671	95:91	.018682	90:88	.009760
112:95	.071494	89:77	.062899	94:83	.054050	91:82	.045228	87:80	.036429	65:61	.027584	96:92	.018483	45:44	.009760
99:84	.071356	52:45	.062791	77:68	.053982	81:73	.045162	100:92	.036212	98:92	.027438	72:69	0.018483	91:89	.009651
66:56	.071356	67:58	.062647	60:53	.053875	71:64	.045078	75:69	0.036212	82:77	.027438	48:46	.018483	92:90	.009545
105:89	.071799	82:71	.062556	103:91	0.053796	61:55	.044967	50:46	.036212	49:46	.027438	24:23	.018483	46:45	.009545
86:73	.071176	97:84	.062493	86:76	.053685	51:46	.044812	88:81	.035998	99:93	.027152	97:93	.018289	93:91	.009442
106:90	0.071063	112:97	.062446	43:38	.053685	92:83	.044710	63:58	.035913	66:62	.027152	73:70	.018225	94:92	.009340
53:45	.071063	90:78	.062148	112:99	.053583	82:74	.044582	101:93	.035839	33:31	.027152	98:94	.018098	47:46	.009340
73:62	.070931	75:65	.062148	69:61	.053519	41:37	0.044582	76:70	.035716	83:78	0.026984	49:47	.018098	95:93	0.009241
93:79	.070856	60:52	.062148	95:84	.053444	72:65	.044419	38:35	.035716	100:94	.026872	74:71	.017973	96:94	.009143
113:96	.070808	45:39	0.062148	78:69	.053246	103:93	.044354	89:82	.035576	50:47	.026872	99:95	.017912	48:47	.009143
100:85	.070581	113:98	.061852	52:46	.053246	93:84	.044204	51:47	.035472	67:63	.026734	100:96	.017729	97:95	.009048
80:68	.070581	98:85	.061807	113:100	.053078	62:56	.044204	64:59	.035328	84:79	.026652	75:72	.017729	98:96	.008955
60:51	.070581	83:72	.061746	87:77	.053029	83:75	.044017	77:71	0.035232	101:95	.026598	50:48	0.017729	49:48	.008955
40:34	.070581	68:59	.061657	61:54	0.052936	52:47	.043905	90:83	.035164	85:80	.026329	101:97	.017550	99:97	.008864
107:91	.070342	53:46	.061518	96:85	.052852	73:66	.043779	103:95	.035114	68:64	.026329	76:73	.017491	100:98	.008774
87:74	0.070288	91:79	.061414	70:62	.052706	94:85	.043709	91:84	.034762	51:48	.026329	51:49	.017374	50:49	.008774
67:57	.070200	76:66	.061270	35:31	.052706	84:76	.043466	78:72	.034762	34:32	.026329	77:74	.017259	101:99	.008686
114:97	.070133	38:33	.061270	79:70	.052529	63:57	0.043466	65:60	.034762	103:97	0.026066	103:99	.017202	51:50	0.008600
94:80	.070038	99:86	.061137	88:78	.052388	42:38	.043466	52:48	.034762	86:81	.026014	78:75	.017033	52:51	.008433
47:40	.070038	61:53	0.061054	44:39	.052388	95:86	.043225	39:36	.034762	69:65	.025936	52:50	.017033	53:52	.008273
74:63	.069891	84:73	.060956	97:86	.052273	74:67	.043157	105:97	.034418	52:49	.025807	79:76	.016814	54:53	.008118
101:86	.069823	107:93	.060901	53:47	.052178	53:48	.043035	92:85	.034369	87:82	.025705	53:51	.016706	55:54	.007969
81:69	.069636	92:80	.060698	62:55	.052029	85:77	.042928	79:73	0.034304	70:66	.025554	80:77	0.016599	56:55	.007825
54:46	.069636	69:60	.060698	71:63	0.051918	96:87	.042752	66:61	.034214	35:33	.025554	81:78	.016391	57:56	.007687
115:98	.069472	46:40	.060698	80:71	.051832	64:58	.042752	53:49	.034080	88:83	.025405	54:52	.016391	58:57	.007553
88:75	0.069421	100:87	.060481	89:79	.051763	107:97	.042612	93:86	.033984	53:50	.025306	82:79	.016187	59:58	.007424
61:52	.069327	77:67	.060416	98:87	.051707	75:68	.042552	80:74	.033858	71:67	.025184	55:53	.016087	60:59	.007299
95:81	.069239	54:47	.060296	107:95	.051660	86:78	0.042404	40:37	.033858	89:84	0.025111	83:80	.015988	61:60	0.007179
68:58	.069081	85:74	.060187	99:88	.051153	43:39	.042404	107:99	.033749	90:85	.024824	84:81	.015794	62:61	.007062
109:93	.068944	93:81	0.059998	90:80	.051153	97:88	.042289	67:62	.033683	72:68	.024824	56:54	.015794	63:62	.006949
75:64	.068881	62:54	.059998	81:72	.051153	54:49	.042198	94:87	.033609	54:51	.024824	85:82	.015605	64:63	.006840
116:99	.068823	101:88	.059839	72:64	.051153	65:59	.042061	81:75	.033424	36:34	.024824	57:55	.015512	65:64	.006733
82:70	.068716	70:61	.059768	63:56	.051153	76:69	.041965	54:50	0.033424	91:86	.024543	86:83	0.015420	66:65	.006631
41:35	.068716	109:95	.059703	54:48	0.051153	87:79	.041892	95:88	.033241	73:69	.024474	87:84	.015240	67:66	.006531
89:76	.068576	78:68	.059586	45:40	.051153	98:89	.041836	68:63	.033168	55:52	.024359	58:56	.015240	68:67	.006434
96:82	0.068457	39:34	.059586	36:32	.051153	109:99	.041791	82:76	.033000	92:87	.024269	88:85	.015064	69:68	.006340
48:41	.068457	86:75	.059437	109:97	.050655	99:90	.041393	41:38	.033000	74:70	.024134	59:57	.014977	70:69	.006249
103:88	.068355	97:41	.059314	100:89	.050610	88:80	0.041393	96:89	.032881	37:35	0.024134	89:86	.014892	71:70	0.006160
55:47	.068265	94:82	.059314	91:81	.050556	77:70	.041393	55:51	.032793	93:88	.024000	90:87	.014723	72:71	.006074
117:100	.068186	102:89	0.059210	82:73	.050491	66:60	.041393	69:64	.032669	56:53	.023912	60:58	.014723	73:72	.005990
62:53	.068116	55:48	.059122	73:65	.050410	55:50	.041393	83:77	.032587	75:71	.023803	91:88	.014559	74:73	.005909
69:59	.067997	63:55	.058978	64:57	.050305	44:40	.041393	97:90	.032529	94:89	.023738	61:59	.014478	75:74	.005830
76:65	.067900	71:62	.058867	55:49	.050167	33:30	.041393	98:91	0.032185	95:90	.023481	92:89	0.014398	76:75	.005752
83:71	.067820	79:69	.058778	101:90	0.050079	100:91	.040959	84:78	.032185	76:72	.023481	93:90	.014240	77:76	.005677
90:77	.067752	87:76	.058706	92:82	.049974	89:81	.040905	70:65	.032185	57:54	.023481	62:60	.014240	78:77	.005604
97:83	0.067694	95:83	.058646	46:41	.049974	78:71	.040836	56:52	.032185	38:36	.023481	31:30	.014240	79:78	.005533
104:89	.067643	103:90	.058595	83:74	.049846	67:61	.040745	42:39	.032185	96:91	.023230	94:91	.014087	80:79	.005463
111:95	.067599	96:84	.057992	74:66	.049688	56:51	0.040618	99:92	.031847	77:73	0.023168	63:61	.014011	81:80	0.005395
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91:78	.066947	80:70	0.057992	102:91	.049558	90:82	.040429	71:66	.031714	97:92	.022984	96:93	.013788	83:82	.005264
84:72	.066947	72:63	.057992	65:58	.049485	45:41	.040429	57:53	.031599	78:74	.022863	64:62	.013788	84:83	.005201
77:66	.066947	64:56	.057992	93:83	.049405	79:72	.040295	100:93	.031517	39:37	.022863	32:31	.013788	85:84	.005140
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63:54	.066947	48:42	.057992	84:75	0.049218	34:31	.040117	43:40	.031409	59:56	.022664	65:63	.013573	87:86	.005021
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42:36	.066947	105:92	.057402	94:84	.048849	80:73	.039767	87:81	.031034	100:95	.022276	66:64	.013364	90:89	.004853
35:30	.066947	97:85	.057353	47:42	.048849	103:94	0.039709	58:54	.031034	80:76	0.022276	33:32	.013364	91:90	0.004799
113:97	.066307	89:78	.057295	66:59	.048692	92:84	.039509	102:95	.030877	60:57	.022276	100:97	.013228	92:91	.004746
106:91	.066265	81:71	0.057227	85:76	.048605	69:63	.039509	73:68	.030814	40:38	.022276	67:65	.013161	93:92	.004695
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92:79	.066161	65:57	.057039	95:85	.048305	104:95	.039310	44:41	.030669	101:96	.022050	68:66	.012965	95:94	.004596
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71:61	.065929	98:86	.056728	38:34	.048305	93:85	.039064	74:69	.030383	103:98	.021611	69:67	.012774	98:97	.004454
64:55	0.065817	49:43	.056728	105:94	.048061	105:96	.038918	89:83	.030312	62:59	.021540	70:68	.012589	99:98	.004409
57:49	.065679	90:79	.056615	86:77	.048008	70:64	.038918	104:97	.030262	83:79	.021451	35:34	.012589	100:99	.004365
107:92	.065596	82:72	.056481	67:60	.047924	35:32	0.038918	105:98	.029963	104:99	0.021398	72:70	.012235	101:100	0.004321
100:86	.065502	41:36	.056481	96:86	.047773	82:75	.038753	90:84	.029963	84:80	.021189	36:35	.012235	102:101	.004279
50:43	.065502	74:65	0.056318	48:43	.047773	94:86	.038629	75:70	.029963	63:60	.021189	73:71	.012065	103:102	.004237
93:80	.065393	107:94	.056256	77:69	.047642	47:32	.038629	60:56	.029963	42:40	.021189	74:72	.011899	104:103	.004196
86:74	.065267	99:87	.056116	106:95	.047582	106:97	.038534	45:42	.029963	85:81	.020934	37:36	.011899	105:104	.004156
43:37	.065267	66:58	.056116	87:78	.047425	59:54	.038458	106:99	0.029671	64:61	.020850	75:73	0.011738	106:105	.004117
79:68	.065118	91:80	.055951	58:52	0.047425	71:65	.038345	91:85	.029623	86:82	.020685	76:74	.011582	107:106	.004078
115:99	.065063	58:51	.055858	29:26	.047425	83:76	.038265	76:71	.029555	43:41	.020685	38:37	.011582	108:107	.004040
72:62	0.064941	83:73	.055755	97:87	.047252	95:87	.038204	61:57	.029455	65:62	.020522	77:75	.011429	109:108	.004002
36:31	.064941	108:95	.055700	39:35	.046997	107:98	.038158	107:100	.029384	87:83	.020441	78:76	.011281	110:109	.003967
101:87	.064802	100:88	.055517	88:79	.046856	96:88	.037789	92:84	.029289	88:84	0.020203	39:38	.011281	111:110	0.003930
65:56	.064725	75:66	.055517	98:88	.046743	84:77	0.037789	46:43	.029289	66:63	.020203	79:77	.011136	112:111	.003895
94:81	.064643	50:44	0.055517	49:44	.046743	72:66	.037789	77:72	.029158	44:42	.020203	80:78	.010995	113:112	.003860
87:75	.064458	92:81	.055303	108:97	.046652	60:55	.037789	93:87	.028964	89:85	.019971	40:39	.010995	114:113	.003827
109:94	.064299	67:59	.055223	59:53	.046576	48:44	.037789	62:58	.028964	67:64	.019895	81:79	.010858	115:114	.003793
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51:44	.064118	42:37	.055048	89:80	.046300	97:89	.037382	94:88	.028645	68:65	.019596	83:81	.010593	118:117	.003696
73:63	0.063982	101:89	.054931	99:89	.046245	85:79	.037324	63:59	.028489	91:87	.019522	84:82	.010465	119:118	.003665
95:82	.063910	59:52	.054849	109:98	.046200	73:67	.037248	79:74	.028395	92:88	.019305	42:41	.010465	120:119	.003634
88:76	.063669	76:67	.054739	100:90	.045758	61:56	0.037142	95:89	.028334	69:66	0.019305	85:83	.010341		
66:57	.063669	93:82	.054669	90:81	.045758	98:90	.036984	96:90	.028029	46:44	.019305	86:84	.010219		
44:38	.063669	110:97	0.054621	80:72	.045758	49:45	.036984	80:75	.028029	93:89	.019093	43:42	.010219		
103:89	.063447	102:90	.054358	70:63	.045758	86:79	.036871	64:60	.028029	70:67	.019023	87:85	.010100		
81:70	.063387	85:75	.054358	60:54	.045758	74:68	.036723	48:45	.028029	94:90	.018885	88:86	.009984		
59:51	.063282	68:60	.054358	50:45	.045758										

Machinery

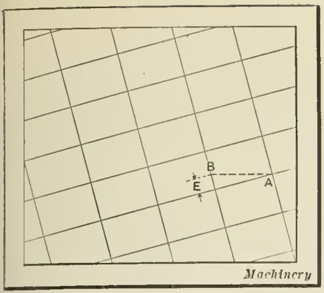


Diagram representing Developed Surface of Spiral Fluted Hob

of driver and driven gears make a general formula covering all makes of gear hobbers impractical. The gear-logarithm method applied to the Barber-Colman machine was published in MACHINERY, June, 1916, under the title "Calculating Change-gears for Hobbing Spiral Gears," and the gear logarithms for all gears supplied with these machines were given. If special gears are necessary, these tables may be used.

Relieving Spiral Fluted Hobs

The problem of relieving hobs that have been fluted at right angles to the thread is an example of the special application of the gear logarithms to difficult problems. The usual method is to alter the angle of the spiral flutes to agree with previously calculated change-gears for the relieving attachment. This only throws the problem to the milling machine, it being necessary in many cases to provide special gears to cut the lead of the flutes accurately. The problem is represented in the accompanying diagram. In one revolution the tool travels from A to B, which is the distance E beyond the flute. Therefore the ratio between the hob and the relieving attachment cam is:

$$(N + \sin^2 a) : C = \text{driver} : \text{driven gears}$$

$$\text{Tan } a = \frac{\text{C.P.}}{H_c}$$

in which N = number of flutes in hob;

a = angle of thread (usually stamped on hob);

C = constant of relieving attachment;

C.P. = circular pitch, corresponding to pitch of hob;

H_c = hob circumference, or 3.1416 × outside diameter.

The constant of a relieving attachment can be found on its index plate, and is determined by the number of flutes that require equal gears on the change-gear studs. This will vary with different makes of lathes, some relieving attachments having cams with different numbers of risers.

The following example shows the method of finding the change-gears to use for relieving a spiral fluted hob: What four change-gears must be used to relieve a spiral fluted hob, 10 diametral pitch, 2½ inches in diameter, 2 degrees, 17 minutes, 30 seconds angle of thread, with six spiral flutes, on a relieving attachment having a constant of 4?

$$\text{Sin 2 degrees, 17 minutes, 30 seconds} = 0.03998;$$

$$0.03998^2 = 0.001598;$$

$$\frac{6 + 0.001598}{4} = \frac{6.001598}{4}$$

$$\log 6.001598 = 0.778267$$
$$\log 4 = 0.602060$$

$$\log \text{ratio} = 0.176207$$
$$\text{From the tables, } \log 79 : 61 = 0.112297$$

$$\text{Subtracting from the log ratio} = 0.063910$$
$$\text{From table, } \log 95 : 82 = 0.063910$$

$$\text{Therefore, the gears } \frac{79}{61} \times \frac{95}{82} = \frac{\text{drivers}}{\text{driven}} \text{ may be used.}$$

The accuracy of the gear-logarithm method of determining the change-gear ratios shown in the foregoing example is indicated by the fact that when using seven-place logs the ratio error is log 0.0000002 in the gears selected. It is hardly necessary to say that backlash in the lathe gears, spring of the relieving tool and inaccuracy of the lead-screw are items of greater inaccuracy than this.

* * *

The exports of ball bearings from Sweden to the United States increased in value from $1,004,345, in 1915, to $1,367,761 in 1916.

EXPORTS OF MUNITIONS

There are persons who would have the American people believe that the increase of our exports from $2,484,000,000, in 1913, to $5,481,000,000, last year, was due almost wholly to shipments of munitions. But the following, taken from official reports, shows the share of munitions in this trade:

	1916	1913
Total	$5,481,423,589	$2,484,018,292
Agricultural products	1,488,195,846	1,071,401,508
Foodstuffs	1,069,339,383	494,414,640
Supplies	924,599,000	218,637,000
Cotton	543,529,808	575,488,000
Breadstuffs	471,952,100	203,391,856
Meat and dairy products	279,198,960	157,486,409
Mineral oils	201,732,563	149,316,400

The head "supplies" covers metal machinery, chemicals, shoes, horses, brass, and copper. Neutrals received a part of these exports and a part was used by belligerents in normal ways. The values of the munitions exported and other products associated with the war are as follows:

	1916	1913
Munitions	$813,791,000	$20,794,000
Accessories	131,128,000	28,907,000
Total	$944,919,000	$49,701,000

It is impossible to classify the exports with absolute certainty concerning their relation to the war. Under the head of munitions are explosives, firearms, airplanes, and barbed wire. The accessories include automobiles (not all of which were war material), motorcycles, and surgical instruments. The exports of munitions as to which there is no room for doubt, were only about one-seventh, or 14¾ per cent, of the total; in 1914, they were less than one-fifteenth, or 6½ per cent. If all the "supplies" and doubtful items are included, the sum of the shipments would be only about one-third of the total in 1916, and less than one-quarter of the total in the preceding year. A large part of the export increase from $2,484,000,000 to $5,481,000,000 was due to the growing sales of foodstuffs, which shows a gain of $574,000,000. The greatest profits due to the war have been those of millions of American agriculturists, wage earners, and manufacturers of all kinds of goods for ordinary consumption. Exports do not show these enormous gains, and in no way can they be accurately measured. For example, the abnormal foreign demand has largely increased the prices of grain and cotton; five cents a pound more for cotton means an addition of about $300,000,000 for the recent crop, and 75 cents more a bushel for wheat is not far from $450,000,000.—*New York Times.*

* * *

METALS AND ALLOYS INVESTIGATION

The Bureau of Standards, Washington, D. C., has undertaken to record the present state of knowledge and practice concerning the data on the properties of metals and alloys used by engineers and others, with the view of making generally available the most acceptable values of the constants and also as a basis for further experimental investigation. Forms are being sent out requesting the name of metals and alloys; condition (whether annealed or hard drawn); chemical composition; density; shrinkage; tensile strength; yield point; elastic limit; elongation; reduction of area; Brinell hardness; scleroscope hardness; behavior in compressing; frictional coefficient (steel); abrasion resistance; melting range; coefficient of expansion; specific heat; thermal conductivity; electrical conductivity; temperature resistance coefficient; resistance to corrosion; hydraulic properties; etc.

Some of the alloys for which data are particularly desired are aluminum and its light alloys with zinc, copper, etc., of stated percentages; nickel, monel metal, copper and nickel alloys; aluminum bronzes; manganese bronzes, cast and wrought; phosphor-bronze; muntz metal, naval brass, tobin bronze, brass (60 Cu + 40 Zn), yellow brass (70 Cu + 30 Zn); red brass; bearing metals; white metals, etc.

The collection of these data and other data that are expected from manufacturers should result in securing material that, when compiled and published, will be of value to manufacturers, metallurgists and all concerned with the making and use of alloys.

ELECTRIC RIVETING[1]

CONSTRUCTION AND OPERATION OF MACHINES FOR WELDING RIVETS

BY DOUGLAS T. HAMILTON[2]

ELECTRIC riveting is accomplished by a machine resembling the well-known spot welder, provided with a number of modifications to facilitate the setting of rivets. Electric riveting in its simplest form is done with two opposing copper electrodes, the center lines of which coincide. One of the electrodes—usually the upper—is movable vertically. The lower one is made to fit the head of the rivet and the upper one is made to the proper shape and size for upsetting the protruding end of the rivet.

Methods Employed in Electric Riveting

There are several methods of riveting in an electric welding machine, one of which is illustrated diagrammatically in Fig. 1,

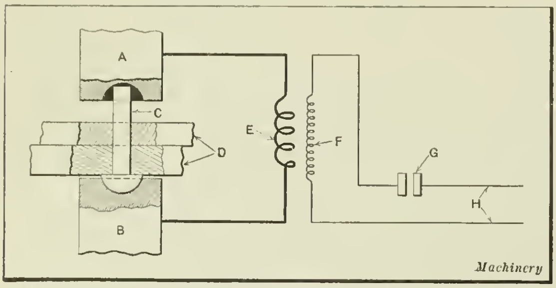


Fig. 1. Diagram illustrating Application of Electric Spot-welding Machine for Electric Riveting, showing Electrical Connections

in which A represents the upper movable copper electrode, and B the lower stationary electrode. C is the rivet, and D the plates to be riveted together. A and B are the terminals of the secondary winding E of the transformer, and F is the primary winding of the transformer, from which leads are brought out to connect to the lines, the switch G being interposed to make and break the circuit.

After the rivet is inserted through the plates and the stock is in position, as shown in Fig. 1, the electrode A is moved down lightly against the end of the rivet. The current is then turned on by closing switch G. The current induced in the secondary winding E flows directly through rivet C. This current is adjusted to such a pressure as to cause the rivet to become heated quickly. As soon as the proper temperature is reached, switch G is opened, cutting off the current, and at the same time a greatly increased pressure is applied to electrode A, which upsets the rivet and forms a head shaped like the recess in the electrode.

The heating of the rivet is done so rapidly that there is little loss by radiation or conduction. Therefore the plates D do not produce much chilling effect, and the rivet is heated throughout its length. For this reason, when increased pressure is applied to electrode A, the rivet is upset in the hole in plates D and fills the holes tightly. Even in the extreme case shown in Fig. 3, where there is considerable clearance between the rivet and hole, the hole is effectively filled by the rivet and a tight joint secured. The heating is done fast enough to prevent the formation of scale, which is always found on rivets heated in a forge fire, and the maximum strength is therefore insured. Further than this there is no overheating or burning of the rivet. Fig. 2 shows a rivet in the process of upsetting. Reference to this illustration will show that there is a gradual bulging and folding of the fibers. The use of an air hammer results in breaking up these fibers somewhat, and hence reduces the shearing strength of the rivet.

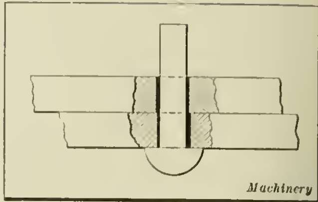


Fig. 3. Extreme Case of Difference in Size between Hole in Sheet and Diameter of Rivet—Electric Riveting effectively closes this Clearance Space

[1] For previous articles on electric welding published in MACHINERY, see "Electric Seam-welding," January, 1917, and articles there referred to.
[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

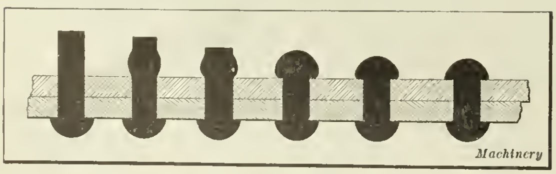


Fig. 2. Sequence of Operations in upsetting a Rivet in Electric Welding Machine

Modifications in Electrodes Necessary for Electric Riveting

Both upper and lower electrodes are made of copper when the rivet to be upset is quite small—say up to and including 3/8 inch diameter. When the rivet is larger than this, the pressure necessary to upset it is sufficient to destroy the upper electrode in a short time, if it is made of copper. On machines for upsetting large rivets, therefore, it is necessary to use a harder material, usually steel, for the upper die. Steel, however, becomes quite hot in carrying the current, which destroys its temper. To overcome this difficulty, machines of recent design carry two upper operating members, one a copper electrode for heating and the other a steel die for upsetting the rivet.

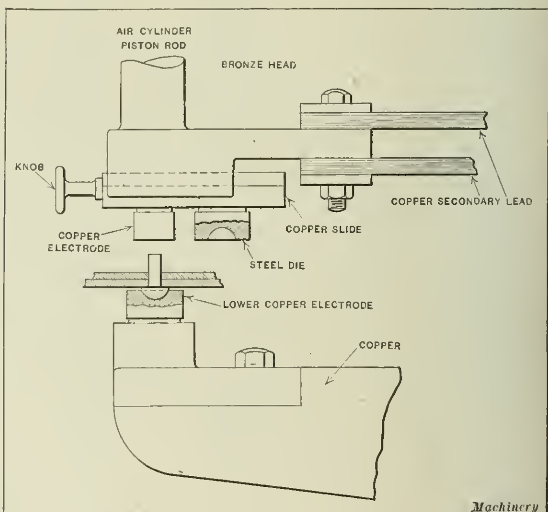


Fig. 4. Method of upsetting Rivets over 3/8 Inch Diameter, using Copper Electrodes for heating and Steel Die for upsetting

Fig. 4 illustrates diagrammatically the modifications necessary in an electric welding machine for upsetting large rivets. Here it will be noticed that the upper movable head carries a copper electrode and a steel die. These are held in a copper slide, which is pushed in or pulled back, depending on whether the rivet is to be heated or upset. Any suitable means can be employed for locating these two members in the desired position when in operation on the work. The copper electrode constitutes one terminal of the secondary circuit and serves to carry the current to the rivet. It is applied to the end of the rivet with just sufficient pressure to insure electrical contact. When this is done and the rivet has attained the proper temperature, the slide is withdrawn, bringing the steel die into position in line with the rivet, and then pressure is applied to upset the rivet.

Method of Upsetting Large Rivets

A simple means of operating an electric welding machine, and one that is frequently made use of for applying the two pressures—for electrical contact and for upsetting—is a cylinder supplied with compressed air. This is provided with a valve having three ports. One port connects directly to the air line and admits air into the cylinder at high pressure (60 to 80 pounds per square inch). The second port admits air at low pressure (5 to 20 pounds per square inch) to the cylinder. The low pressure is secured directly from the high-pressure piping by means of a suitable reducing valve. The third port in the valve allows the cylinder to exhaust and the steel upsetting die to return to its original high position. The valve is provided with a handle which moves in a horizontal plane through an angle of 90 degrees; this movement is sufficient to connect the cylinder with any one of the three ports. A small push-button switch *A* mounted on the valve handle *B*, Fig. 5, serves to control a remote solenoid switch for handling the welding current. Reference to Fig. 5 will show that the complete cycle of operations is taken care of by the right hand of the operator, which leaves the other hand free to handle the work. Inasmuch as all plants doing riveting use compressed air, the advantages of this type of machine are apparent.

When air pressure is not available or desirable, a machine may be driven by a belt or motor and employ the well-known punch press action. Electric riveters have also been built for manual operation or for a combination of manual and some sort of power operation, as shown in Fig. 6. In a machine of this type the left hand is used to bring the electrode lightly against the rivet and the current is controlled by thumb pressure on push-button *A*. When the temperature is right for upsetting, the right hand is used to turn the valve handle *B* to admit air under pressure to the cylinder.

Advantages of Electric Riveting

A number of machines are now in successful operation in this country which have shown quite a saving over the older methods of riveting and, in addition, make a tighter joint. In some cases one machine has taken the place of five men using air hammers. Except for the slight flash which results when contact is made, electric welding machines make no noise or smoke and are quiet as compared with air hammers.

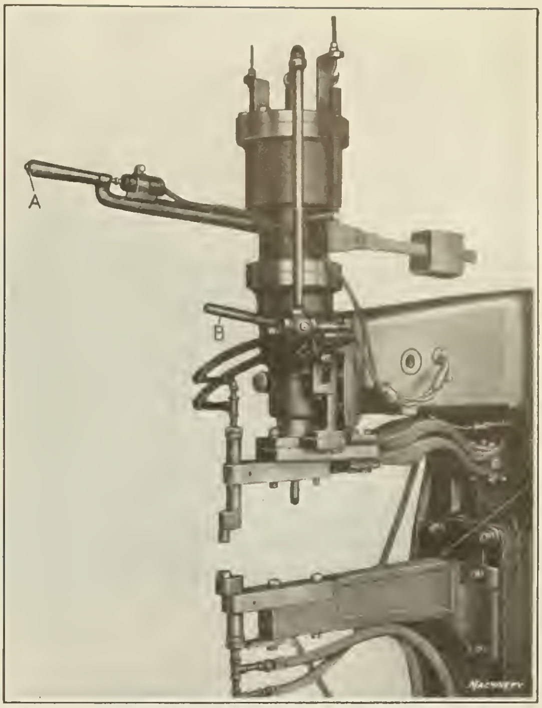


Fig. 6. Toledo No. 140 Type Electric Welding Machine fitted with Air Cylinder for Electric Riveting

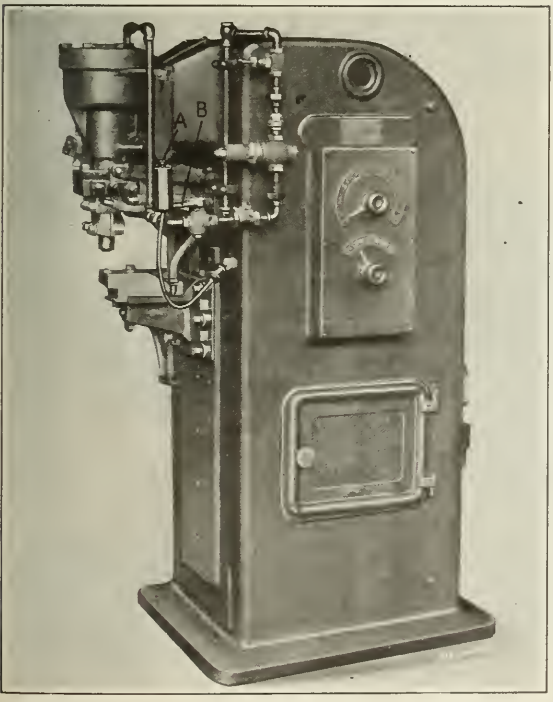


Fig. 5. Special Toledo Electric Welding Machine fitted with Air Cylinder and Three-port Valve for operating Electrode and Steel Riveting Die—Steel Riveting Die not shown in Position

The actual time taken in one plant using these electric riveting machines for setting 5/16-inch rivets was 1½ second, and the electrical energy used, 15 kilowatts. This means 2400 rivets for 15 kilowatt-hours. At two cents per kilowatt-hour, the actual cost for current is thirty cents, or, roughly, one cent per 100 rivets. Variations in the size of rivets would cause a corresponding variation in these figures, but they serve to give some idea of the comparative cost. Electric riveting machines are now being used by automobile manufacturers for riveting the chassis frames, gear housings, differential and rear axle casings, and similar work. Gear rims are riveted to their spiders and structural arm sections are riveted together by this method.

* * *

In an article in *Industritidningen Norden* (Stockholm, Sweden), a review is given of the increased costs in the iron and steel industry in Sweden. The price of iron ore has trebled compared with the prices before the war, the higher cost of ore alone adding, in some cases, as much as $8 to the cost of a ton of pig iron. The price of charcoal—which is used in Sweden almost exclusively in the iron and steel industries—has increased to 250 per cent of what it was before the war. This increase adds $20 to the price of a ton of pig iron; nor can coal be substituted for charcoal in order to decrease costs, because coal, which cost from $5 to $5.50 per ton before the war, now costs from $17 to $20 a ton, and the quality is not as good as before the war. The same quality as was obtainable at the price quoted before the war would cost from $21 to $25 a ton. Coke has increased in price from $6.50 to from $17 to $18 a ton, and the quality is not as good. If compared on the basis of quality, the price is now from $22 to $25 a ton. Pig iron is now sold at from $95 to $105 a ton. Ferro-manganese used in steel production is three and one-half times as expensive as before the war. Firebrick has doubled in price. Nitric acid is eight times; sulphuric acid, five times; oils used for hardening and tempering, six times; and machine oils, three times as expensive as before the war. Tungsten has risen to $13.50 per pound. Rolled wrought iron is quoted at from $145 to $150 a ton, and open-hearth steel from $195 to $202 a ton.

GRIDLEY AUTOMATIC TURRET LATHE[1]

DESIGN, CONSTRUCTION, OPERATION, TOOL EQUIPMENT AND ATTACHMENTS

BY DOUGLAS T. HAMILTON[2]

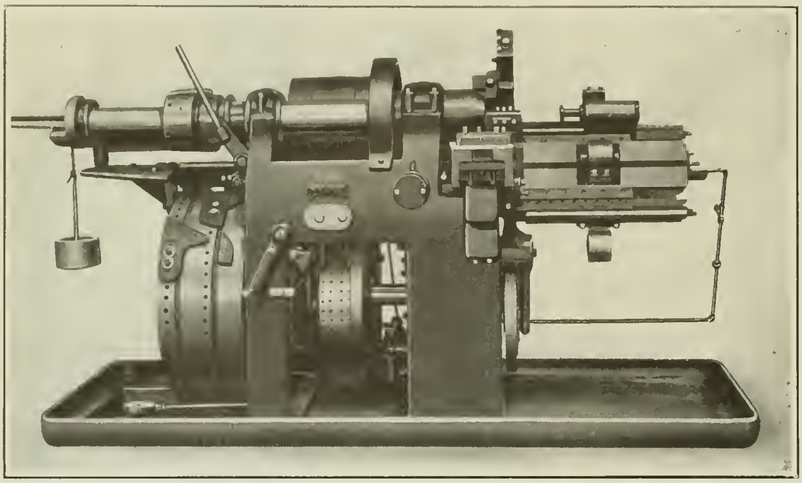


Fig. 1. Front View of Gridley Single-spindle Automatic Turret Lathe

GRIDLEY automatics are built in three types, namely, a single-spindle automatic turret lathe, a four-spindle automatic screw machine and a semi-automatic piston and piston ring machine. The original Gridley automatic, which was designed by G. O. Gridley in 1907, was of the single-spindle type, having a maximum capacity for bars up to $2\frac{1}{8}$ inches in diameter. This machine met with such success that a multiple-spindle machine was designed and put on the market in 1908. With the exception of a few minor improvements in detail, these two machines are essentially the same today as when first put on the market. The piston and piston ring machine is patterned after the single-spindle automatic turret lathe, and differs from it chiefly in the design of the turret, which travels back and forth and does not index. It is also much simpler in construction and is not fully automatic in that it is necessary for the operator to insert and remove the work by hand. In the following article, attention will be directed chiefly to the design, construction, operation, tool equipment, etc., of the single-spindle automatic turret lathe.

Principles of Design

The chief point of interest in the design of the Gridley automatic turret lathe is the turret or tool-slide around which the machine is built. The turret is of practically square cross-section, the four surfaces being in a plane parallel to the axis of the spindle; on each face is a tool-slide for carrying the holders for the various cutting tools. This design makes it possible to support the tools close to the cutting point and completely obviates spring and consequent inaccuracy, which cannot be so easily overcome when the tool is held by a long shank in the turret, as is generally the case. This design of turret also permits one tool to be placed behind another, thus greatly increasing the range of the machine and particularly adapting it for handling work requiring the use of a greater number of end-working tools than there are tool-slides.

On the belt-driven type of machine, the spindle is driven by a belt through back-gears from the pulley shaft at the rear of the machine which carries three pulleys—two drivers and one loose pulley. In the majority of cases, both belts are arranged to drive the spindle in a forward direction, but one can be reversed to give a backward speed for threading, when desired. The turret drum carries four slides which are moved back and forth by means of cams on the large camshaft drum at the left-hand end of the machine; this movement is secured through a draw-bar which will be described later. The cross-slides are operated by cams on the drum at the right-hand end of the machine, the rear or cutting-off arm being operated on the rocking arm principle. The turret is indexed by means of a worm-wheel on the turret shaft, which is driven at a faster speed while the indexing is being accomplished; this is effected through a planetary gear mechanism which will be described in detail later.

Construction and Operation of Headstock

The headstock comprises a work-spindle A, Fig. 3, which rotates in two phosphor-bronze bearings, A_1 and A_2; the spindle is driven by gear A_3, attached to it by a key as shown, which receives power from a pinion on the pulley shaft at the rear of the machine. The pulley shaft carries three pulleys B, C and D. The two belts can be thrown alternately onto the idler pulley C when it is desired to rotate the spindle in either direction or at different speeds, or they can both be thrown onto the idler pulley when it is desired to stop the rotation

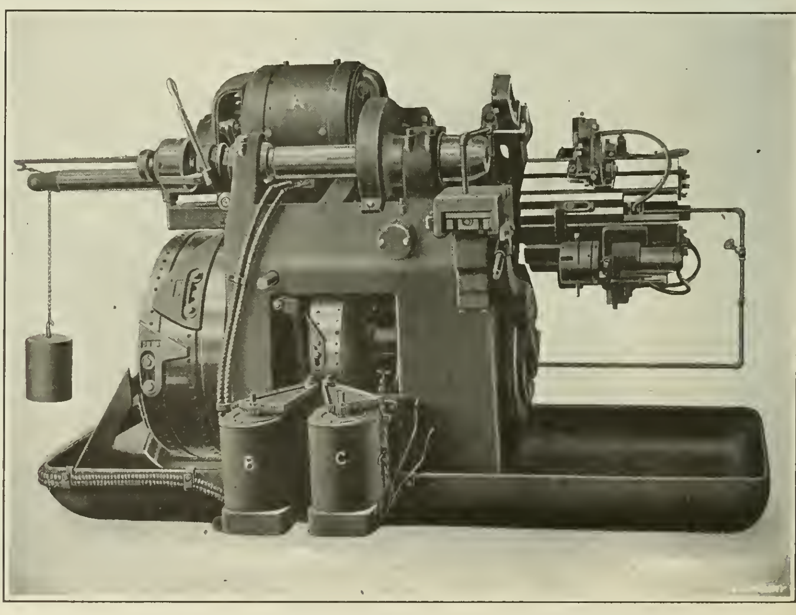


Fig. 2. Gridley Single-spindle Automatic Turret Lathe equipped with Variable-speed Motor Drive

[1] For information on automatic screw machine practice previously published in MACHINERY, see "Examples of Screw Machine Set-ups" in the November, 1914, number, and articles there referred to.

[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

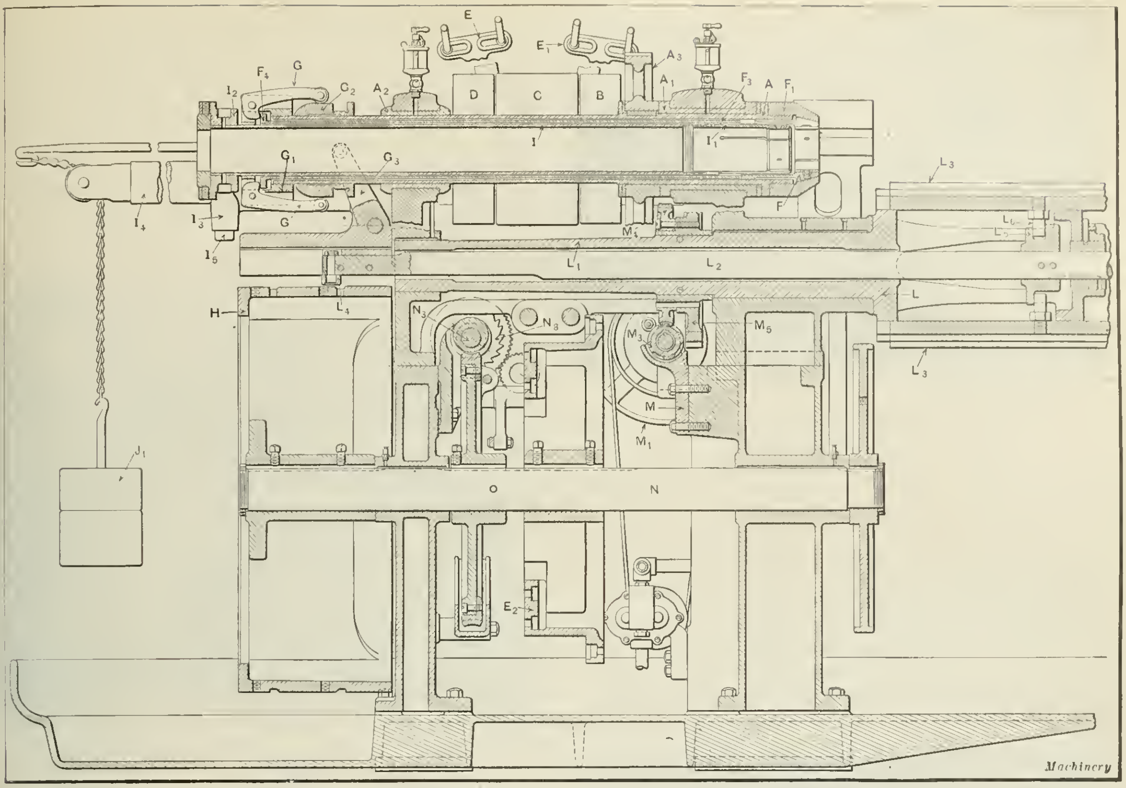


Fig. 3. Sectional View taken through Gridley Single-spindle Automatic Turret Lathe, showing Spindle Construction, Turret Construction and Operation of Main Cam-shaft. Note that Turret is swung around out of Correct Position to show Section

of the work-spindle. The belt shifting levers E and E_1 are controlled by dogs mounted on cam drum E_2.

Operation of Chuck-closing and Stock-feeding Mechanism

The bar stock being operated on is held in the spring collet or chuck F in spindle A and is closed by being forced into a nose cap F_1 that is screwed onto the nose of the spindle. The closing of the chuck on the stock is effected through the sleeve F_3 which bears against the rear end of the chuck and passes completely through the spindle of the machine. At the rear end of this sleeve is a flanged collar F_4, against which bear two fingers G. These fingers are fulcrumed in collar G_1, which is screwed onto the rear end of the spindle. The long arm of fingers G carries rollers running on sliding collar G_2, which is moved back and forth by the bellcrank lever G_3 carrying a roll on its lower arm that is operated by cams on the main cam drum H. This cam drum carries cam blocks K_1 and K_2, Fig. 5, cam K_1 withdrawing the collar from beneath the fingers and allowing the spring tension in the chuck to force the sleeve back and thus release the grip of the chuck

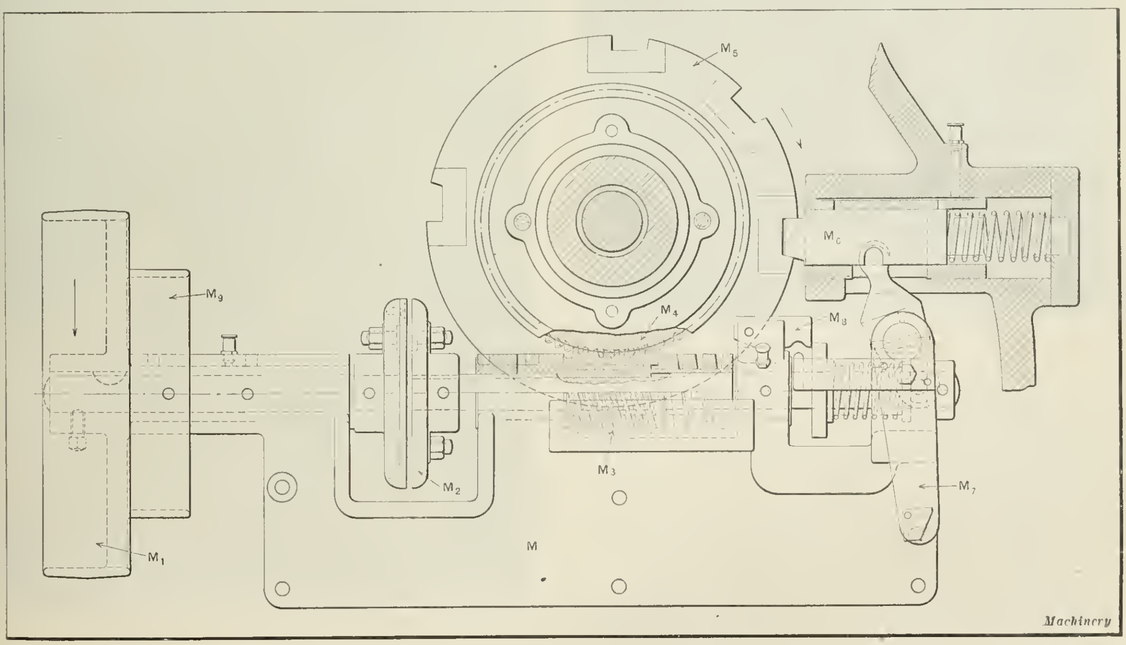


Fig. 4. Sectional View, showing Revolving Mechanism for indexing Turret on Gridley Single-spindle Automatic Turret Lathe

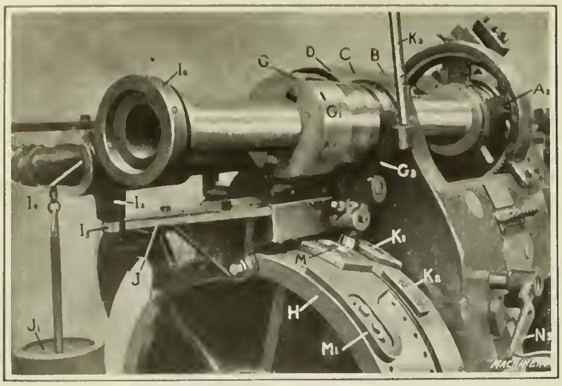


Fig. 5. End View of Gridley Single-spindle Automatic Turret Lathe, showing Cams for opening and closing Chuck and advancing Turret Slide, also Cams for operating Stock Pusher

on the work, whereas cam K_3 through bellcrank lever G_3 forces collar G_2 beneath the fingers, raising them up and, through the short arm of the fingers, forcing sleeve F_3 forward to close the chuck. Bellcrank lever G_3 has a hole in it in which an operating lever K_3 is inserted for opening and closing the chuck by hand when setting up the machine and adjusting the grip of the chuck on the work.

The feeding of the stock is accomplished by a combined weight and cam action. As shown in Fig. 3, a pusher or tube I carries at its front end a split chuck or pusher I_1, which has jaws suitably shaped for gripping the stock. The rear end of pusher tube I carries a collar I_3 in which a half yoke attached

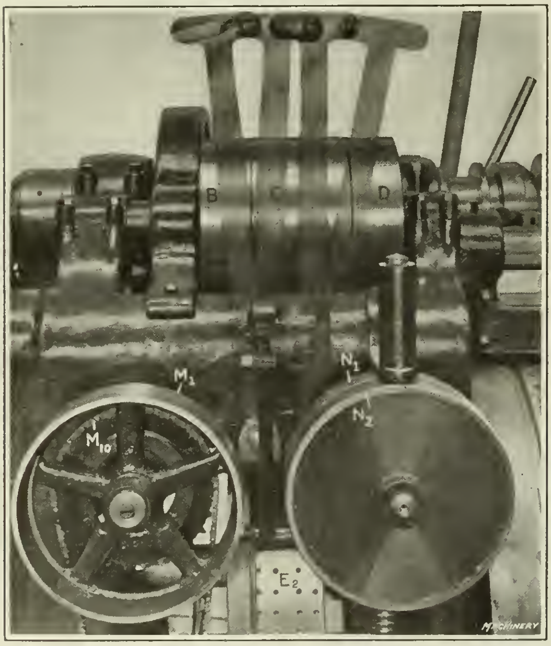


Fig. 6. Rear View, showing Drive for Main Cam-shaft and Indexing Mechanism

to bracket I_3 runs; bracket I_3, in turn, is free to slide on the bar-type bracket I_4. In action, cam J attached to cam drum H withdraws the pusher tube I so that the feed chuck I_1 is drawn back on the stock an amount equal to or slightly greater than the desired length of feed. Then when roll I_5 passes down the return side or incline of cam J, weight J_1, which has been lifted by the cam carries pusher I forward, and the chuck is opened. The feed chuck carries the stock forward until it contacts with the stop held on one corner of the turret, as will be described later. The feed chuck then remains in the forward position until cam J again comes into action to withdraw it.

Construction and Operation of Turret

The turret, as has been previously explained, is the feature about which this machine has been built. In construction, it comprises a square casting L, having an extended shank L_1 that passes through the machine and is supported in bearings located in both ends of the headstock. Passing through the center of this extended shank is a pull-rod L_3 for operating the four tool-slides L_3. This pull-rod carries a roll L_4 which is operated upon by cams on drum H. The turret drum L does not move back and forth, but is indexed to bring the various

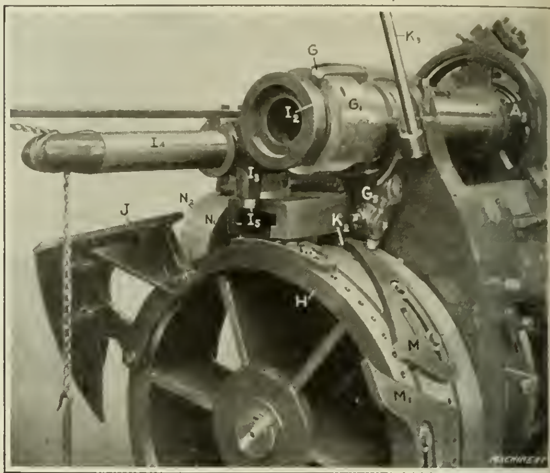


Fig. 7. Front End View of Gridley Single-spindle Automatic Turret Lathe, showing Stock-pusher Operating Cam out of Engagement with Operating Roll

tool-slides in line with the work, as will be subsequently explained. The tool-slides L_3 are operated by collar L_5 on rod L_3; there is a groove in the collar which is cut away, as shown, for the greater part of its circumference, the full part of the groove being in the position where the various tool-slides are to be advanced toward the chuck. This collar also returns the slides to their backward position. Each tool-slide,

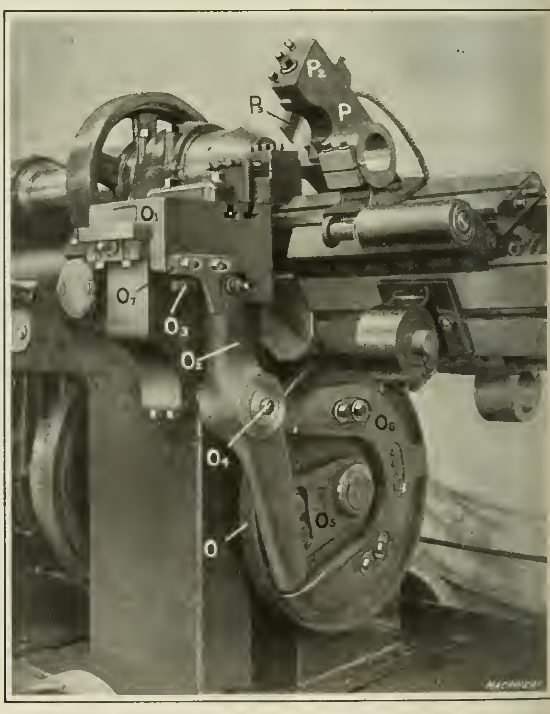


Fig. 8. Close View, showing Method of operating Forming Slide and Cutting-off Arm

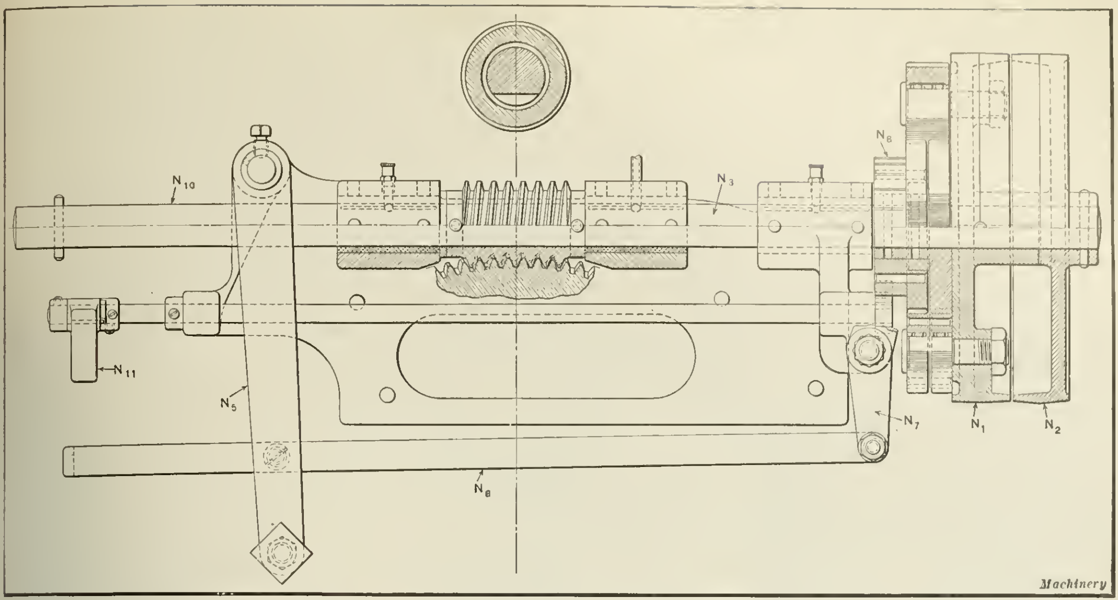


Fig. 9. Sectional View through Power Feed Bracket, showing Differential Gear Mechanism and Indexing Worm and Driving Worm and Worm-wheel

as shown, carries a roll L_6, which engages with the slot in collar L_5 when the turret has been indexed to bring the various slides into the operating position.

Pull-rod L_2 is operated by cams on drum H, a set of two cams being required for each turret position. Cam M advances the turret slide toward the work and cam M_1 returns the slide to its backward position. The turret tools, as shown in Fig. 1, are clamped directly to the faces of the slides, which are provided with T-slots for aligning purposes; these slides, as previously explained, are moved back and forth in gibbed grooves, in the four slide grooves in the turret. One corner of the turret is machined to receive the corner stop for limiting the feed of the stock.

Turret-indexing Mechanism

The indexing mechanism for the turret is operated by a separate belt from those used for driving the spindle and for rotating the main cam-shaft. Fig. 4 shows a sectional view taken through the indexing mechanism. Reference to this illustration will show that the indexing mechanism is carried on a separate bracket M and consists of a pulley M_1 which is belted to the countershaft, and through a friction clutch M_2 drives worm M_3; worm M_3, in turn, meshes with worm-wheel M_4, which is screwed and doweled to the index plate M_5, the latter being pinned to the extended shank L_1, Fig. 3, of the turret casting. Worm M_3 is also backed up by a stiff spiral spring as shown, which always keeps its teeth in

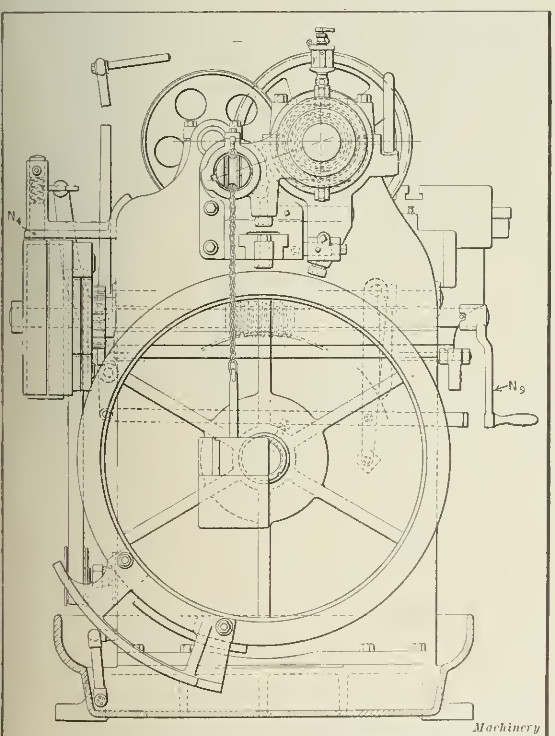


Fig. 10. Rear End View, showing Power Feed Mechanism and Main Cam Drum

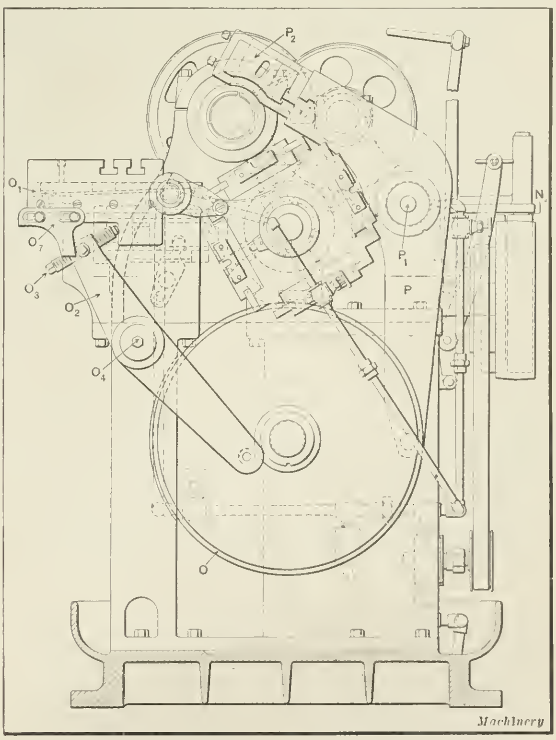


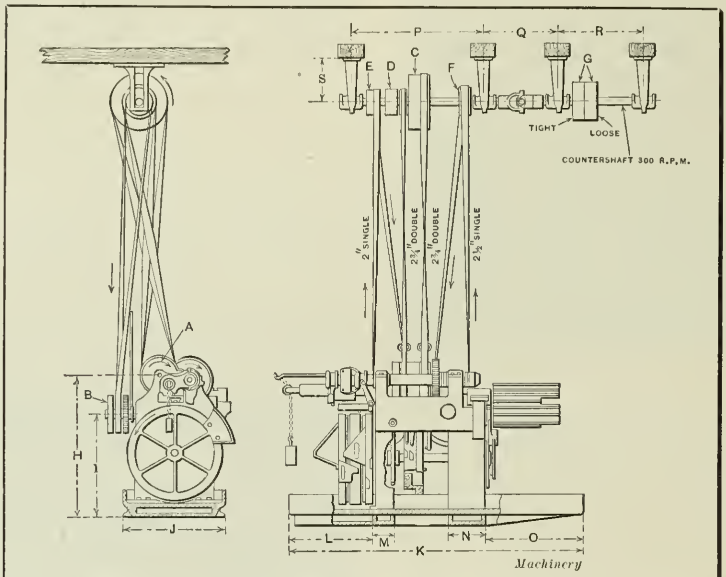
Fig. 11. Diagram illustrating Method of operating Forming Slide and Cutting-off Arm, also showing Construction of Turret and Turret Slide

accurate mesh with the indexing worm-wheel. The index plate M_5 is provided with five hardened blocks which act as locating stops for the locking pin M_6. These blocks are carefully hardened and ground and then set in place so that each indexing of the turret is accurately accomplished. The locking stop is also hardened and ground and is backed up with a stiff spring so as to keep it in constant contact with the turret index plate. It will be noted that, although there are five locating points in the index plate, there are only four turret faces. The fifth point is used for indexing for the stop held on one corner of the turret when all the other positions are full.

The operation of this indexing device is as follows: Upon the completion of the operation of any of the turret tools on the work and when the slide has receded far enough so that the tool clears the work, a dog set on cam drum E_2, Fig. 3, operates lever M_7, Fig. 4, and withdraws locking pin M_6 from contact with the block in the index plate M_5. At the same time trip M_8 is operated, allowing the spring on the friction shaft to come into play and engage friction disks M_2.

In order to eliminate the shock of quick engagement, these disks are provided with leather faces which engage before the driving blocks contact. When the lever M_7 leaves the indexing cam, locking pin M_6 is forced forward by the spring behind it, and at the same time a dog compresses the spring on the friction shaft, bringing the friction disks out of engagement and locking them by means of the trip previously mentioned. The indexing cams can be so placed on the drum that the turret can be made to skip one or more indexings if desired. The friction shaft continues to rotate the turret until the spring is compressed by the dog on the cam and lock M_8 falls into place. On the latest type of machine, pulley M_9 is replaced by a sprocket M_{10}, as shown in Fig. 6, for driving the oil pump.

TABLE 1. PRINCIPAL DIMENSIONS OF PULLEYS, COUNTERSHAFT, FLOOR PLAN, ETC.



Machine Size	Principal Dimensions of Pulleys, Floor Plan, Etc. — Pulleys: Pulley	A	B	C	D	E	F	G
$2\frac{1}{4}$	Diameter, inches	11	12	18	8	8	9	12
	Width of face, inches	..	..	6	6	4	4	4
$3\frac{1}{4}$	Diameter, inches	11	12	18	8	8	9	12
	Width of face, inches	..	..	6	6	4	4	4
$4\frac{1}{4}$	Diameter, inches	11	12	15	10	6	9	15
	Width of face, inches	..	..	6	6	4	4	6

Machine Size	Principal Dimensions, Inches: H	I	J	K	L	M	N	O	P	Q	R	S
$2\frac{1}{4}$	45	32	$32\frac{1}{2}$	93	25	$7\frac{1}{2}$	$11\frac{1}{2}$	34	41	$22\frac{1}{2}$	27	$14\frac{1}{2}$
$3\frac{1}{4}$	45	32	$32\frac{1}{2}$	93	25	$7\frac{1}{2}$	$11\frac{1}{2}$	34	41	22	$36\frac{3}{4}$	$14\frac{1}{2}$
$4\frac{1}{4}$	50	32	$32\frac{3}{4}$	104	$35\frac{1}{4}$	$7\frac{1}{2}$	$11\frac{1}{2}$	34	41	$22\frac{1}{2}$	27	$14\frac{1}{2}$

Operation of Main Cam-shaft

The main cam-shaft N, Fig. 3, which runs the entire length of the machine and carries all the operating cams, is driven by a separate belt from the overhead countershaft. As shown in Fig. 6, the power feed is contained in a separate bracket which is located at right angles to the main cam-shaft. This bracket carries two pulleys N_1 and N_2; the former rotates the shaft N_3, Fig. 3, through planetary gears and reduces the speed for driving the cam-shaft at the "cutting" speed. Pulley N_2 drives shaft N_3 direct and at a fast speed for taking care of the idle movements, such as indexing the turret, returning and advancing the tool-slides to the cutting position, feeding the stock and closing the chuck. This action is accomplished by a plunger N_4, Fig. 10, which is normally kept in contact with pulley N_2 and prevents it from being driven direct by the belt which runs on both pulleys.

The change from fast to slow speed is accomplished through lever N_5, connecting-link N_6 and lever N_7, Fig. 9. When lever N_5 is tripped by a dog on the main cam-shaft, friction plunger N_4 is raised from contact with pulley N_2 and allows the belt to drive it direct. Then as this pulley is connected directly to the power feed shaft, it drives it direct, and so much faster than the planetary gears that the ratchet N_8 runs away from the pawl, thus rotating the shaft at a higher speed. When setting up the machine, the power feed shaft can be rotated by hand-lever N_9, Fig. 10, which is located directly on worm-shaft N_{10}. When it is desired to stop the rotation of the feed shaft, the feed-release clutch N_{11} is operated, thus lifting the pawl from contact with ratchet N_8, which results in breaking the connection between the planetary gears and the main feed shaft.

Operation of Forming and Cutting-off Slides

The forming and cutting-off slides are both operated from cam drum O, Fig. 8, on one side of which are placed the cams for operating the forming slide, and on the other side the cams for operating the cut-off slide. Reference to Figs. 8 and 11 will show that the forming slide O_1 is operated by a lever O_2 and adjusting screw O_3 that comes in contact with a projection on the lower face of the forming slide. Lever O_2 is fulcrumed at O_4, and on its lower end carries a roll which, as shown in Fig. 8, runs in the groove formed by the forming cam O_5 and the return cam O_6. The forming slide is returned by the lever O_2 coming in contact with bracket O_7 attached to the side of the slide. The upper part of the forming slide can be adjusted on the lower member by means of an adjusting screw, as shown, to bring the forming tool into the required relation to the work. The forming tools used on this machine, which are generally of the dovetail type, are held in a forming-tool holder that is fastened to the top face of the forming slide.

The cutting-off slide is in the form of a bellcrank lever P, which is fulcrumed on a stud P_1. The lower end of this lever

carries a roll that contacts with a cam on the inner side of cam drum O; whereas the upper end has a machined face in which there is a T-slot for carrying the tool-holder P_2. This tool-holder carries a blade type of cutting-off tool P_3. The tool-holder proper can be adjusted longitudinally in relation to the axis of the work to bring the cutting-off tool into the correct position, but for diameter adjustment it is necessary to move the blade in or out as required. One cutting-off cam generally covers a large range of work and can be used in all cases where it is not necessary to bring in the cutting-off tools more than once for the completion of a certain part.

Cams and Dogs

The main cam drum, located at the left-hand end of the main cam-shaft, carries cams for operating the closing and opening of the chuck, withdrawing the stock pusher or feed tube and operating the turret slide through the medium of the pull-bar previously mentioned. The cam drum located in the center of the machine, which is also mounted on the main cam-shaft, carries cams for shifting the belt, dogs held in the T-slot in its rim for indexing the turret and cams for moving the high-speed lever which operates the quick and slow movements of the cam-shaft.

The cam-shaft has a quick and slow movement in a ratio of 70 to 1. The cam drum held on the extreme right-hand end of the main cam-shaft carries cams having several angles for operating the cutting-off and forming tools. The cams for operating the turret have three angles, giving fine, medium and coarse feeds. These cams, as has been previously mentioned, are easily located on the drum and can be changed to the desired position. For special work, of course, the cams are cut to suit the conditions, as in some cases it is necessary to start with a fairly coarse feed and then gradually slow down when approaching the end of the cut, as in counterboring or facing operations.

Sizes of Gridley Single-spindle Turret Lathes

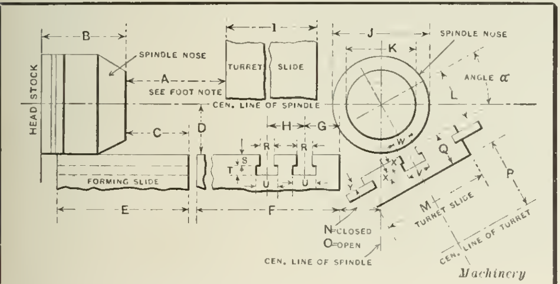
The Gridley single-spindle turret lathe is built in six sizes, which, rated according to the largest chuck capacities, are as follows: 1¼, 1¾, 2¼, 3¼, 4¼ and 5¼ inches. In all cases the feed of the turret slides is 12 inches. The spring collet or chuck, as well as the stock pusher or feeding finger, are provided with pads suitably shaped to accommodate the work being handled. These pads are hardened and are changed when a different size of bar is to be handled. The illustration accompanying Table 1 shows the belting arrangement on the belt-driven type of Gridley automatic turret lathe for the 2¼-, 3¼- and 4¼-inch sizes, and gives the principal dimensions, including sizes of overhead pulleys, floor plan, countershaft, etc.

The machine shown in Fig. 1 is a belt-driven machine. Fig. 2 shows the Gridley automatic turret lathe equipped with motor drive. When motor-driven, the machine is provided with two variable-speed motors, each having its own controller, resistance, etc. Motor A drives the work-spindle through the back-gears, and is provided with a controller B for producing the desired speed. The other motor, which is located at the rear of the machine and is geared to the power feed shaft, has a controller C. These two controllers are operated by cams located on the operating cam drum.

Table 2 includes all the tooling dimensions of the 2¼-, 3¼- and 4¼-inch sizes of Gridley single-spindle automatic turret lathes. These dimensions include the spindle nose, turret slide and forming slide and show the relation of the forming slide to the spindle nose and turret slide; referring to the illustration accompanying this table, it will be noticed that dimensions N and O, respectively, represent the relative positions of the forming slide when at its extreme forward and return strokes. These dimensions must be taken into consideration when designing special tools for use on the turret slide. The dimensions of the turret slide, of course, are necessary when laying out special types of turret tools, the distance on the various machines from the face of the turret slides to the center of the spindle being the same, or 4 inches.

Table 3 gives the principal dimensions of the cutting-off arm and its relation to the nose of the spindle; this arm brings the cutting-off blade in on an arc of a circle, instead of on a straight line in relation to the axis of the spindle. The top face of the arm, of course, does not always retain the same relative position in relation to the axis of the spindle, as shown in the illustration accompanying Table 3.

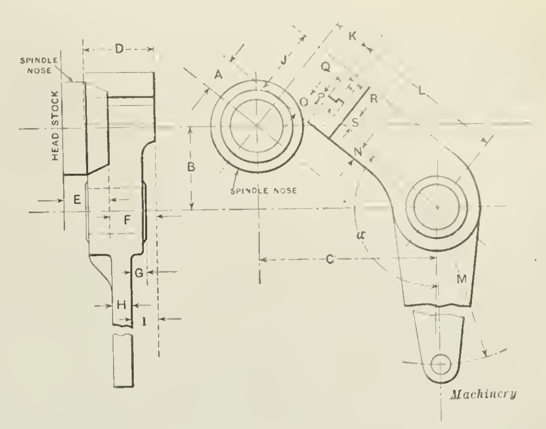
TABLE 2. TURRET SLIDES, FORMING SLIDE AND SPINDLE NOSE DIMENSIONS AND RESPECTIVE RELATIONS



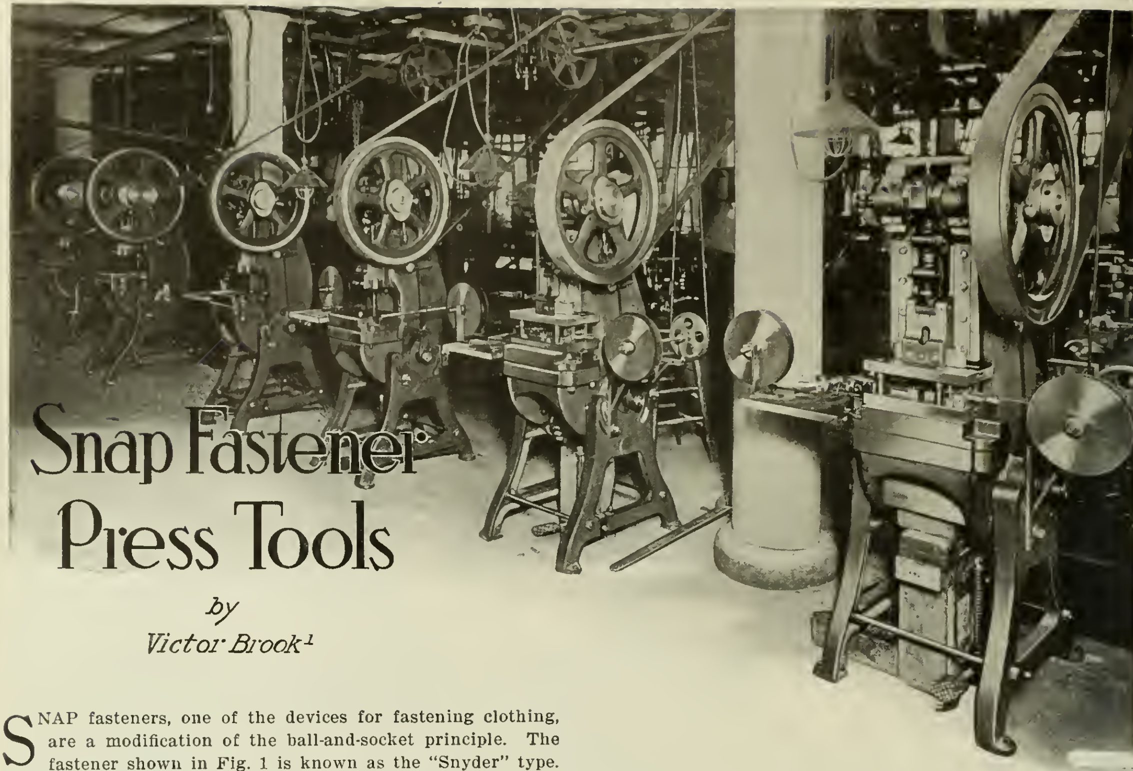
Dimensions, Inches	Rated Chuck Capacity of Machine, Inches			Dimensions, Inches	Rated Chuck Capacity of Machine, Inches		
	2¼	3¼	4¼		2¼	3¼	4¼
A	5⅛	5	5¼	N	2¼	2¼	2⅞
B	5⅛	5¼	5⅜	O	6	6	6½
C	3⅝	3½	4¼	P	4	4	4
D	2¾	3 5/16	5 3/16	Q	2	2	2
E	7½	7½	8¼	R	¾	¾	¾
F	10¼	10¼	10	S	⅝	⅝	⅝
G	2 1/16	2 1/16	2 1/16	T	½	½	½
H	2 1/16	2 1/16	2 1/16	U	1⅜	1⅜	1⅜
I	21	21	21	V	1⅜	1⅜	1⅜
J	5⅜	6⅞	7⅞	W	⅞	⅞	⅞
K	3⅞	5	5⅞	X	½	½	½
L	3	3½	4	Y	½	½	½
M	6	6	6	Angle α	29° 45′	28′ 10″	33° 7′

Dimension A gives the position of the tool-slide in the position it occupies when the turret is being revolved. The slide has a total movement of 8½ inches when using the regular cams.

TABLE 3. DIMENSIONS OF CUTTING-OFF ARM AND RELATION TO NOSE OF SPINDLE



Dimensions, Inches	Size of Machine, Inches			Dimensions, Inches	Size of Machine, Inches		
	2¼	3¼	4¼		2¼	3¼	4¼
A	1 9/32	1 13/32	2 13/16	K	3	3 11/16	3
B	6	6 9/16	6 9/16	L	11¼	11¼	12⅜
C	12.968	13½	14.463	M	18	18	18¼
D	5¾	5¾	5¾	N	⅝	⅝	1⅛
E	3½	3⅝	3¾	O	1½	1½	2
F	4⅛	4	3⅞	P	¾	¾	¾
G	1⅜	1⅜	1	Q	13/16	13/16	13/16
H	1¼	1¼	1½	R	½	½	½
I	2¼	2¼	2⅛	S	1⅜	1⅜	1⅜
J	4⅝	4⅝	5½	α	120°	120°	130°



Snap Fastener Press Tools

by
Victor Brook[1]

SNAP fasteners, one of the devices for fastening clothing, are a modification of the ball-and-socket principle. The fastener shown in Fig. 1 is known as the "Snyder" type. The tools for making this type of fastener are made by the Automat Tool Works, Inc., 252 Greenwich St., New York City. A set of press tools for making either the socket or the stud is practically a complete unit. Besides containing all the tools for the various steps required to complete the product, it also contains a roll feed, which is a part of the die unit. These tools are operated by a standard power press. The only special attachments are the reel for the stock and the power-operated scrap reel shown in Fig. 3. The power scrap reel, which is driven by a round belt from the lineshaft, takes up the scrap as it comes through the tool, but has no effect on the feed of the die. A complete set of tools will produce approximately 30,000 sockets or studs per hour. Four sockets are made at each stroke of the press, as the die is of the quadruple type.

All the working parts of these dies are small inserts, which are made interchangeable as far as possible, so that they can be replaced with the minimum loss of time. Besides, the various blocks for holding the dies, punches, etc., are made in short sections, so that an error in the construction of the die may be easily corrected. If the error cannot be corrected, a new block can be easily supplied without making any change in the remainder of the die.

Operations on Socket

There are nine operations on the socket. An assembly view of the punch and die for performing this work is shown in Fig. 5. Thirteen steps are shown in Fig. 6, but four of these are idle. A strip of metal in process of manufacture is shown in Fig. 2. In the first draw, the metal is drawn to the maximum depth and diameter. The dimensions of the punches and dies for the various operations are shown in Figs. 9 and 10. In the first redraw, the metal is reduced in diameter and depth and the radius at the bottom of the cup is greatly reduced. The exact reduction in the dimensions may be seen in the illustration by comparing the punches for the first draw and first redraw. In the second redraw, there is a slight reduction in diameter and depth, but the chief object of this operation is to harden the metal in the center of the socket, so as to give spring tension to the prongs, which are subsequently formed from this part of the material. The hardening is effected by crowning the punch. In the third redraw, the metal is hardened around the rim, and the socket is brought to the final depth. In addition, a sharp corner *a*, Fig. 6, is formed.

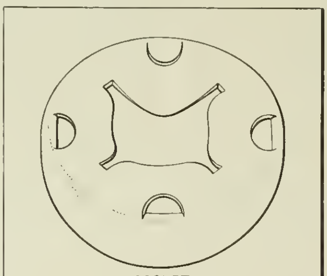


Fig. 1. Perspective View of Snap Fastener (Five Times Full Size)

In the sixth operation, the star-shape is pierced; this makes a separation between the four prongs. In the seventh operation—embossing—the points of the four prongs are turned under. Between the eighth and ninth operations, Fig. 6, the strip is shown broken at b–b, to indicate that the views are turned through an angle of 45 degrees in order to make the construction clear.

In the ninth operation, the four sewing holes are pierced. The blank is not removed from the socket in this operation, but is simply bent against the wall. By this plan a smoother edge is given to the hole, and there is less probability of its cutting the thread when the socket is sewed on. The punch for this operation is of the built-up type, as can be seen in Fig. 10. In the eleventh operation—re-embossing—the prongs are bent to their final position.

[1] Associate Editor of MACHINERY.

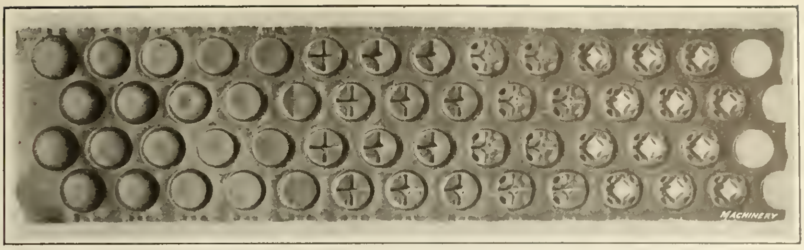


Fig. 2. Strip from Socket Dies showing Various Steps in Process of Manufacture

which is such that the stud will spring into the hole formed by the bent-under prongs, with just the correct tension. In the thirteenth operation, the completed socket is blanked from the metal strip.

Because of the condition of the socket at the time of blanking, it is not practicable to blank it in a downward direction. The punch is carried in the lower part of the die and the blanking die is mounted above. The finished work is ejected from the chute shown in Fig. 12. This chute is divided into two outlets, in order to bridge the strip of metal from which the sockets are being blanked.

Operations on Stud

There are nine operations on the stud, accomplished by the punch and die shown in Fig. 7. Fig. 8 shows twelve steps, but three of these are idle. A strip of metal showing the various operations is illustrated in Fig. 4. In the first draw, the metal is drawn to the maximum depth. The dimensions of the punches and dies for the various operations are shown in Figs. 13 and 14. In the second draw, the body is reduced in diameter and height, and the radius at the corner is decreased; the exact reduction may be found by comparing the dimensions of the first draw and first redraw punches and dies.

In the third draw, the body is reduced perceptibly in diameter and is given a slight taper. No attempt is made to reduce the height in this operation. In the fourth draw, the body is again reduced in diameter, but not in height. In the fifth draw, the upper part of the body is reduced in diameter and the sides are made perpendicular to the base. The sides of the lower half, however, form the frustum of a cone, which is the final shape. In the sixth operation, a head is formed; this produces a projecting rim of metal around the top of the stud. The lower part retains its conical shape because it is filled by the lower punch. In the eighth operation, the four sewing holes are pierced; these are oblong and are shown in detail in Fig. 14.

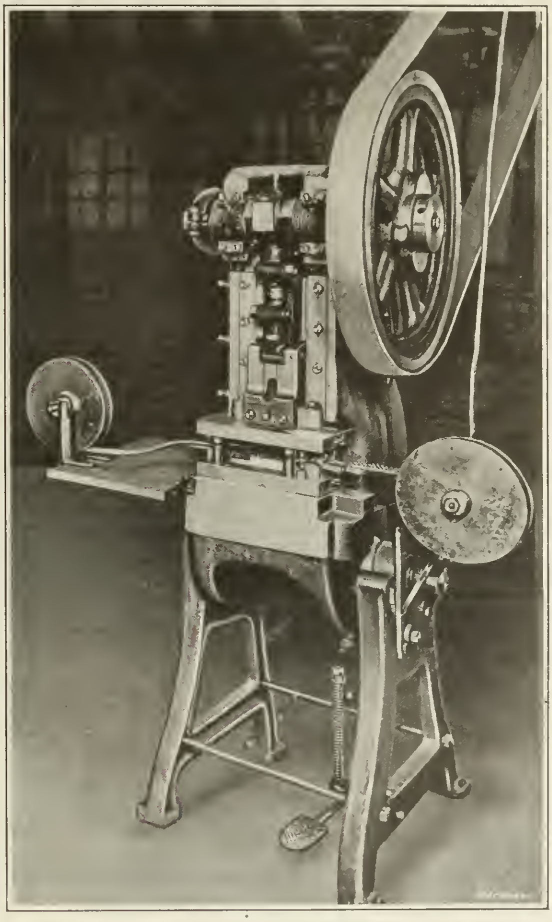


Fig. 3. Press Tools in Working Position on Press

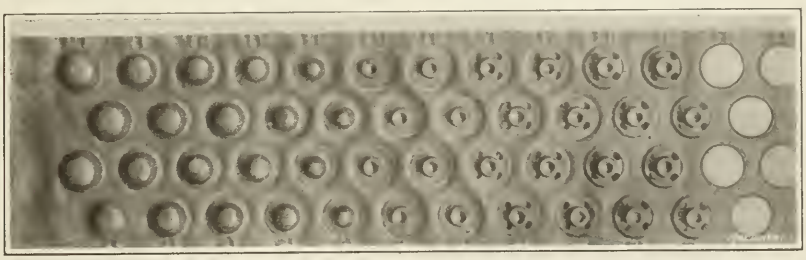


Fig. 4. Strip from Stud Dies showing Various Steps in Process of Manufacture

In the tenth operation—embossing—a reinforcement is thrown up all around the outside rim of the stud. In the twelfth operation — blanking—the stud is pierced from the strip in a downward direction, the finished stud dropping directly through a hole in the lower die bolster. Operations seven, nine and eleven are idle, as previously mentioned.

Method of Feeding Strip

The method employed for gaging the advance of the strip for every stroke of the press is rather uncommon. Briefly, it consists in blanking off from the edge of the strip a narrow piece that is as long as the lead of the die. This is shown at *E*, Fig. 11. The punch, die and stop are shown in detail in Fig. 15, in which *a* is the punch, *b* the stop, and *c* the die. Punch *a* and stop *b* are carried by the upper member of the die. Stop *b* runs in the hole in die *c* and does not leave the die even when the ram of the press is in the "up" position. The strip is fed forward automatically by rolls *a*, Fig. 5. These rolls are moved part of a revolution at each stroke of the press and advance the strip approximately 0.01 inch more than the lead of the die, the extra amount being taken up in slippage. Rolls *a* are rotated by a pawl attached to rod *b* that engages with a ratchet on the roll. The feed may be varied by adjusting collars *c* up or down on rod *b*.

Method of Making Dies

The methods of constructing the dies for the stud and the socket are the same, so the method of making the socket die only will be described. This die is shown in Fig. 16. It consists of two main die-blocks *A* and *B* on which are mounted sectional strips that are bored out for punch-holders, die-holders and strippers. The strips, of course, are securely doweled to members *A* and *B*. The punch- and die-holding members are not hardened. The accuracy with which the holes are located in them governs the success of the entire tool, and thus presents a very fine toolmaking problem. The four

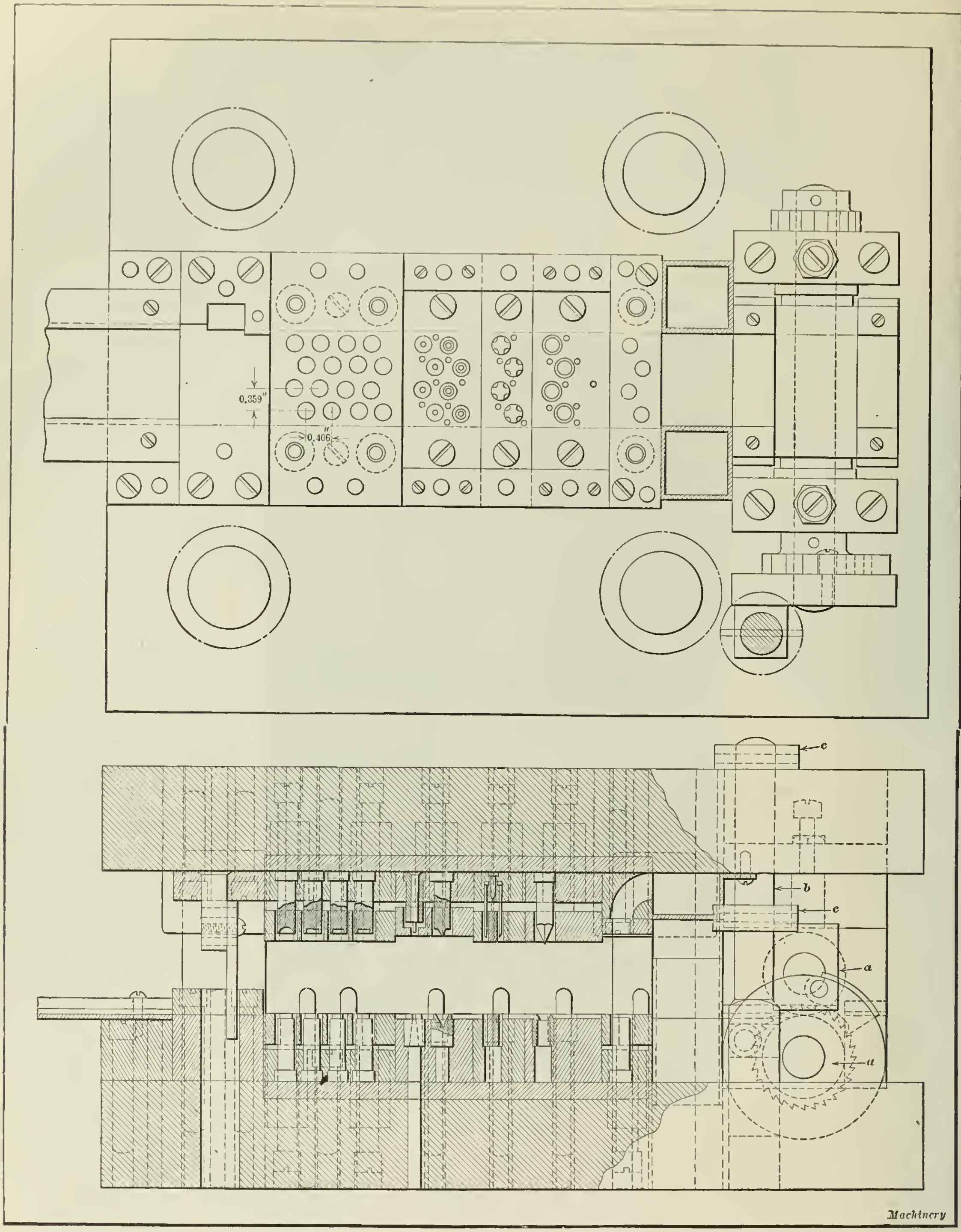


Fig. 5. Cross-sectional View of Punch and Die for Socket, and Plan View of Lower Member

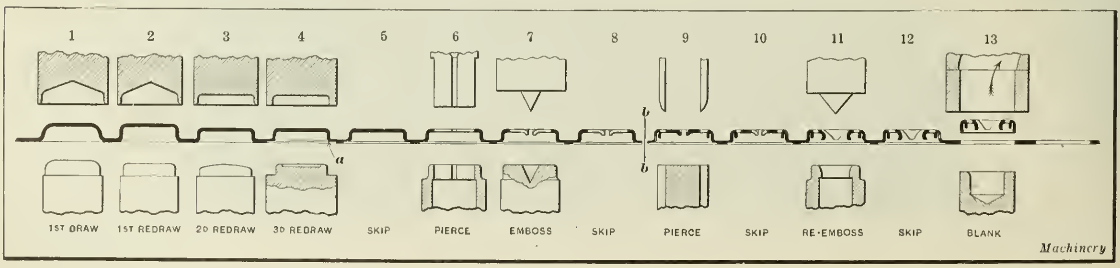


Fig. 6. Diagrammatic View of Upper and Lower Set of Tools and Strip, showing Progressive Steps in making Socket

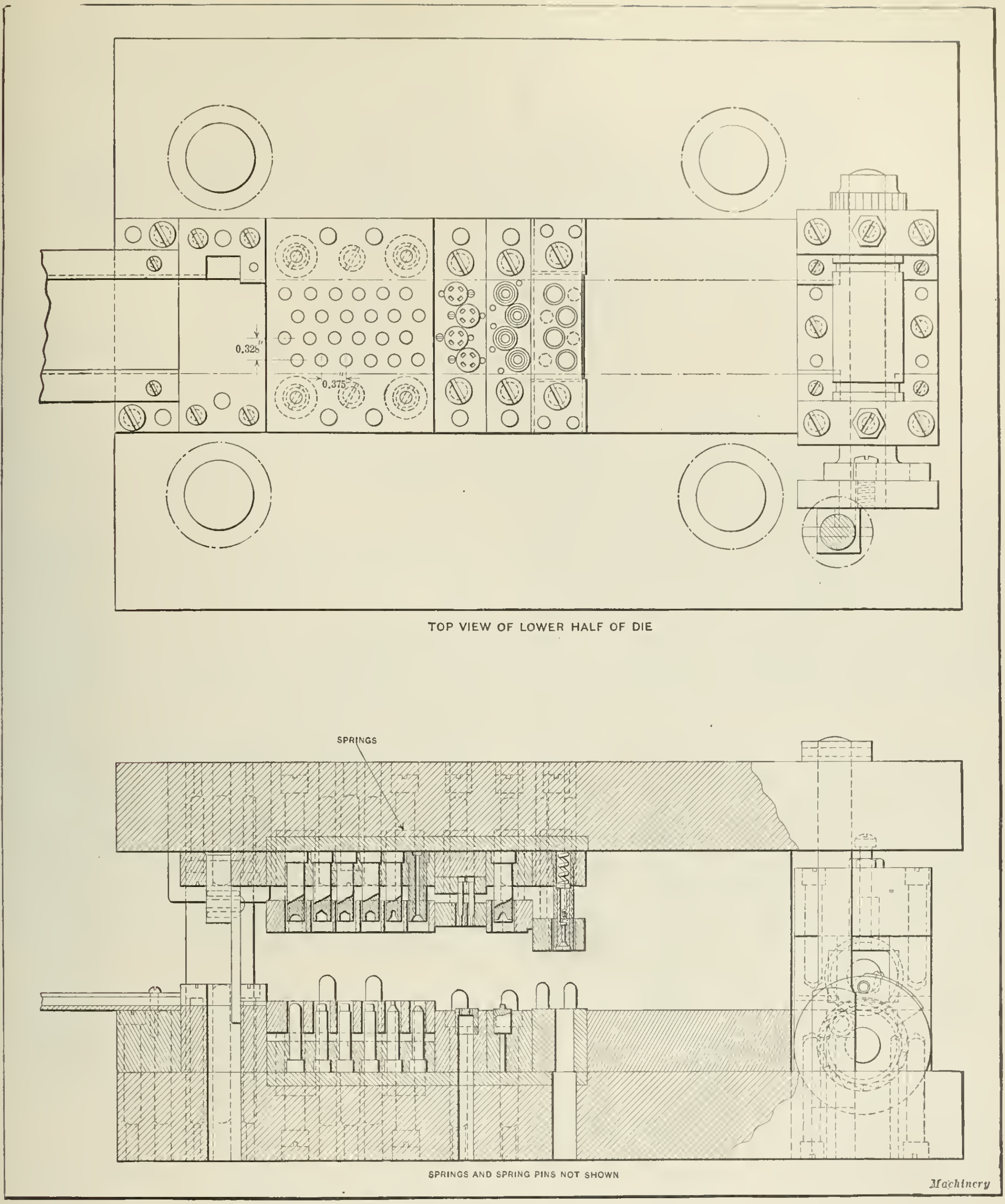


Fig. 7. Cross-sectional View of Punch and Die for Stud, and Plan View of Lower Member

posts of the die are fixed securely to B and run in bushings in A.

When making the die, blocks A and B are clamped together and the post holes a are drilled and accurately bored in line with each other. The accuracy of the center distances is not essential; it is simply necessary that the holes correspond in both blocks. Next, blocks c are clamped in the correct location on block B and the holes for the screws and dowels that are to hold the die-holders, punch-holders and strippers are drilled, reamed, tapped and counterbored. Previous to this, however, blocks c have been machined and ground all over except on the end. Die-block B is then mounted in an upright position on a horizontal milling machine and the thirty-six holes d are located. This is one of the most difficult and exacting jobs in the construction of the entire die, since these holes must bear an exact relation to one another in every direction. Rather than bore the holes entirely in the

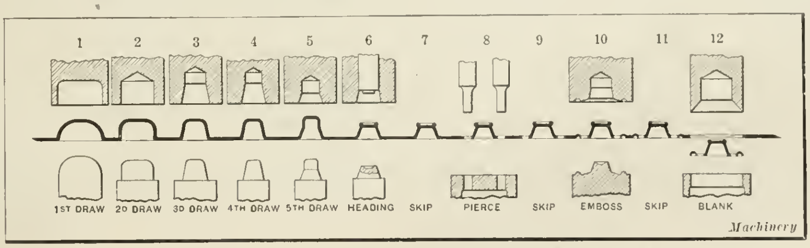


Fig. 8. View of Upper and Lower Set of Tools and Strip, showing Progressive Steps in making Stud

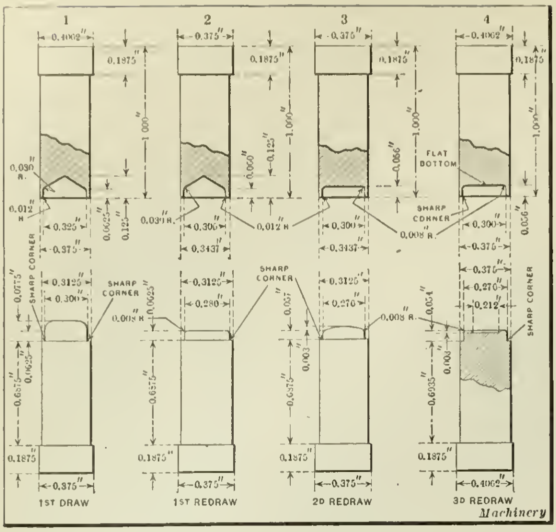


Fig. 9. Drawing Punches and Dies for Socket

milling machine, the position of each is accurately determined by a countersunk hole, approximately 3/16 inch in diameter at the large end. The tool used for this is an ordinary combination drill and countersink. Each block *c* is then removed and mounted individually on the faceplate of a bench lathe. Here they are accurately indicated from the countersunk holes, and the holes are drilled and bored and reamed to the required sizes. The dowel-holes *e* in blocks *b* are drilled and reamed by locating from blocks *c*, thus making the dowel-holes in the upper and lower blocks correspond. Blocks *b* are approximately 1/4 inch longer than blocks *c*, and when locating dowel-holes *e* this extra length is divided equally on each side, as shown at *A*, Fig. 11.

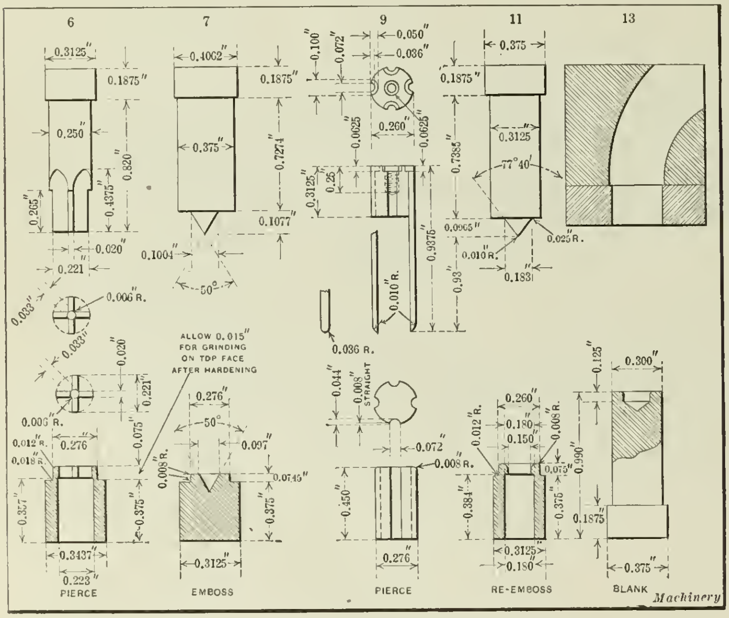


Fig. 10. Piercing, Embossing and Blanking Tools for Socket

After all the blocks *b* have been provided with dowel-pin holes, located from blocks *c*, they are held, one at a time, on a bench lathe faceplate, as indicated at *B*. The two blocks *b* and *c* are placed together, being accurately held by the dowel-pins *e*, and the various holes in block *c* are accurately indicated in block *b*. After each hole is centered, block *b* is clamped securely to the faceplate by the straps, block *c* is removed and the hole is drilled. This process is continued until the thirty-six holes have been transferred and drilled in blocks *b*. The extra length of *b* provides a surface for clamping it to the faceplate without interfering with block *c*.

The next step is to put in all the inserts, such as the punches and dies shown in Figs. 9, 10, 13 and 14. The piercing punches and dies, as may be seen in the views in Figs. 10 and 14, are adequately keyed to prevent turning while the die is in operation. The blocks *c*, Fig. 16, are then assembled on base *B*.

At the next step, the liner pins *a* and liner-pin bushings *f* are assembled, as illustrated at *C*, Fig. 11. Next, dowel-pins *e* are driven upward until they protrude a considerable distance above the surface of blocks *c*. Blocks *b* are placed on top of blocks *c*, locating from dowel-pins *e*. While in this position,

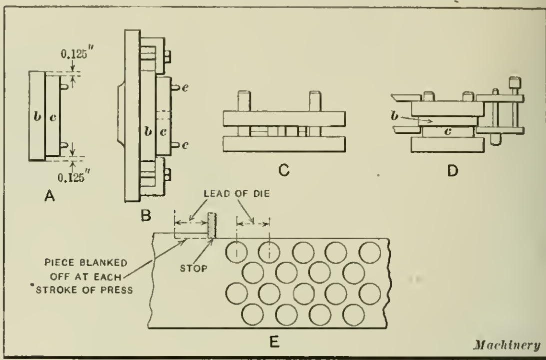


Fig. 11. Diagrams showing Steps in making Die, also Method of gaging Feed of Strip

the upper member *A*, Fig. 16, is slid down the liner pins *a* until it rests on blocks *b*. In this position blocks *b* are securely clamped to base *A*. Blocks *b* and base *A* are then taken to a machine where the necessary screw holes are drilled, tapped and counterbored, as illustrated at *D*, Fig. 11.

After loosely screwing blocks *b* to base *A*, they are accurately aligned by the dies engaging with the punches in blocks *c*; blocks *b* are then tightened to die-block *A*. The alignment is carefully tested by working the two members *A* and *B* up and down on the posts *a*, verifying the alignment by entering dowel-pins *e* into the dowel-holes in blocks *b*. When the alignment is assured, the upper member is removed from liner pins *a*, the dowel-holes in blocks *b* are duplicated in the main member *A*, and the dowel-pins inserted.

Making Piercing Die for Stud

The piercing die for the stud has four oblong holes in it, equally spaced about a circle. As the piercing dies are made in duplicate, and as the holes are oblong, the prob-

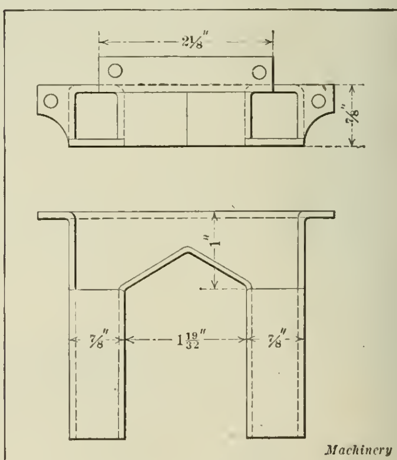


Fig. 12. Chute used on Socket Die for discharging Finished Parts

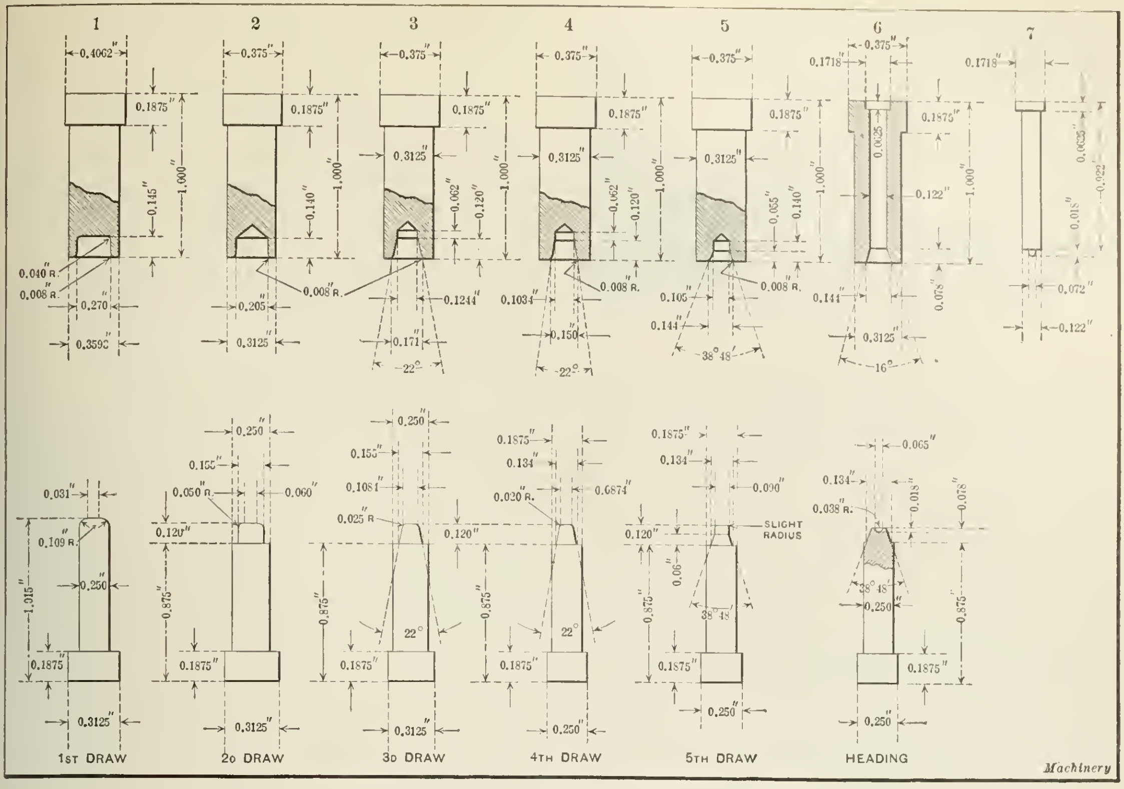


Fig. 13. Drawing and Heading Punches and Dies for Stud

lem presented is a rather difficult one. In addition, a semicircular keyhole must be formed in accurate relation to the other holes. With interchangeable dies and punches, it is a simple matter to replace a broken punch or die quickly, new parts being kept in stock.

For making these dies, the three broaches *e*, *f* and *g* and the fixture shown at *A*, Fig. 19, are used. The fixture consists of

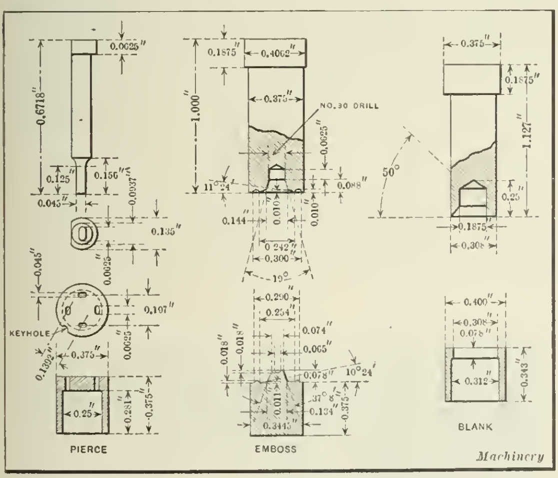


Fig. 14. Piercing, Embossing and Blanking Punches and Dies for Stud

a body *a*, a split ring *b* and two jig plates *c* and *d*. The entire fixture is hardened with the exception of the split ring *b*. The jig plates *c* and *d* are accurately and interchangeably doweled and screwed to the body *a*. In jig plate *c* there are five drilling holes, four of which give the location of the oblong holes, the fifth being used for drilling the keyhole in the die. The jig plate *d* has a square hole in it, the sides of which bear an accurate relation to the drilling holes in plate *c*.

When a die is to be made, it is placed in the slip ring *b*, which is held in the fixture by a set-screw. Then the five holes are drilled by the use of jig plate *c*. The keyhole is drilled partly in the die and partly in the split ring *b*; it is for this reason that the ring is left soft. After the ring has been drilled into all around its periphery, a new one is used.

Jig plate c is replaced by plate *d*, which is used to guide the three broaches *e*, *f* and *g*. Broach *e* is placed in one of the drilled holes and is gently tapped with a hammer. By repeating this for the four holes, the exact oblong impression is left on the face of the die. The broach *f*, which is of oblong shape, but approximately 0.003 inch smaller in size than the oval hole to be produced in the die, is located from jig plate *d*

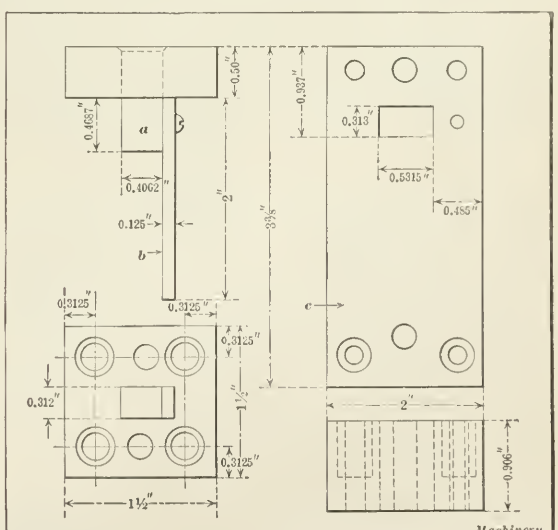


Fig. 15. Details of Die, Punch and Stop for gaging Advance of Strip

and driven into the die, removing the surplus stock. Then broach g is driven through the die, removing the small amount of material left by broach f and making the hole the correct size. When this work has been done on the four holes, the die is complete.

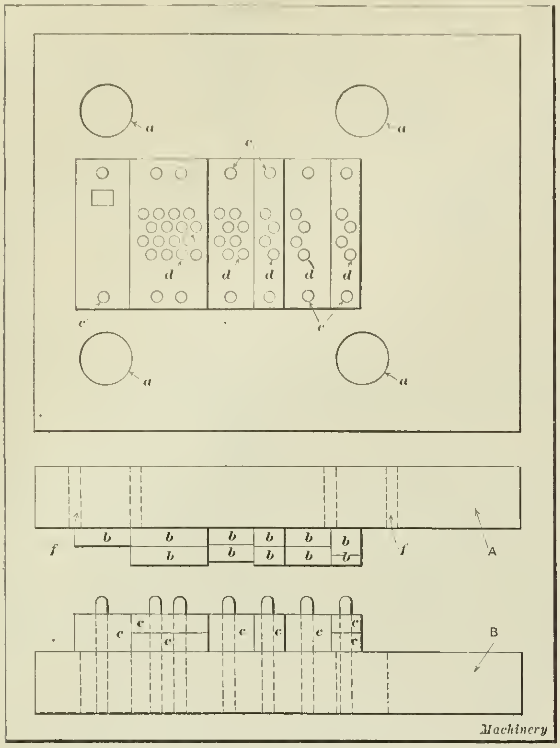


Fig. 16. Diagrammatic View illustrating Method of constructing Socket Die

Making Piercing Die for Socket

The making of the die for piercing the star-shape in the socket is also a difficult tookmaking problem, especially as these dies and punches are made in quantities, and have to be interchangeable. The star arms are only 0.02 inch wide,

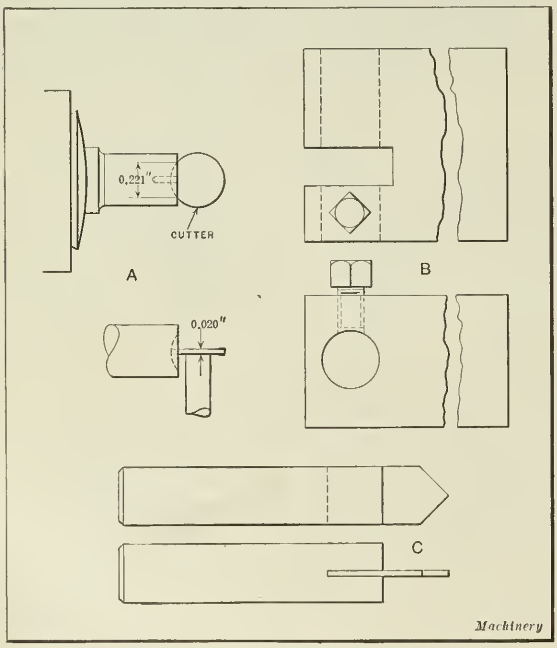


Fig. 17. Method of making Star Piercing Die for Socket

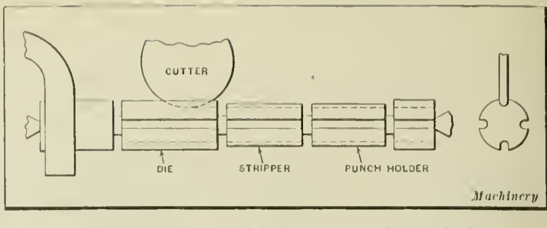


Fig. 18. Method of milling Die, Stripper and Punch-holder

so to finish them accurately by the ordinary toolmaking methods would be tedious and expensive. The following method was adopted and interchangeable dies were produced.

The stock from which the die is turned is held in the spring collet of a bench lathe and rough-turned. After this, a small hole is drilled exactly in the center of the die about 1/8 inch deep. Next, the bench lathe milling attachment is brought into position and, with a small milling cutter 0.020 inch in width centered accurately from the previously drilled hole, a cut 0.221 inch long is made in the face of the die. After this, the cutter is backed straight out and the work-spindle revolved 90 degrees, clamped into position, and the same milling operation repeated. This is illustrated at A, Fig. 17. After this milling operation, the die is turned on the outside diameter, cut off, turned around in the collet, and the back of the die is drilled out for clearance to within 0.075 inch of the face.

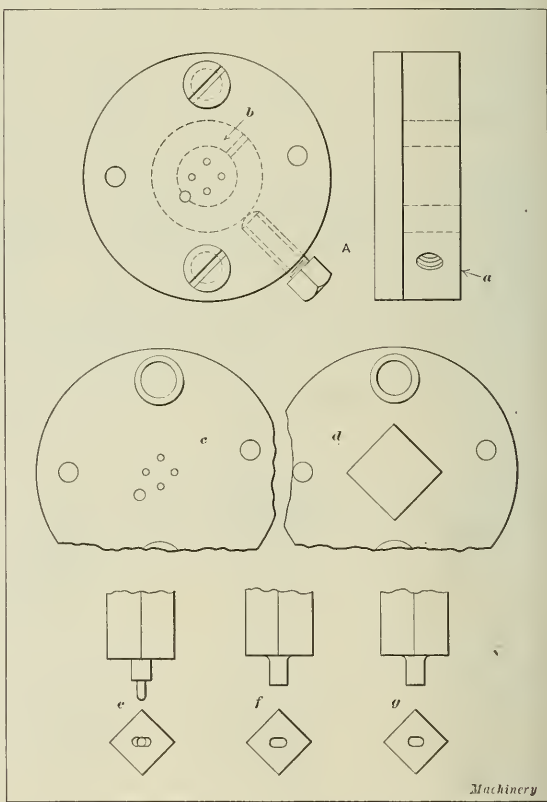


Fig. 19. Fixture and Broaches for making Piercing Dies for Stud

To complete the star-shaped hole, the inserted-blade broach C and the fixture B are used. The die is held in the lower part of the fixture and clamped by a set-screw. The broach C is located in the hole in the upper part of the fixture. The blade of the broach is guided into the face of the die by the previously milled slot and is driven through the die, first in one slot and then in the other, with a hammer. This completes the die except for smoothing the slot with a file, hardening and grinding the face.

The making of the punches is not so difficult. They are milled to size, using a simple dividing head and milling cutter, indexing four times. The dimensions for this punch and die are shown in Fig. 10.

Die, Stripper and Punch-holder for Socket

The punch-holder, die and stripper for the socket are similar in general construction and vary only in length and diameter. The distance from the center to the bottom of the semicircular slot is the same for all three parts. For this reason they are all turned out of one rod, and necked, as illustrated in Fig. 18; the semicircular slots are milled in the three pieces simultaneously. By this method interchangeability is readily obtained. This is, of course, essential in this case, as all three parts must work together and line up perfectly.

* * *

RAPID METAL SAWING

There is, perhaps, no class of shop work that is given so little consideration, as a rule, than the cutting off of bar stock and other material used in the machine shop. Because the operation is simple, it is often left to men who have no training whatever for the work, and is carried on in a slip-shod manner.

At the plant of the J. L. Mott Co., Trenton, N. J., a battery of five 21-inch special Lea-Simplex saws, built by the Earle Gear & Machine Co., has been installed; these saws are cutting off 1¾ inch diameter brass bars at an unprecedented rate. Each of the saws is equipped with a special clamp or vise for holding twenty-four bars at once. The bars are 5 feet, 6 inches long, and are cut into sixteen short lengths, requiring fifteen cuts. The time required for one cut through the twenty-four bars is approximately two minutes, forty-eight seconds, or seven seconds per bar. Two operators work on each machine, and helpers are provided to see that each of the machines is supplied with twenty-four bars to replace those being cut immediately after the fifteenth cut is finished. When the bars are first placed in the machine in the cutting position, they are securely clamped at the rear to a carriage which is moved forward by a screw and handwheel. By this means the twenty-four bars are advanced simultaneously after each cut to the next cutting position by simply turning the handle and advancing the rear carriage until the ends of the bars meet the gage-plate, which is set to gage four-inch lengths. Since the cutting time for each lot is less than three minutes, the operation is practically continuous and the two operators on each machine are kept busy. The entire operation of cutting up one load of twenty-four bars takes about forty-five minutes, and in the course of a ten-hour day one machine with two operators handles approximately 15,360 pounds of brass rods.

After one lot of bars has been cut, it is necessary to move the rear carriage backward about five feet to receive the next load. This would be a slow operation if it had to be accomplished with the screw and handwheel, so for this purpose the carriage is provided with a split nut engaging the screw, which may be released so that the carriage can be pushed back quickly by hand.

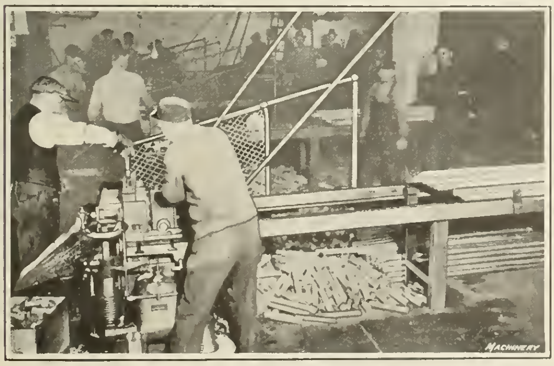


Fig. 1. Battery of Five Saws cutting Twenty-four 1¾-inch Brass Bars

Fig. 2. Rear View, showing Carriage for holding Twenty-four Bars to be cut

The bars are stacked in eight rows, three high, and are held by clamping screws over each row. On account of the number of these screws, it seemed at first as though an air clamp might be more effective, but after the saws were in operation, it was found that the cut could be started as soon as the two screws over the bars first touched by the saw were tightened down and the rest of the screws could be tightened while the saw was cutting. This method of handling is so rapid that little time could be saved by the use of an air clamp.

A sheet-iron apron has been placed on each saw in front of the blade and above the limit of travel of the swing arm. This apron is sloping and allows the pieces that are cut off to roll down into boxes which are on wheels for convenient handling. A certain amount of the cutting compound flows down into these boxes, which have double bottoms and a spout to permit the compound to flow back into the base of the saw. The saw-blade expense has been about one cent per one hundred cuts, or one-twenty-four-hundredth cent per piece. V. B.

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AMERICAN GEAR MANUFACTURERS' ASSOCIATION

An organization of gear manufacturers was formed at Lakewood, N. J., at a meeting held there March 25-27, that will be known as the American Gear Manufacturers' Association. Its purposes are to advance and improve the gear industry in a general way by standardizing gear design, manufacture and application. The association includes in its membership the foremost and better known manufacturers of gears. The executive committee is composed of the following: F. W. Sinram, Van Dorn & Dutton Co., Cleveland, Ohio; H. E. Eberhardt, Newark Gear Cutting Machine Co., Newark, N. J.; F. D. Hamlin, Earle Gear & Machine Co., Philadelphia, Pa.; Frank Horsburgh, Horsburgh & Scott, Cleveland, Ohio; Biddle Arthur, Simonds Mfg. Co., Pittsburg, Pa.; George L. Markland, Philadelphia Gear Works, Philadelphia, Pa.; Milton Rupert, R. D Nuttall Co., Pittsburg, Pa. The following officers were elected at the Lakewood meeting: president, F. W. Sinram; vice-president, H. E. Eberhardt; secretary, F. D. Hamlin; treasurer, Frank Horsburgh. The next meeting of the association will be held at Pittsburg, May 14-15.

* * *

A "PROTECTED" LABOR MARKET

A high protectionist only could have written a letter containing the following gem:

> We don't believe in trade papers conducting a "Help Wanted" bureau. If it is done, it should be carried on separately, and the advertisements should not be found in with the regular issues. We have found by experience it is bad practice to let trade papers come to any of our offices, on account of these advertisements; it generally results in loss of help. The advertisements for help wanted could be printed on sheets and sent to the manufacturers, dealers, merchants, etc., separately.

In short, this manufacturer would deny to his workmen opportunity to change their jobs and perhaps improve their condition while he would give manufacturers and employers opportunity to hire men who have advertised. Why should the initiative be lodged with the employer as regards response to advertisements? Is it always right for employers to seek new employes and wrong for employes to seek new employers?

DIE-FORGING TROUBLES—2[1]

FORGING FORKED BARS WITH HEAVY BOSSES, CROSSHEADS AND EYE-PLATES

BY JOSEPH HORNER

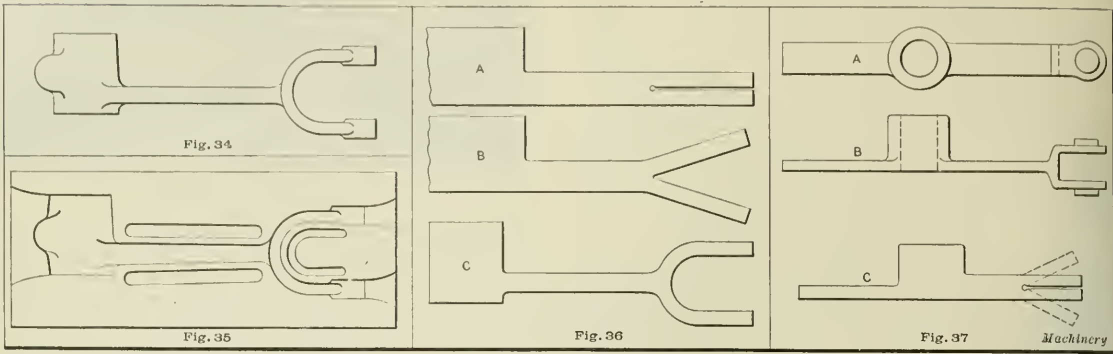


Fig. 34. Forked Bar with Heavy Boss on End
Fig. 35. Die for forging Bar in Fig. 34

Fig 36. Preliminary Stages in forging Bar in Fig. 34

Fig. 37. Forked Bar with Heavy Boss in Center

THE lever shown in Fig. 34 has a heavy boss extending from a slender stem at one end, and a widely spreading fork at the opposite end. This lever can be dummied down from a cubical lump in steel, but that would set up strains in the metal, besides imposing severe work on the dies. Such work is not profitable, because both dummying and stripping dies are required. The better method is to follow generally the same lines as the smith would adopt when forging in iron. A bar having a cross-section about equal to that of the boss should be drawn down under the hammer to the form shown at *A*, Fig. 36. The reduction is made on one side, as shown, until the thickness equals that of the two forks. That end is then divided with a hot set, opened out as at *B*, and curved over a form block. The stem portion is then reduced and drawn out until the forging has the rough form shown at *C*. It is finished in the die shown in Fig. 35. As it has been prepared roughly to outline, one pair of dies will suffice for finishing. There will not be much fin, and what there is may be expelled by sloping the die faces away from the edges of the impressions for the forging, by making a shallow gutter around the impressions, or by sloping channels away from the ends, as shown. The hole in the boss may be punched subsequently or drilled.

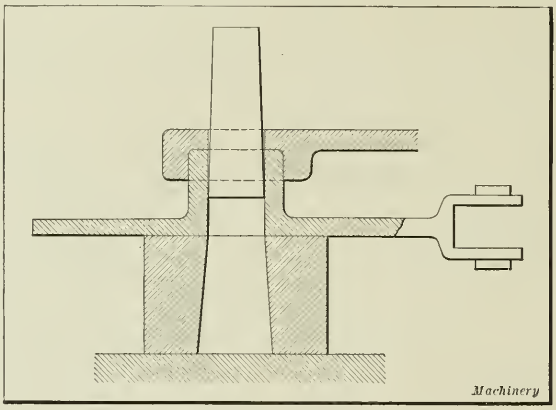


Fig. 38. Punching Hole in Boss of Bar in Fig. 37

The lever shown at *A* and *B*, Fig. 37, is similar to that shown in Fig. 34 as regards the difference in adjacent dimensions. Properly, it should be forged of steel by a method not very different from that which must be adopted if it is made of iron; this is indicated at *C*. A lump or a bar about equal in cross-section to the boss is reduced to a thickness and width roughly equal to that of the web, at the left hand, and at the right, to a thickness equal to that of the two prongs of the fork, with a width corresponding to the diameter of the bosses of the fork. Then the end is punched, divided and opened out as shown. The ends are bent roughly over a former, and the dies, Fig. 41, finish the outlines.

Two sets of dies are shown, between which there is little to choose, the jointing of one pair being at right angles with that of the other. In the one shown at *A*, which may be preferred, the flat of the web lies in the joint faces, with the deep boss standing up in the top die. This necessitates fitting the loose block *B* as a former on which to mold the forked end.

[1] The first installment appeared in the March number.

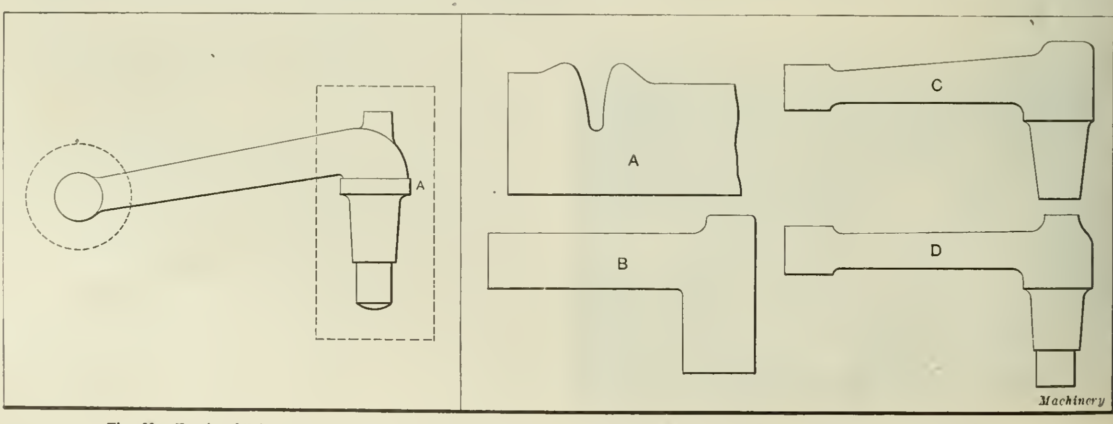


Fig. 39. Forging having a Sharp Bend

Fig. 40. Stages in forging Piece shown in Fig. 39

The hole in the boss may be punched in the same dies. By the other method, shown at *C* and *D*, the joint of the dies lies in the axis of the boss and the internal part of the fork is finished with projections made solidly in the dies. The hole can be punched subsequently as shown in Fig. 38. The objections to this method are that the web goes edgeways into the dies, which leave a mark around it, and the punching is done separately with less support for the boss.

Examples of Forgings with Sharp Bends

The forging shown in Fig. 39 may be made by bending either in iron or in steel. But in either material the curved portion

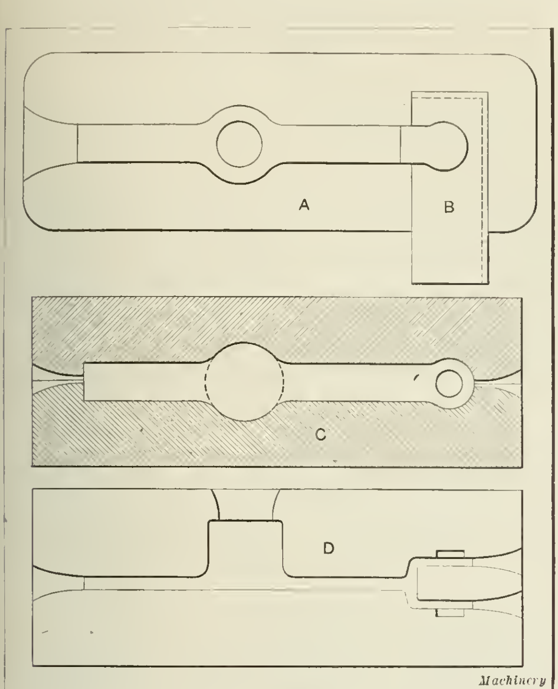


Fig. 41. Dies for forging Bar in Fig. 37

would be severely stressed, the outer fibers being strained excessively and the inner crumpled up. If made of iron, a weld is preferable; if made of steel, the bending must be performed at a high temperature and a good deal of work done in the elbow. The bar should be of the same diameter as collar *A*, or rather larger, so that there will be some reduction with the bending. A better way is to take a massive rectangular piece, as shown at *A*, Fig. 40, fuller it deeply as shown, and then draw down on each side under the power hammer to form the two arms. The second stage is shown at *B*, the third at *C*, and the fourth at *D*. The first rough reductions are made between the anvil and the tup, the second set between the bottom and top swages. Properly, the entire forging should be finished in dies because of the large number of

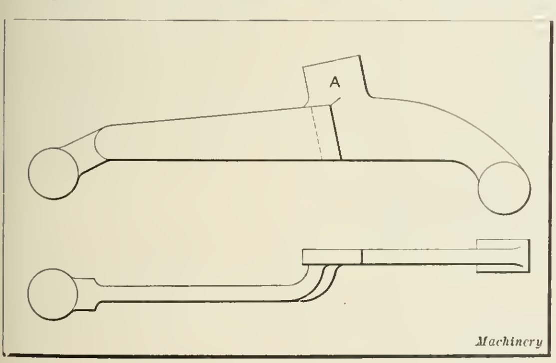


Fig. 42. Lever made from Straight Piece of Bar

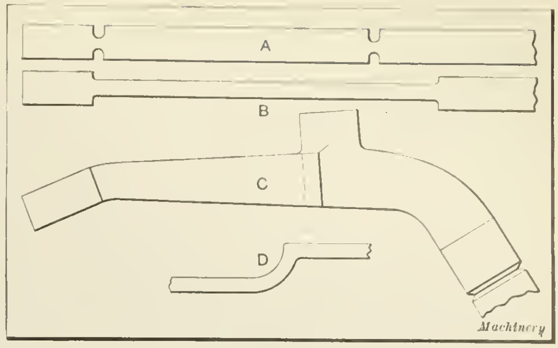


Fig. 43. Preliminary Stages in forging Lever

changes in dimensions; or the part adjacent to the bend may be made in one pair of dies and the bossed end in another pair, leaving the stem to be finished in swages. The outlines of these sectional dies are indicated by dotted lines in Fig. 39.

The curious lever shown in Fig. 42 is made from a straight piece of bar roughed down under the hammer and finished wholly in dies. To employ sectional dies only for the ball at one end and the boss at the other would still leave a good deal of awkward work to be done about the central portions. To make this lever, a bar having a cross-section rather greater than that of the boss and the ball is fullered in and drawn down, as at *A* and *B*, Fig. 43, to form the web thickness. Width is required to give material for the abutment piece *A*, near the center in Fig. 42. The forging is first dummied down as a straight piece. The blows should alternate between the flats of the web on each side, mostly on one edge in order to make the abutment portion *A* stand out from that edge. As shown at *D*, Fig. 43, the web is set down beside this portion *A* under the hammer, and the ends are bent over the edge of the anvil, or over a block having a curved face. At this stage the forging

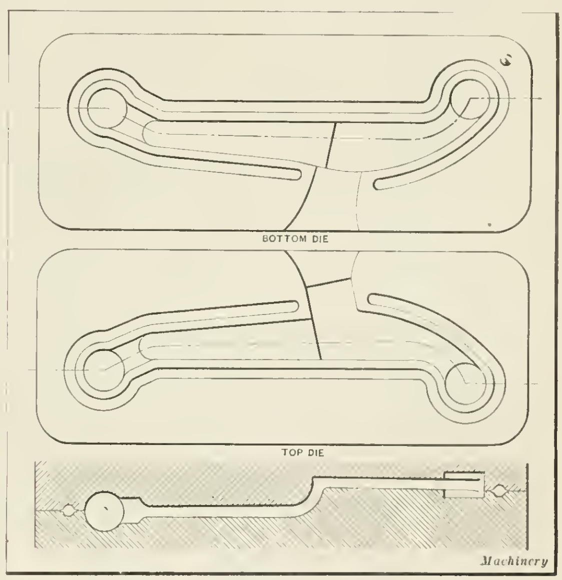


Fig. 44. Dies used in forging Lever shown in Fig. 42

is as shown at *C*, Fig. 43. A templet may be used to check the curvatures. The end of the bar that served as a porter is then cut off, and the rough forging put into the dies shown in Fig. 44. These are not quite alike at the abutment portion. They are shown thrown open in the joint face and have gutters to receive the fin.

Forging Crossheads

The crossheads in Fig. 45 are examples of a class of forgings in which two substantial parts stand at right angles with each other. The difference between the two is that the crosshead

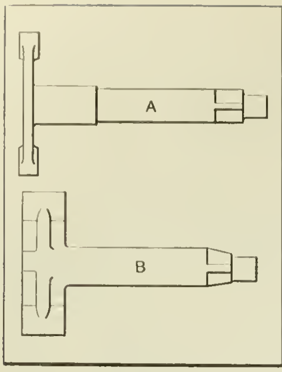


Fig. 45. Common Types of Crossheads

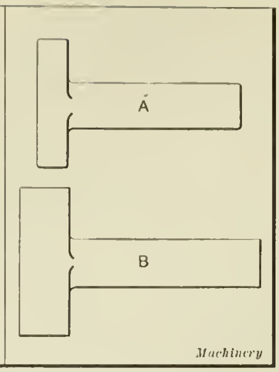


Fig. 46. Preliminary Stages in making Crossheads

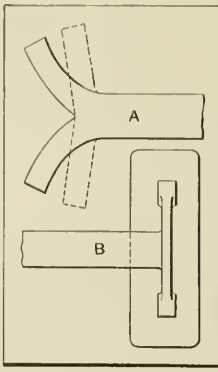


Fig. 47. Making Slender Crosshead in Iron

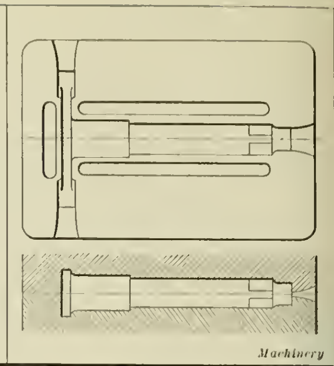


Fig. 48. Dies for making Slender Crosshead in Steel

portion is relatively slender at *A* and comparatively heavy at *B*, which suggests a variation in the method of treatment. When making the crosshead *A* of iron, the correct method is to divide one end of a round bar, open it out as at *A*, Fig. 47, and bend the forks to a right angle, or nearly so, following which the finishing may be done in dies. Only the crosshead and a small part of the stem need be finished in dies, which are shown at *B;* the stem may be made with swages under the steam hammer, unless large quantities have to be made.

When making the crosshead of steel, the better method is to take a bar larger than the stem, to afford sufficient material for spreading, and draw down at one end, and on opposite sides to provide material for the crosshead bosses as at *A*, Fig. 46; the web portion is then reduced in dies and the stem is swaged down under the hammer, being finished in the same dies as the stem, Fig. 48. This is alternative to the method shown at *B*, Fig. 47. Gutters are provided for the fins to flow into.

The proportions of the second crosshead *B*, Fig. 45, are different, there being a more substantial head. To make this, a cubical lump of about the same section as the crosshead should be taken and the stem drawn down as at *B*, Fig. 46. This would be suitable for either iron or steel; the finishing may then be done in dies like those shown in Figs. 47 and 48. The ribbings must be stamped wholly in the dies, for little preliminary work can be done there. The fin can be taken care of, as shown in Fig. 48, at the ends of the bosses and in gutters, and the dies may include the entire forging or the crosshead only.

The crossheads shown in Figs. 49 and 50 are examples of preliminary drawing down and punching and finishing in dies. They each comprise a relatively large central boss and hole, with tapered cylindrical arms of much smaller section. The method just mentioned is therefore the only feasible one.

The two-arm crosshead shown in the upper view, Fig. 49, is first roughed out from a solid square bar, as shown in the upper view, Fig. 50, from which two ends are swaged down to form the arms. The corners of the boss are cut off with a hot set. The hole may be punched at this stage and finished later in dies, or the punching can be done in dies. The ad-

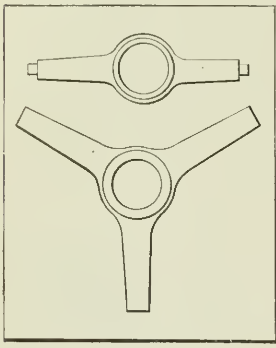


Fig. 49. Two-arm and Three-arm Crossheads

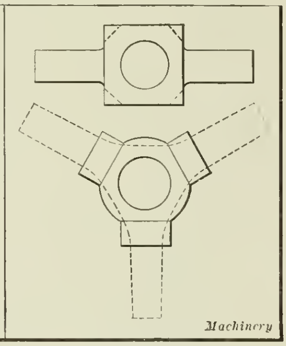


Fig. 50. Preliminary Work in forging Crossheads in Fig. 49

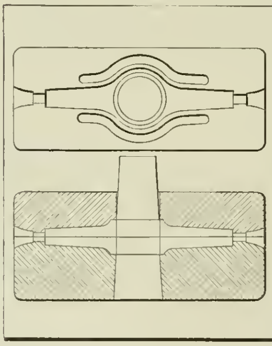


Fig. 51. Dies for forging Two-arm Crosshead

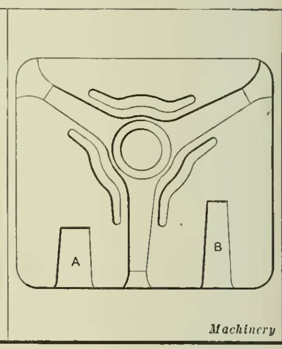


Fig. 52. Die for forging Three-arm Crosshead

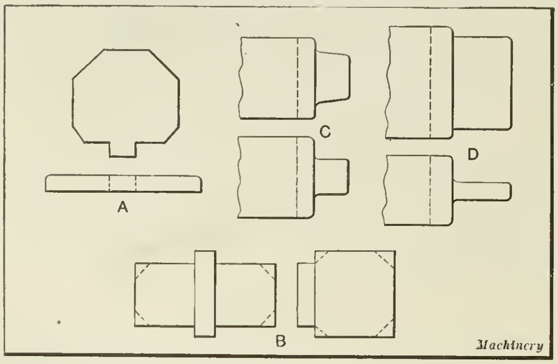


Fig. 53. Stages in making Some of the Eye-plates shown in Fig. 56

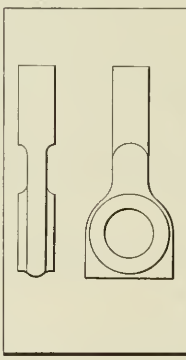


Fig. 54. Eye-plate made from Large Bar

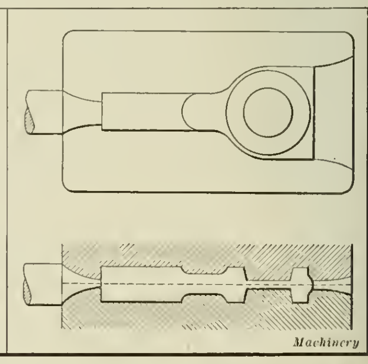


Fig. 55. Dies for making Eye-plate from Large Bar

vantage of the latter method is that the metal is well supported against the punch. But as the lump is quite heavy, the hole may be punched as a first operation before drawing down. The dies are shown in Fig. 51 with provision for making the hole. If the hole has been roughly punched, it can be finished in these dies either by driving a bellied drift through or by forming punches in each half die; the latter should not quite meet in the center. The provision for receiving the fin is shown.

The three-arm crosshead shown in the lower view, Fig. 49, is treated similarly. A circular lump is swaged down in three equidistant places and the interspaces worked back with the help of fullers. The lower view, Fig. 50, illustrates stages in the work—the full lines an early stage and the dotted lines a later one, following which it goes into the dies. One half die is shown in the joint face, Fig. 52. The two recesses *A* and *B* are used for swaging down the arms nearly to the finished dimensions before putting the forging into the dies to

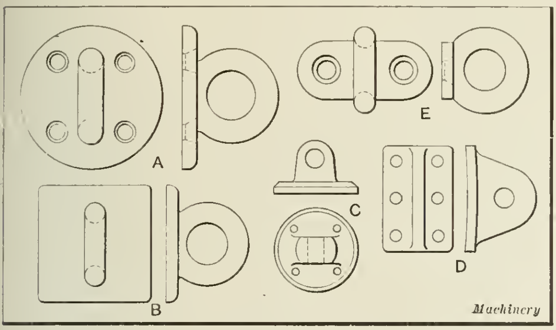


Fig. 56. Types of Eye-plates

be completed. The central hole may be made in the same manner as in the two-arm crosshead.

Forging Eye-plates

Eye-plates are made in various forms, as shown in Fig. 56. The pieces of metal from which they are formed bear little or no resemblance in outline to the articles produced. Dies are essential if labor is to be reduced. The plate, or foot, is the proper element to start from if the forging is to be made in the solid. The objection to this is the thickness of metal to be severed. This, however, is a matter of little mo-

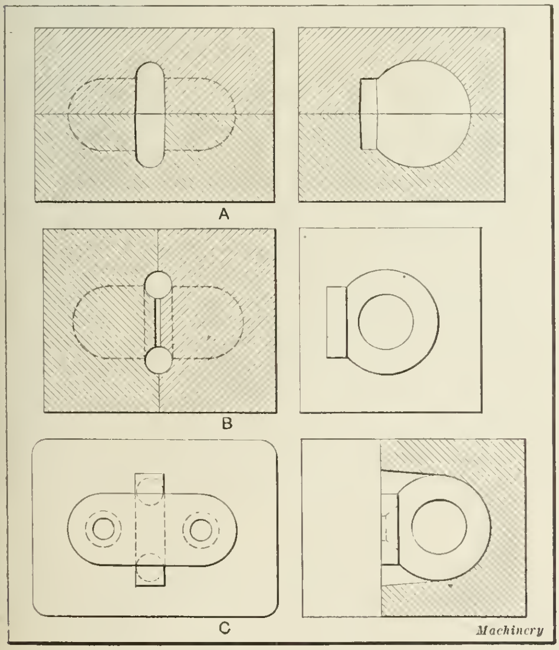


Fig. 57. Dies for making Eye-plate E, Fig. 56

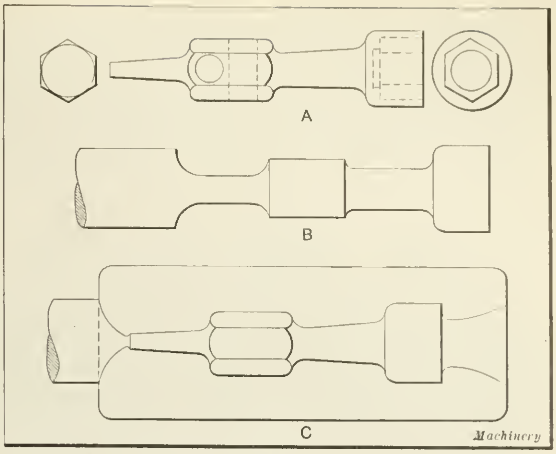


Fig. 58. Making a Box Spanner

ment if a hot saw is available; severance with a set would be tedious. The alternative is to weld the eye and the plate together, in which case each portion can be cut from pieces of plate having the approximate finished outlines. A tenon joint *A*, Fig. 53, will help the union.

Another method, suitable for producing the shape shown at *E*, Fig. 56, is to take a square piece rather larger than the diameter of the eye and thick enough to permit of fullering down material for the flanges, as at *B*, Fig. 53. The corners having been cut off with the hot set, the finishing can be done in successive pairs of dies. In consequence of the depth of the plate, it is best to divide the formation between two pairs of dies. The first pair *A*, Fig. 57, imparts the curves to the edges of the plate and the circular outline to the eye.

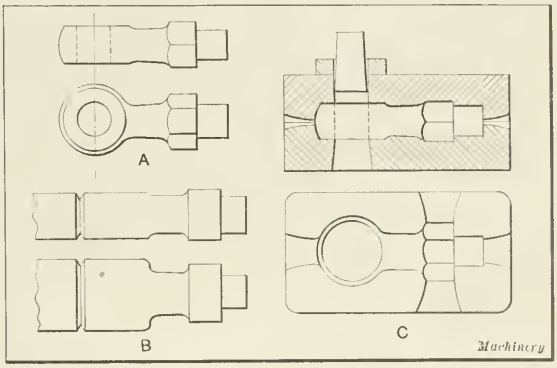


Fig. 59. Making Pillaret from Round or Rectangular Bar

A little draft is put on the vertical faces to favor the delivery of the forging. Afterward the forging is put into the next pair of dies *B*, which stamp the eye. The punching portions do not quite meet in the center, thus leaving room to receive the fin. If the screw holes are punched, this is done in a third pair of dies *C*. The method of dummying generally used is shown at *C* and *D*, Fig. 53. That illustrated at *C* is used for the eye shown at *C*, Fig. 56, and the method illustrated at *D* is used for the eye shown at *D*, Fig. 56. The bars are then cut off at the dotted lines with the hot saw, and the remainder of the work is done in dies similar to those illustrated in Fig. 57.

The eye shown in Fig. 54 is produced from a bar of about the size of the diameter of the eye, and the stem is drawn down roughly under the hammer. It may then go directly into the dies shown in Fig. 55. The hole is punched nearly half way in each die, leaving a space between to receive what fin forms there. Enough provision is made at the ends for squeezing out the fin from the boss and stem.

The box spanner, shown at *A*, Fig. 58, is easily forged if the hexagonal recess is omitted, this being a case for reduction only. A bar of the same diameter as the spanner end

is swaged down, as shown at *B*, and finished in the dies *C*, which also nick and practically sever the forging from the porter bar.

The pillaret shown at *A*, Fig. 59, is easily made from either round or rectangular bar, as shown at *B*. Using the latter, the fullering and swaging produce the rough outline indicated. After being cut off, it goes into the dies shown at *C*. The punching may be done as shown, or by having each half of the punch solid in each half die.

* * *

CUTTING A METRIC PITCH WORM

BY GUY H. GARDNER [1]

A delicate and costly piece of astronomical apparatus, imported from Europe, was badly injured in transportation, a hardened steel worm, on whose accuracy the usefulness of the instrument largely depended having its thread broken in several places. It was sent to a large city jobbing shop, which declined to undertake the repair, as it "had no facilities for cutting metric threads." Its owner then applied to a country job shop near his summer home, which made a new worm to his complete satisfaction. The rural mechanic confesses that he might not have undertaken the work if he had realized that the thread was metric, but having started the job he would not give it up, and proceeded to find means for carrying it to completion.

The worm had evidently been cut with a tool of 29 degrees angle, and by measuring the worm-wheel, counting its teeth, and then calculating the spiral angle of the worm, he had all the required data. Having no metric micrometer, and little if any knowledge of metric gearing, he made his calculations exactly as if the apparatus were of indigenous manufacture. This, if done arithmetically, would have involved him in a maze of fractions, but as he is expert in the use of logarithms he found by a single operation the logarithm of the axial lead of the worm, $\bar{2}.786822$, which corresponds to 0.0612 inch, about.

He had no gears to cut this lead, of course, but he knew how to make a lathe cut a slightly coarser lead than that to which it is geared by setting over the taper attachment and tailstock to the proper angle, a wrinkle which he had employed in threading taps with a slightly increased lead to compensate for shrinkage in hardening. The next finer lead at his command was 17¼ threads per inch, which he could get by compounding in the ratio of 2:3 with the gears for a 11½ pipe thread. This lead is about 0.0579 inch. Dividing the lead to which the lathe is geared by that desired gives the cosine of the angle of set-over:

[1] Address: New London, N. H.

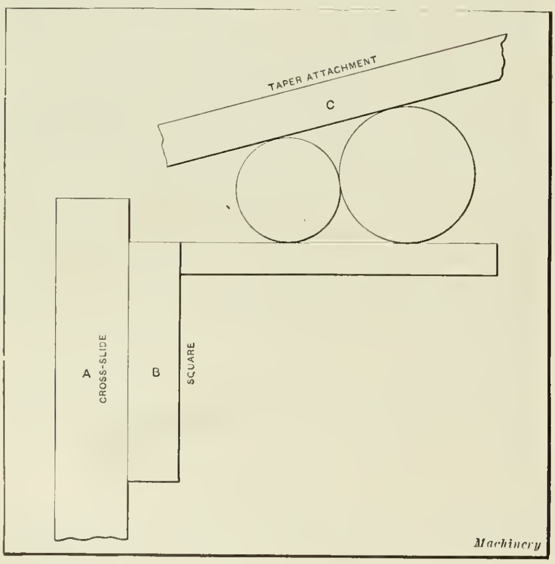


Fig. 1. Method of setting Taper Attachment with Two Disks

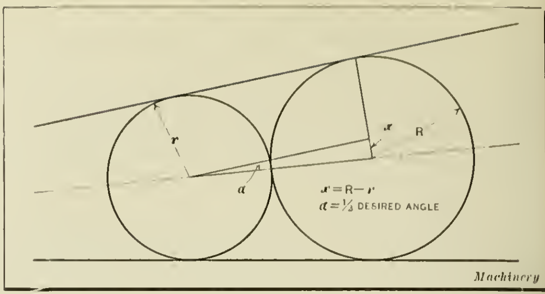


Fig. 2. Diagram to illustrate Formula for finding Disk Diameter used in setting to an Angle

Log of lead (17.25 threads per inch)	$\bar{2}.763211$
Colog[1] of lead desired	1.213178
Log cosine of angle of set-over	$\bar{1}.976389$

which shows the angle of set-over to be 18 degrees, 43 minutes, 20 seconds.

He did not feel certain how exact a setting was necessary, but determined to secure the highest degree of accuracy in his power. The method adopted is shown in Fig. 1. A steel square *B* was used, with its beam clamped against the cross-slide *A*, the taper attachment *C* being set by placing between it and the square blade two disks, in contact with each other; one was one inch in diameter and the other of such size (yet to be determined) that their common external tangents would be at the required angle, 18 degrees, 43 minutes, 20 seconds.

Referring to Fig. 2, the formula for finding the difference x between the radii of the two disks is $x = \frac{2r \sin a}{1 - \sin a}$, r being the radius of the smaller disk, and a one-half the desired angle. On substituting the known values the calculation gives 0.1943 inch as the value of x. All the preliminary figuring now being complete, he made the worm of "non-shrinking" steel, and after hardening polished it with a zinc lap and diamantine.

There may be better ways in which he might have done this job. Certainly an element of inaccuracy is introduced when a thread is cut on work set out of line with the lathe bed, as its angular velocity of rotation does not exactly correspond with that of the spindle, but nevertheless the worm made as described above has filled the very exacting requirements imposed by its position in a piece of astronomical apparatus to the entire satisfaction of its owner.

* * *

BRITISH GUN AND SHELL PRODUCTION

Great Britain has now reached its maximum gun and shell production, according to the Ministry of Munitions, so that there will be a gradual return of plants and labor to domestic and export production. In addition to the regular government factories, 4623 plants are now controlled by the government; in these, 2,225,000 persons, or about one-half the entire membership of the trade unions, are employed. The present capacity of these plants is shown by the statement that for every heavy howitzer produced in June, 1915, 323 are produced now; for every field howitzer produced then, 46 are produced now; and for every gun of medium size produced then there are 66 now. The output of 60-pounders and 6-inch guns went up eighteenfold and has now dropped back to twelvefold, as the supply is too great. In a single day, as many shells for heavy guns are made as were turned out during the whole first year of the war; and in a week the factories turn out as many shells for field howitzers and 3-inch field-guns as were turned out in the first year of the war.

[1] Tables of cologs are not common, and it is not out of place to state for the benefit of those who are unfamiliar with them that the colog of a number is the remainder after subtracting its log from zero, the mantissa being made positive. In the absence of a table, cologs may be easily derived from a table of logs. Cologs have no properties essentially different from those of logs, except that they enable division to be carried out by addition instead of subtraction, since the addition of a colog is the same as the subtraction of the corresponding log. In the case of division of fractions, as in the above, the use of the colog of the divisor simplifies the operation and avoids confusion due to the negative characteristics.—EDITOR.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

LAYING OUT A HOPPER MITER JOINT

A machinist, enjoying a day off, strolled into a carpenter's shop and watched with interest the labors of a trade so unlike his own. Presently he noticed a man marking out pieces of board which he saw, from the drawing on the bench, were to

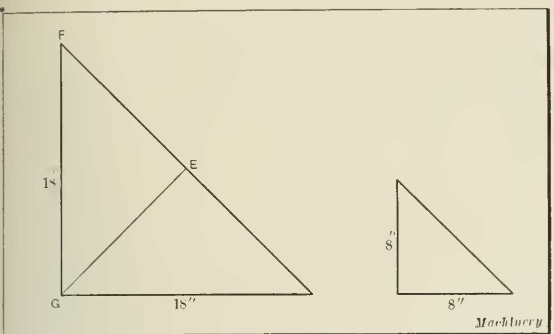
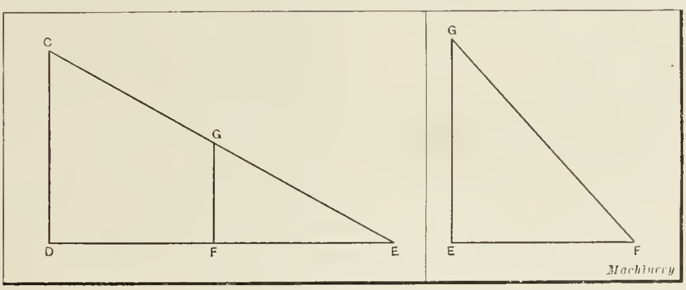


Fig. 1. Half-plans of Top and Bottom of Hopper

be the sides of a hopper, 18 inches square at the top, 8 inches at the bottom, and 12 inches high, with miter joints.

He was curious to see how the workman would obtain the angle for the beveled edges of the sides, as he recognized the problem as one which he had often dealt with himself, when he had had to find the angle to which to set the planer head in making "bits" for thread tools. In this case, as we all know, the angle of the tool differs from that of the thread it is to cut, because of the front rake. Though he waited, expecting to see the carpenter divide the tangent of 45 degrees by the cosine of the angle of rake, thus finding the tangent of the angle for his bevel, nothing of the kind occurred. Instead, the workman took a smooth piece of straight-edged board and drew upon it some diagrams whose meaning and purpose were at first incomprehensible to the watcher. Soon, however, he began to understand their aim, and this is what he discovered:



Figs. 2 and 3. Diagrams for laying out Miter Joints for Hopper Sides

The first triangle, 18 inches on a side, Fig. 1, represents a half-plan of the top of the hopper, the smaller, 8 by 8 inches, that of the hopper bottom. Measuring the two hypotenuses, the carpenter found their difference, which he transferred to the diagram Fig. 2, where he laid it off on the perpendicular, *CD*. (He could have found this difference more easily by making a triangle 10 inches on a side—(18 — 8)—and taking its hypotenuse, but he was probably unaware of this fact.) Now, making *DE*, Fig. 2, equal to twice the height of the hopper and drawing *CE*, he had the "angle of rake" graphically determined. As $EF \div EG$ (Fig. 1) = tan 45 degrees, $\frac{EF}{\cos CED} \div EG$ will equal the tangent of the desired bevel. Hence, laying off in Fig. 2 *EF* equal to *EF*, Fig. 1, and erecting a perpendicular at *F*, he found *EG*, which is $EF \div \cos CED$. Making *EF* and *EG* in Fig. 3 equal to the same lines in Fig. 2, he drew *GF*, set his bevel square to the angle *GFE*, sawed and planed the boards to this angle, and the job was done.

The inquiring bystander learned that the carpenter knew nothing of trigonometry and had no idea of the reasons for making the diagrams as he had, but simply followed the method taught him during his apprenticeship. If one may judge by the excellence of the joints in the hopper, this scheme is abundantly accurate for the use to which it is put, and its simplicity and ingenuity so impressed the spectator that he made a memorandum of it in his notebook.

New London, N. H. GUY H. GARDNER

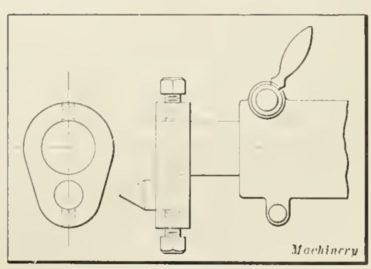
HOW A BROKEN SCREW WAS REMOVED

A few years ago I had a job quite out of my regular line, which was the result of an attempt to beat the plumber out of his prey. A brass flush box inlet valve leaked badly, and it was found necessary to put in a new cup leather in that part of the valve which balances the water pressure against the part closing the inlet. Both of the 3/16-inch screws holding the cap in place twisted off while being removed, but one yielded to the persuasion of a hammer and punch and was easily backed out. It was not so, however, with the other, which resisted all efforts to loosen it. Heating and cooling quickly did not work, neither did hammering or several of the other schemes used by machinists for backing out broken screws. Having no breast drill, it was truly a case of "being in a hole" until I thought of the expedient of sawing through the ear of the brass casting into the screw, and thus loosening it. The parts were then readily worked out. A 3/16-inch iron screw was then screwed into place. The ear was heated with a blow-torch, and a drop of acid and a bit of soft solder were applied which filled the saw cut as neatly as could be desired. The screw was quickly turned out, leaving a perfect thread, and the ear was practically as strong as before, as the saw cut had not weakened it. The remainder of the job was then plain sailing.

M. E. CANEK

TURNING TAPERS WITHOUT A TAPER ATTACHMENT

On lathes without a taper attachment, it is difficult to turn a taper on a long shaft because the tailstock cannot be placed far enough off center. The device shown in the accompanying illustration makes it possible to bring the center as far over as may be necessary. It can be made with little expense and used in many cases. It consists of a ma-



False Center for turning Tapers

chine steel body, which is fastened on the tailstock barrel by means of a set-screw, and a tool-steel center, which is also fastened by means of a set-screw, as shown in the illustration.

Plainfield, N. J. -Henry Daut

LOYALTY OF EMPLOYERS AND EMPLOYES

Referring to J. P. Brophy's article on loyalty in the April number, I think that Mr. Brophy has more loyal employes than he thinks he has. A man is most willing to believe that which he most desires. If he is looking for loyalty he will get it, and if he is not expecting loyalty he will not be disappointed. It has been my experience that where loyalty exists it does not begin at the bottom and work up. On the other hand, it begins at the top and works down. You can generally judge an organization by the character of the man at the top. If he is constantly distrustful of his fellow-men, his fellow-men will distrust him. A successful manager should be a careful student of human nature. It is not necessary that he know all about his product from the foundation up; he can employ men who have the experience, skill and ability required for all that. His mission is to fit the square plugs into square holes—to act as a peacemaker and counsellor. The time has gone by when loyalty can be obtained by slave driving. Current events go to prove that better than any words of mine.

One of the greatest drawbacks in the average manufacturing plant is the distinction that is made between the men in the office and the men in overalls. To regard these men as being of different clay is a great mistake, and I am glad to say that some concerns have seen light, and shape their policies on the basis that the men in the shop are just as essential to the welfare of the organization as anyone else connected with it. Say that a manufacturer is building a machine that requires careful and accurate work and extremely careful inspection to fulfill the requirements demanded of it; has the man in the office, or, in fact, the head of the concern, any control over the product? No; he must trust the inspector or the workman. No matter how well the instructions may be drawn up, a manufacturer always has to depend on his workmen to maintain the excellence of his product. The necessity, therefore, for close and friendly cooperation between the management and the workmen should be obvious.

A fact that is many times lost sight of is that a man who, through economic conditions, is required to don overalls does not at the same time lose his intellectual capacity. Clothes do not make the man. The management that does not take into consideration the fact that the workmen are intelligent human beings makes one of the greatest blunders. In many cases a machine has been designed, the drawings made and everything looked over carefully to discover weakness and errors. But after all has been done to make the product perfect, errors have been found by workmen in the shop, who, by reporting them, have saved the concern a great amount of expense and trouble. If this is not an expression of loyalty, I do not know what is. Yet it happens every day in manufacturing plants. Another fact that might be mentioned in this connection is that the average employer does not think it essential to take the workmen into his confidence, but expects them to be loyal without any evidence of trust on his part. How can a manufacturer expect his workmen to be loyal when they are kept in the dark? Distrust on the part of the management breeds distrust in the workmen.

One point in the editorial "Building up an Organization" that is probably the keynote to the situation is as follows: "Concerns that make a practice of attracting men from other organizations by offers of high salaries are not organically sound, nor are they likely to become sound and efficient by pursuing this method of recruiting." The average manufacturer takes exactly the opposite view. He believes that money is everything to the workman, and in that conclusion he makes a big mistake. What could be more unsatisfactory than to have workmen employed from different plants put on the same work and given different rates, because one has the ability to sell his service for a higher rate than another? If there is no unity between management and workmen, there is in many cases a unity among the workmen. If one man gets fair treatment and the other does not, it is not long before the information travels and distrust spreads. A uniform scale of wages for a certain class of work with a bonus is the most satisfactory method of rewarding labor. The bonus should be fixed according to the rate paid as well as by the efficiency of the workman. Had it not been for the distrust of manufacturers and a lack of loyalty toward their men, workmen would never have cooperated to form unions to fight them. Protection is an instinctive element of human nature. If the manufacturer does not protect his workmen, the workmen must protect themselves.

In reference to one part of Mr. Brophy's article I wish to make further comment. Does Mr. Brophy appreciate the psychological effect of these remarks on the men in his employ? He says, "No matter what you do nor how you do it, can you for one minute feel safe when you have labor troubles?" In answer to this I would say that the only way to avoid it is not to have labor troubles, and the only way not to have labor troubles is to deal honestly and fairly with your men. Fair treatment always brings fair treatment in return. You can't buy loyalty with a gold brick.

Springfield, Vt. Douglas T. Hamilton

Having read the article in the February number of Machinery entitled "Building up an Organization," and also the article entitled "Loyalty" in the April number, the writer wishes to give a workingman's idea of the word "loyalty."

When a young man, or rather a boy, starting out as a machinist after having been kicked and cuffed through three years of apprenticeship as a "bound-out boy," the writer had the idea that all owners of shops had their heads together "to get him," for it seemed as if he could not stay in a shop over three months, no matter how hard he worked. At last he got a job that lasted three years. He attended night school and heard many lectures, most of them on the subject of loyalty, or else containing illustrations showing that a person should always be loyal to his employer. The writer was advanced several times and at last placed in the tool-room, where, apparently, there were all kinds of chances to get ahead.

At this time an organizer entered the shop and formed a union. The men were not paid as well as in some shops in the city, and some of the gang bosses were unusually severe; so, as the company would not remedy this, a strike was called. The president of the firm spoke to the men and his talk was mainly on loyalty. He said that he had always done the right thing by his men, so they ought to wait until he could afford to pay more, etc. As for the foremen, he claimed that they were efficient men and could not be removed. As several of the men had been discharged by these bosses for some slight mistake, which they could have remedied and which others did remedy, all the men looked forward to their removal.

A strike was called. Two men in the shop and two in the tool-room (the writer was one) would not strike, but kept on working because the president, in a personal talk to each man, promised to protect and care for every man who would stick by him. That strike lasted three weeks, after which the president gave in. When the strikers returned, the four men were told that they would be given twenty minutes to get out of the works. They went at once to the president's office, where they had trouble gaining admission; and when they entered, the president said to them, "Well, what do you men want now?" When the matter was laid before him, he said, "Well, the only thing you fellows can do is to square yourselves with the union," and when told that the union would give each man a card only on payment of $50 and a promise to get out of town, he laughed and said, "Well, you made $50 in three weeks, didn't you? Get out." That was all.

Practically the same thing happened a few years later in a plant capitalized for half a hundred million dollars, when the writer again stayed in, only to be kicked out later on. The third time this happened he was buying a house while working in a railroad shop. The strike lasted two years; but before that time, when he had worked twenty hours a day for four days and also had had sickness at home so that he had

been unable to sleep, he laid off one day without asking permission. When he returned to work the master mechanic reprimanded him severely. Later, when a bolt which he had tightened up had stripped the threads and fallen out, so that one end of the crosshead guide of the locomotive fell down, he was told that he could go to work pending an investigation; afterward he was discharged.

Now, Mr. Editor, will you kindly tell the writer what pay he has received for being loyal? The owners, through their foremen, do not stand on ceremony in giving any employe the little end of any deal, so why should a man endanger his standing with his fellow-men by doing or saying anything in favor of an employer, who will not live up to his word a minute if his pocketbook is touched for a dollar thereby?

The writer tries to be honest. He tries to give an honest day's work and to make his word as good as any bond issued by a national bank, but he cannot and will not give loyalty to a corporation whose head will only say "square yourself" and then "get out." There are thousands who have had this experience, and more are learning the lesson every day.

Miles City, Mont. C. G. Williams

In the April number of Machinery there is an article entitled "Loyalty," in which an effort is made to show that loyalty is not a common trait of employes, and the attitude of the employes in cases of labor troubles is considered to show this. But if there had been a general spirit of loyalty, there would have been no labor troubles. Why not consider those shops that have not had labor troubles?

Loyalty is a natural trait of humanity—loyalty to any organization with which a person is connected, whether it is a school, shop or country—and it takes considerable to change this spirit to hostility; however, it can be changed. It is not long ago that I was acquainted with a management that appeared to be trying to change the spirit of the employes to hostility, not by anything that would be considered objectionable by a social reformer, but by simple ignorance of human nature.

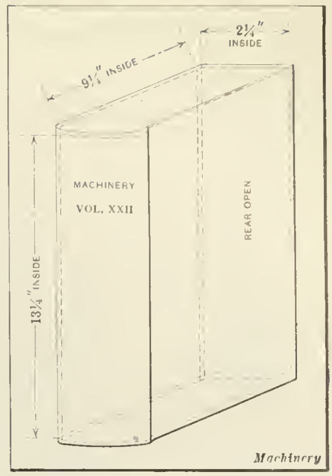
The fact that an employe has been working for one shop for a long time is no indication of loyalty. In many shops, it shows that he has not enough energy to look for a better position, and no more energy should be expected in showing his loyalty. There is probably as much loyalty to the American small college as to any organization aside from the nation, but this seldom results in an additional year at the college. A loyal employe is one that will stand by the employer when he is needed, not one that will decline an opportunity to advance when no injury will be done thereby. The writer's experience with labor troubles is quite limited, as he has never seen any, either as employe or employer, but he has seen enough of both large and small shops to be convinced that loyalty is the rule wherever it is given an opportunity by the management.

Worcester, Mass. A. W. Forbes

CONVENIENT FILING SYSTEM

Doubtless many Machinery readers make some attempt to preserve and file for future reference the matter published from year to year. But among the methods suggested from time to time, none has really satisfied the three chief requirements: convenience, minimum labor, and cheapness. I decided that all the published matter should be kept; and the value of doing this was shown a few months ago. Having accepted a new position, I began to search the files of Machinery for articles on the special line into which I was going and found a comprehensive article upon the shop methods of the very firm with which I was to be connected. If only the matter of interest at the time this article was published had been preserved, this article would undoubtedly have been discarded with the others.

I wanted a system that would allow any particular article or diagram to be withdrawn for use on a drawing-board if necessary, and that would protect the papers from dirt and wear. It is now about two years since the system was devised, and it has given complete satisfaction. About a dozen cloth-covered cardboard cases like that shown in the illustration were procured from a bookbinder. The papers were then prepared for filing, which actually required about fifteen minutes per volume, by grasping the open edge of the copy with the left hand, leaving about fifty pages at the back free, and with the back of the copy facing upward, tearing the free pages at the back off the binding wires with a quick motion of the right hand. The binding wires now project so they may be cut off with wire nippers and the rest of the advertising at the back may then be readily removed. It will generally be found that the article and the advertising sections come between two of the many units that make up the magazine, so that there will be no need of tearing the pages where they fold at the back. The article section may be removed by simply lifting it from the wires. This plan gives a loose-leaf collection of all the articles in the magazine. These pages are placed in the cases, twelve issues to a case, and are ready for use after the title and volume number have been placed on the front. If it is desired to keep any of the advertising pages, they should be filed in a separate case.



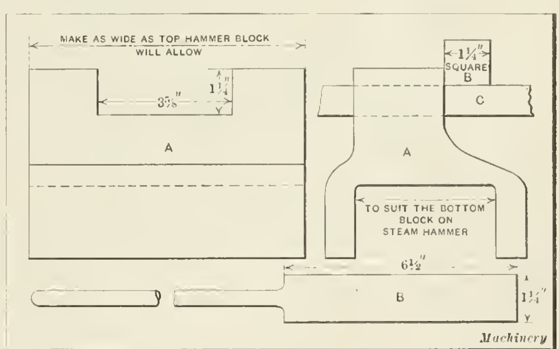
Convenient Magazine File

The indexing is simple also; all the annual indexes issued by the publishers are kept in a separate case, so that the more recent matter may be consulted first. On one side of the case is pasted a blank sheet of paper for noting the withdrawal and return of matter used. For carrying papers to the shop, a cardboard folder with protecting flaps is used.

Springfield, Mass. Wilfrid Griffin

CUTTING BLOCK

The cutting block shown in the accompanying illustration may be used in a blacksmith's shop that does not have shears for cutting steel. The writer has used it for years and has thereby saved much time. The block *A* is fitted on top of the bottom block of the hammer, so that the cutting edge is over the center. In the side view a piece of steel *C* is shown ready to be cut off. As the hammer strikes the block *B* it shears the steel. Both blocks are tempered. Block *B* has a handle about three feet long, so that it can be held with both hands. The piece being cut should be held firmly, or it will jar when the hammer strikes the top block. With this device, it is possible to cut steel up to 1 by 3½ inches with one or two blows of the hammer.



Block for cutting Steel under Steam Hammer

Plainfield, N. J. George C. Dawson

MACHINING RIFLE PARTS IN THE AUTOMATIC SCREW MACHINE

The automatic machining of parts for military rifles frequently necessitates the design of unusual tools and attachments for use in the automatic screw machine. Fig. 1 shows

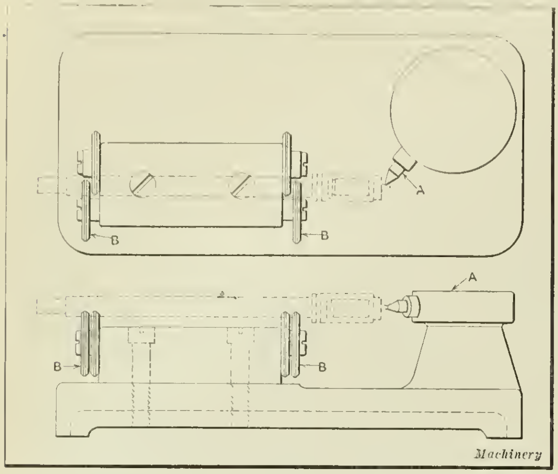


Fig. 1. Testing Concentricity of Nose with Body

an assembled firing pin for a military rifle being tested by an indicator gage *A*. The firing pin consists of two parts, the body and the nose; the body is made from medium carbon steel and the nose from tool steel. In the illustration, the pin is shown resting on the rollers *B* on which it is turned while the gage tests the concentricity of the nose with the body.

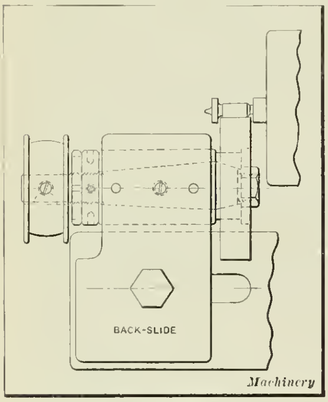


Fig. 2. Grinding Attachment mounted on Rear Slide

The nose section, as machined in a No. 0 B. & S. automatic screw machine, is shown in Fig. 6, and the circular forming tool is shown on the front slide. When finished, the nose section is hardened only on the point. The body of this section is ground to be a light drive fit in the internally ground section of the firing-pin body. The attachment for grinding, shown in Fig. 2, is mounted on the rear slide and the grinding wheel is driven by a flat belt ½ inch wide from the overhead works; an end view is shown in Fig. 3.

The cut is so light that it is seldom necessary to true the face of the grinding wheel. When this is done, however, the diamond and special holder shown in Fig. 4 are used. The holder is mounted in the turret and fed to the wheel by the turret operating handle furnished with the machine. When the truing device is used the spindle and the turret of the machine are covered with a cloth; the oil pan is also covered to prevent the emery dust from settling in it. When in use, the abrasion of the grinding wheel for this light cut is so slight that no trouble is experienced by the emery getting into the bearings. To make sure that it does not, however, the lubricating oil is replenished more frequently than is customary.

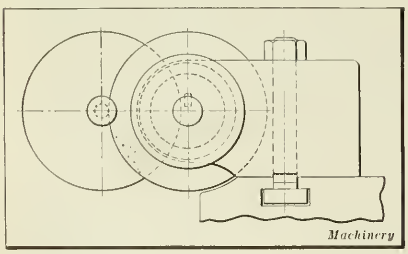


Fig. 3. End View of Grinding Attachment shown in Fig. 2

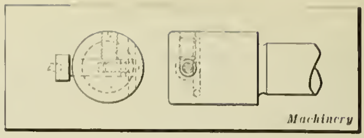


Fig. 4. Diamond and Holder for truing Emery Wheel

An attachment for diverting the flow of oil is shown in Fig. 5, where *A* is a link that connects the end of the oil-pipe to the rear cross-slide so that when the grinding wheel comes forward to the cutting position the oil-pipe is rotated by this link, swiveling on bracket *B*. The coil spring is not used to return the oil-pipe to position, but keeps the socket in contact with the tapered base, thus preventing a leak. As the oil-pipe and socket are revolved around the tapered base, the flow is automatically shut off by the socket closing the hole in the base. When the oil-pipe is in position, the link is attached to the rear cross-slide when the roll is on the bottom of the rear cross-slide cam. The order of operations is as follows:

Operation	Number of Revolutions	Hundredths
Feed stock to stop	12	2.5
Cut off, 0.04 inch travel at 0.0009 inch feed	47	9.8
Form, 0.18 inch travel at 0.0005 inch feed	361	74.9
Index turret while forming	(12)	(2.5)
Clearance	16	3.3
Grind, 0.003 inch travel at 0.0001 inch feed	30	6.2
Index turret while forming	(12)	(2.5
Clearance	16	3.3
Total	482	100.0

The spindle speed is 445 revolutions per minute, the maximum surface speed of the stock is 42 feet per minute, and for forming and grinding, 29 feet per minute. Hence, the time required for machining one part is 65 seconds and the net production is 490 in ten hours. The gears used are, driving shaft 30 and worm shaft 65. From 2.5 hundredths to 12.3 hundredths on the cam circle, the cutting-off part of the cutter enters the stock; and from

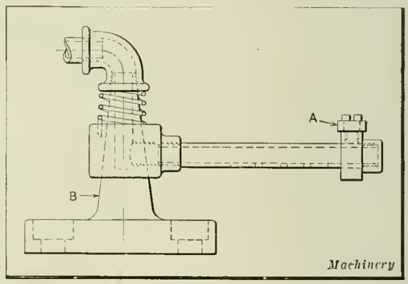


Fig. 5. Special Attachment for diverting Flow of Oil

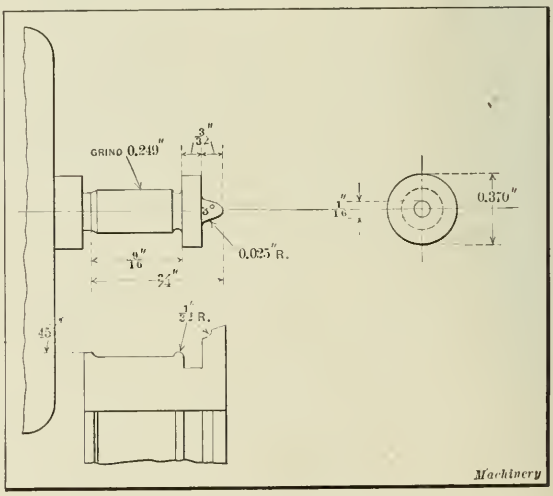


Fig. 6. Nose of Firing Pin and Circular Forming Tool

12.3 hundredths to 87.2 hundredths, the full width of the tool is cutting. The clearance from 87.2 hundredths to 90.5 hundredths is for shutting off the flow of oil, and the clearance from 96.7 to 100 on the cam circle is to allow the combination form and cutting-off tool to clear the stock before feeding to the stop.

EDWARD NEWMAN

SUCCESSIVE PRESS OPERATIONS

Very often an article is to be manufactured in several sizes which vary only in one dimension. For instance, the varying dimension in the case of the trial frame used by oculists when testing the eyes is the "pupillary" distance, or the center-to-center distance of the lens openings. These frames are made in four sizes, the difference in the pupillary distance of the smallest and largest frames being six millimeters. In Fig. 1 are shown the operations necessary to obtain the finished blank. The notching in the second operation serves as a locating point for the blanking operations. Without running into the curved outline of the blank, it is possible to vary the position of these notches three millimeters, which is the actual distance the dimension *A* must vary between the largest and smallest sizes.

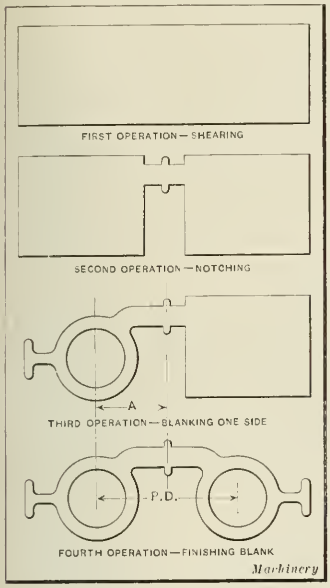


Fig. 1. Successive Press Operations in making Trial Frame

The distance *A* is regulated by the position of the guide *B*, Fig. 2; the method of holding is obvious. It will be seen that there are graduations for locating the different distances. Guide *C* is used only for the last operation of blanking, to keep perfect alignment of the lens openings; it is also adjustable as shown. Guide pin *D* keeps the blank in alignment for the second operation, the width of guide *B* not being sufficient, as it would allow the blank to cramp a little one way or the other. The pieces are ejected by a pad *E*, actuated by a rubber pad *F*. The method of supporting the notching punch is shown in Fig. 3. This punch is about 5/16 inch longer than

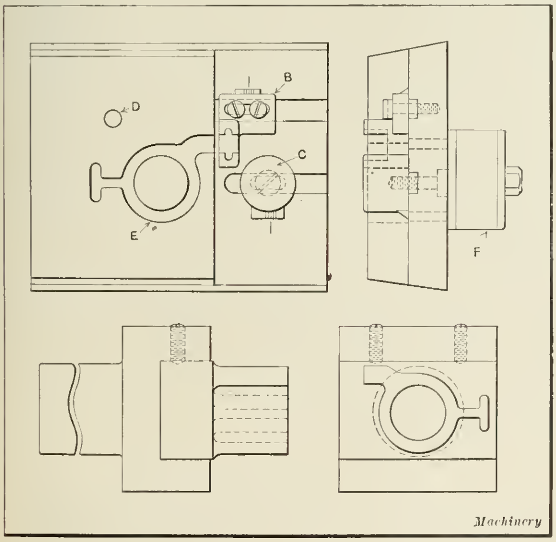


Fig. 2. Punch and Die for blanking Trial Frame

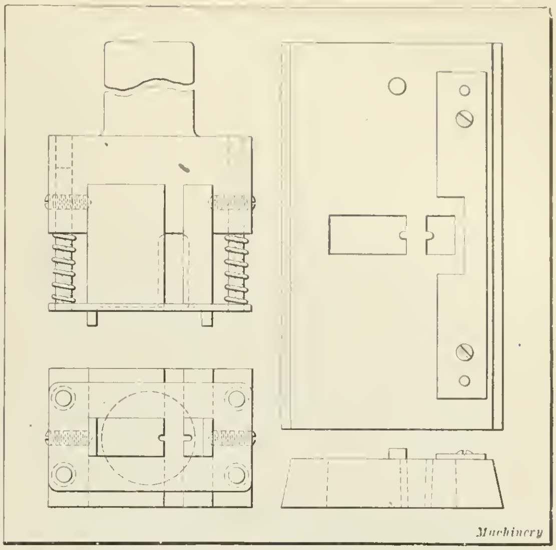


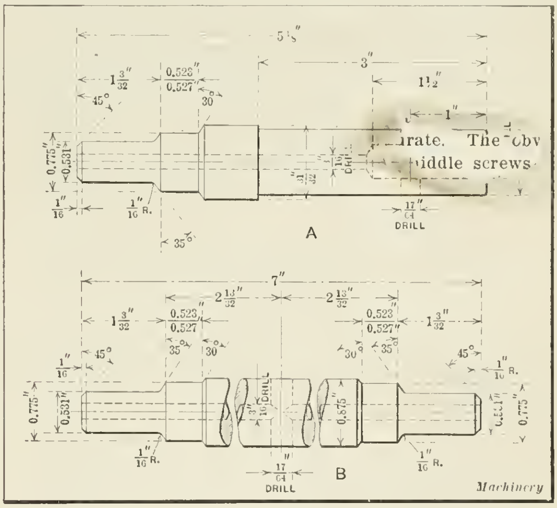
Fig. 3. Punch and Die for notching Trial Frame

the width of the blank. One-half of this amount on each side is allowed to enter the die before the punch actually begins to cut. This is a decided improvement when a punch does not cut on all sides, as it acts as a guide for itself and prevents the tendency to shear off to one side. The making of the tools in this way has saved several hundred dollars, and a satisfactory job is produced.

Philadelphia, Pa. A. DANE

ECONOMIZING IN HIGH-SPEED STEEL

The high cost of high-speed steel in the last two years has been a strong stimulus to the generation of ideas for its economical use. A collection of these ideas will unquestionably



(A) Old Form of Reamer; (B) New Form that reduced Cost

form an interesting and useful chapter in any book on machine-shop practice. That a considerable saving can often be effected in a simple way is demonstrated by the cost of the reamers shown at *A* and *B* in the accompanying illustration. These reamers are used on standard automatics. The one shown at *A* cost $9 when ordered in dozen lots. At *B* is shown a similar reamer, double-ended; this cost $12, and twice as much service is obtained from it as from the old style. The saving thus amounts to one-third, or $6 on every double-ended reamer. It will be interesting to note that the actual saving of material runs in the same ratio, namely, 7 inches, as against $10\frac{3}{4}$ inches, as do also the labor costs.

M. V. T.

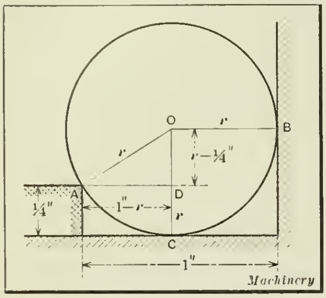
PLACING NUMBERS ON TWIST DRILLS

One great fault with the average twist drill is that the figures indicating its size are not stamped on plain or deep enough. The writer has found many brand-new drills on which the marks were so blurred that it was impossible to distinguish the size of the drill without the aid of a reading glass. If the drill should happen to slip a little in the chuck, the markings will usually be found to have been ground out beyond all signs of recognition. This trouble is particularly noticeable in the smaller sizes, from No. 30 to 3/8 inch in diameter. On work where the drills are constantly being changed, it means considerable extra labor to try out each drill in a drill gage to learn the size; and with unskilled labor this method will usually prove unsatisfactory. One way of overcoming this trouble is to stamp the size on the butt end of the larger drills and grind off a little on the side of the smaller drills and stamp the size upon this flat surface. When this method is used the marks cannot be ground off by the drill slipping in the chuck.

Plainville, Conn. HARRY B. STILLMAN

PROBLEM IN MENSURATION

A much simpler solution to the "Problem in Mensuration" in the February number of MACHINERY, is to draw radii OA, OB, and OC. Then draw AD perpendicular to OC. AD equals 1 inch — r and $OD = r - 1/4$ inch. In a right-angle triangle, the sum of the squares of the two sides equals the square of the hypotenuse; therefore $r^2 = (r - 1/4)^2 + (1 - r)^2$. Solving for r, $r^2 = r^2 - 1/2r + 1/16 + 1 - 2r + r^2$; $0 = r^2 - 5/2r + 17/16$. Adding 1/2 = 8/16 to each side of the equation, $1/2 = r^2 - 5/2r + 25/16$, and $\sqrt{1/2} = r - 5/4$. $\pm 0.707 = r - 1.25$, $r = 1.25 \pm 0.707 = 0.543$, or 1.957. The diameter is $2r$, or $2 \times 0.543 = 1.086$ inch. The formula for this may be written, diameter $= 2\sqrt{(r - 1/4)^2 + (1 - r)^2}$, where r equals the radius.



Problem in Mensuration

J. L. L.

A[illegible]on of the problem in mensuration in the February number of MACHINERY is as follows: If B is the center of the circle, draw AC parallel to the base line and BC perpendicular to AC. Then in the triangle ABC, $AB = x$. It is evident that AC will then equal $1 - x$ and that $BC = x - 1/4$; therefore, $(1 - x)^2 + (x - 1/4)^2 = x^2$, which simplifies into $16x^2 - 40x + 17 = 0$. This simple quadratic equation, when solved, gives

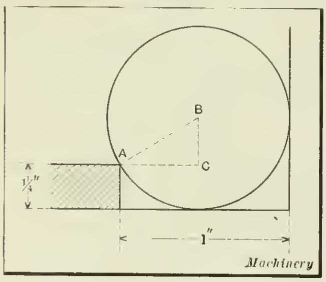


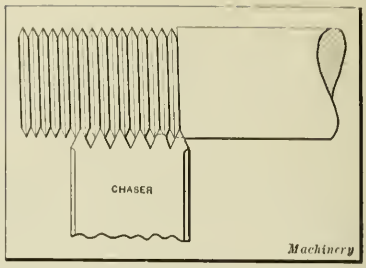
Diagram illustrating Problem in Mensuration

$$x = \frac{5 \pm 2\sqrt{2}}{4} = 0.5428$$ for the smaller value. The diameter is, therefore, twice this, or 1.0856.

Springfield, Mass. F. B. FULLER

CHASING A 100-PITCH THREAD WITH A 50-PITCH CHASER

A factory recently had forty parts of a certain product to manufacture which necessitated putting a 100-pitch vee thread on a steel bar about four inches long. At first, the thread was made with a 100-pitch chaser, but the finished thread was unsatisfactory; it looked like a drunken thread and chatter marks were plainly visible. As every effort to prevent this undesirable effect failed, a hob for cutting a fifty-pitch chaser was made and a six-tooth chaser was formed and hardened.



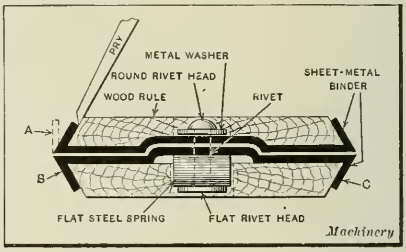
Six-tooth 50-pitch Chaser used for chasing 100-pitch Thread

As shown, the first tooth was backed off to cut into the piece only about one-quarter the depth of the thread. The next tooth was not backed off so much and went into the work a little deeper. These two teeth took what might be termed the roughing cut, and the remaining teeth took the finishing cut. The fifty-pitch chaser was put in a lathe geared up for one hundred threads to the inch. Its travel, as shown, appears to be in each alternate thread, but the travel really is in every thread, as the lathe is geared for one hundred threads to the inch. This chaser allows plenty of clearance, the teeth in it are stronger, and it is not so hard to make. Besides, it gives a satisfactory thread.

New Haven, Conn. ERIC LEE

REPAIRING A BROKEN FOLDING RULE

A great many mechanics and other users throw away their folding rules when they break at the joint or elsewhere. Very often a broken section is mended with glue, and as the repair lasts only a short time, the mending is repeated several times; repairs made in this way are worthless. A break at the joint, wood section, or fold, however, can be easily and quickly repaired in such a way that the rule will be as good as new, although this is not done with a view to economy. Without a folding rule, the workman is at a great inconvenience and it may be several days before he can purchase a new rule.



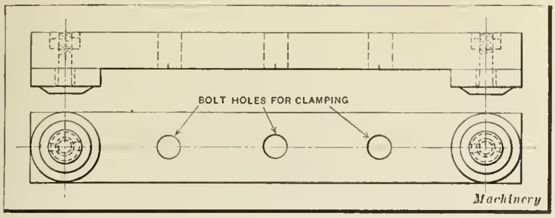
Method of mending Broken Folding Rule

One large plant that keeps on hand a supply of these rules for the convenience of the workmen, passes out about three hundred and fifty rules each year. One-third of these are furnished free to the heads of departments and others, and the rest are purchased by the workmen. All broken rules are sent to one man, who repairs them. Rules that are not worth repairing are placed in a box, so that the parts may be used to repair other rules. The tools required in this repair work are a file, small hammer, guard, and pry. The pry is made from an old file about one-half inch wide, one end being slightly beveled as shown. The guard is made of thin steel, square or round, and has a hole in the center that fits over the head of the rivet. A repair is made as follows: With the pry, the sides of the metal clip are opened, as shown at A; if only the flat spring is broken, the sides B are opened. The rivet can be removed by filing the sides of the round head and then pushing the head through the hole; the metal guard is placed over the rivet to protect the wood during the filing operation. The rivet is drawn out, the broken spring removed, and the new spring put in.

Kenosha, Wis. M. E. DUGGAN

ADJUSTABLE SINE BAR

A few years ago the sine bar was unknown, but today it is used in the toolmaking departments of all up-to-date shops;



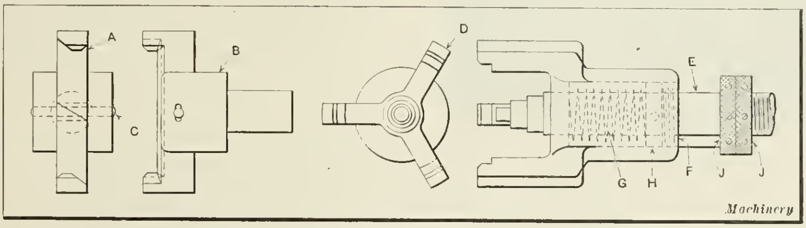
Adjustable Sine Bar

it has been instrumental in arousing the toolmaker to a more diligent study of the mathematics of his trade. The bar here shown was devised to make unnecessary the boring or grinding of the two holes an exact distance between centers. One-inch micrometer test pieces are used for buttons. The bar is 6 inches long, ½ inch thick, and 1 inch wide, which gives a 5-inch center to center distance. The bolts are smaller in diameter than the holes in the buttons, so that the buttons can be shifted to allow for any inaccuracy in drilling the holes and make the center distance exact. It is possible that the buttons may be displaced in use, so it is desirable to test them before using. Another advantage of this design is that the bar can be easily reground when damaged.

Bridgeport, Conn. E. P. Davis

TOOLS FOR MACHINING CARTRIDGE CASES

Munition manufacture has brought into play considerable inventive genius and ingenuity, for obstacles have arisen in tooling which at first appeared to be insurmountable. One of the great difficulties encountered has been the inability of the manufacturers to obtain tools that would continuously and accurately perform the work, called for by the excessive speed of production, within the close limits of accuracy to which the finished product had to be held.



High-speed Sizing Cutter and Pilot Reamer for machining Cartridge Cases

The machining operations on a cartridge case, whether French, British, Russian or Italian, are: machine face, form head, cut to length, drill primer hole, thread primer hole, finish-turn head diameter, and finish-ream primer hole. The first operation is performed by means of a round-nose tool mounted in an adjustable tool-holder on the cross-slide, which permits the tool to be drawn away from the face of the cartridge case upon the return stroke of the cross-slide. The second operation is performed by means of a circular forming tool mounted on the end of the adjustable tool-holder, and held by a left-hand threaded stud, which prevents the tool from working loose. The case is cut to length by a V-shaped finishing mouth tool and the primer hole is formed by a twist drill, which is used in preference to a flat-nose drill. A collapsible threading die-holder, equipped with interchangeable thread chasers, is used for threading the primer hole.

In the sixth operation a hardened and ground high-speed sizing cutter *A* is used. This cutter, which is held in holder *B* by pin *C*, is an adaptation of the Kelly reamer, as it permits the cutter to "float," machining the high spots from the head of the cartridge case by utilizing the old principle of centrifugal force.

The final operation—finish-reaming the primer hole—is the one that calls for the greatest accuracy. The reamer *E* is held in a pilot *D* and the depth of cut is regulated by screw collars *J*. The machining operation is as follows: The pilot *D* engages the head of the cartridge case to which it is adjusted by means of the adapter carried in the turret. Then collars *J* are adjusted to permit the reamer to cut to the proper depth. A spring *G*, held in place by collar *H* on reamer *E*, maintains a constant pressure on pilot *D* and keeps it in contact with the face of the cartridge case. As the reamer enters the primer hole and performs its operation, collars *J* are brought into contact with pilot *D*, which acts as a positive stop. By using these two tools, the most unskilled operator will produce satisfactory work.

Chicago, Ill. Fred. H. Korff

BONUSES

My experience with bonuses is that most employes would rather have $5 a month than $100 at the end of the year. The relation is the same as that existing between the trophy cup actually displayed in a shop window before a race and one promised to be made after the event; the visible, immediate reward is the greater stimulus. I would, therefore, recommend paying employes' bonuses monthly, or at least quarterly. As regards minors' bonuses, I have found that in those cases where parents take all the minors' earnings, the latter have no inducement to increase their output. If they are given a daily or weekly "stunt," and allowed to go when that is accomplished, they get through an hour or so ahead of the usual closing time. When they work independently and not progressively in groups or teams, passing work from one to the other, it enables more rapid manufacture, mailing, delivery, etc.

New York City Robert Grimshaw

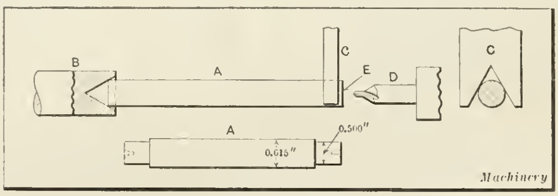
BUILT-UP SNAP GAGES

The long lower jaw of the built-up snap gage shown in the March number of Machinery does not seem to be as well supported as it should be. The illustration shows the long jaw resting on two bosses of the central piece, with two of the four holding screws passing through the space between the end bosses. It stands to reason that when the screws are tightened the long jaw will be sprung and the measuring ends thrown outward, making the gage inaccurate. The obvious remedy is to put a pad between the two middle screws that is wide enough to reach them both.

St. Louis, Mo. Louis A. Schlossstein

ECONOMICAL METHOD OF MAKING STEEL PINS

A recent order for several thousand machine steel pins *A*, taken at a low figure, made it necessary to get the pieces out as cheaply as possible without sacrificing quality. These are made of ⅝-inch, cold-rolled stock and are cut to length by a power hacksaw. The piece is then turned to size on the ends and the large part is ground on a No. 11 B. & S. plain grinder. To center the pieces, a female center *B* was made for a small lathe that had been discarded, being considered worn out; this was then hardened and ground so as to run perfectly true and a V-shaped steadyrest *C*, hardened and highly polished on its bearing surfaces, was held in the tool-post and carefully adjusted so that when piece *A* was placed

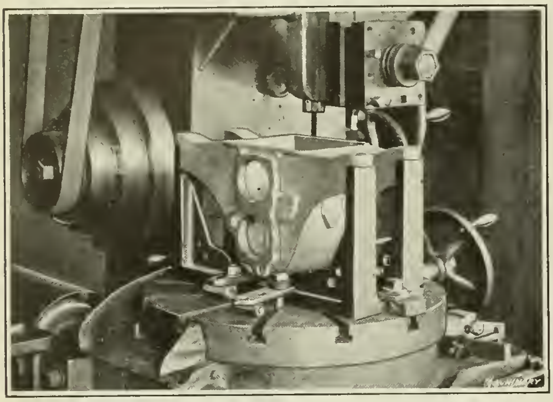


Quick Method of making Steel Pins

in the position shown, the end E was central with a countersink D held in the tailstock. The female center B runs continuously; so, to center the piece, one end is placed in the center and the other end in the steadyrest C, where it is held with the fingers while the countersink is fed forward. The friction of the end of the piece on the center is sufficient to allow a good center to be drilled. As there is no shifter to operate or chuck to open, the operation is fast and accurate, running within 0.004 inch of being true. This method of centering has also been used on other work where a small amount of stock was to be removed, and it has been found very satisfactory and economical. J. F. S.

MACHINING TRANSMISSION CASES ON VERTICAL BORING MACHINE

The illustration shows a job that is usually done on a vertical milling machine. But where there is no other work to do on the face, that is, where all the surfaces to be machined are at the same level, the boring mill beats the milling machine two to one. With a single-pointed tool held as shown,



Machining Transmission Case on Vertical Boring Machine

a transmission case can be turned off in three minutes, including setting and removing from the machine; in a vertical milling machine the best time is about six minutes. The work from the boring mill is also much smoother than that from the milling machine. With the jig shown, only two clamps are necessary to hold the work, one on each side in the lower holes; these clamps are not shown, the ones shown being those used to hold the jig in place. Robert Morris

MILLING THE TAPERING SIDES OF A BAYONET

Nothing unusual would be noticed by a casual glance at the dimensions of the bayonet shown in Fig. 1. But should a person be given this bayonet to machine, he would find that there was a pretty little problem to be worked out in milling the front, or cutting edge, of the blade. It will be noticed that there are two thicknesses of the blade, as shown in sections A and B, and it is with the surface that lies between these sections that the problem is found. In Fig. 2 is shown an enlarged view of this surface; the dimensions given are

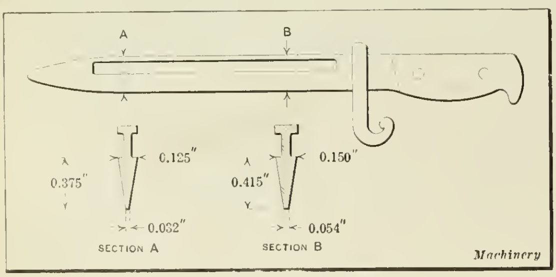


Fig. 1. Side View and Sections of Bayonet

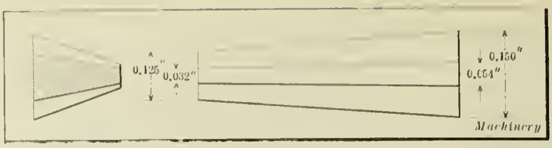


Fig. 2. Enlarged View of Part of Bayonet between Sections A and B, Fig. 1

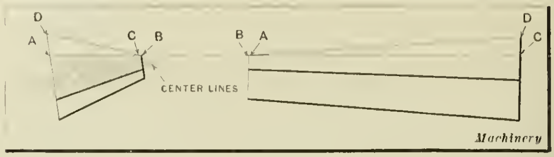


Fig. 3. Diagram showing why Bayonet cannot be milled at a Plain Taper

identical with the dimensions of the cutting blade shown in Fig. 1. It might appear, offhand, that the angular sides were straight surfaces and could be milled with a straight faced cutter, but Figs. 2 and 3 show that this is not so.

Figs. 1 and 2 convey the impression that the two sides of the blades are tapered and merely connect four points. But upon attempting to set the work up to mill it is found that, although the work can be tipped around to bring the three points A, B, and C, Fig. 3, in line for plain milling, the fourth point D cannot be brought into the same plane if the center lines of the two ends are kept parallel; and if the center lines are not parallel the work is being bent to conform to the requirements which, of course, should not be done. As it is necessary, when milling these surfaces with a flat-faced cutter (whether this cutter is angular or a plain surface mill) to turn the work as in spiral milling in order to connect the four points, it follows that these surfaces are spiral.

The writer was recently up against the proposition of milling these surfaces without resort to spiral milling, and adopted

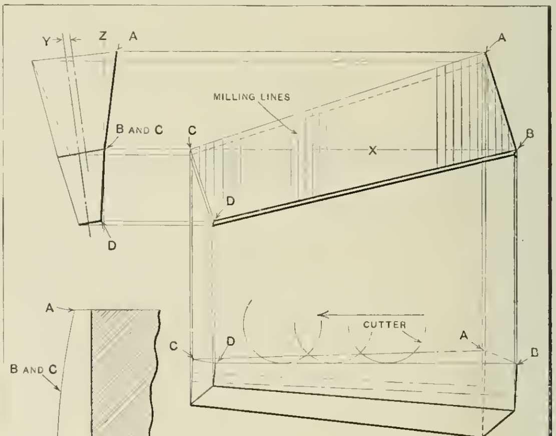
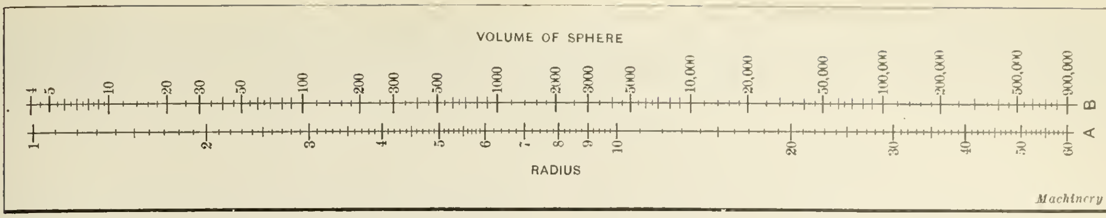


Fig. 4. Section of Blade in Milling Position

the method shown in Fig. 4, although it did not give a perfect surface. Point B was swung around until it came in line with point C, as indicated by line X. This, in itself, was not sufficient, so point C was raised until it came in line with point B, as indicated by line Z. In doing this, the center lines through a section taken at both ends were parallel, thus proving that the work was not distorted. With the work in this position, a block was made to conform to the shape of the under side, and the work was placed on it. In making the cut, with the cutter traveling in the direction of the arrow, the metal at point B is the first to come in contact with the cutter; this actually leaves a concave surface at any one point, but this concave, as it worked out, was very slight. Although only four points have been taken into consideration by the description, points taken anywhere along the lines shown will vary from the true form in the same proportion. F. M.



Handy Chart for determining Volume of Sphere

DIE FOR ASSEMBLING ASH-PAN HANDLES AND BODIES

Fig. 1 shows a portion of the top view and cross-section of an ash pan, with handle inserted, as used in steel ranges. At *M*, Fig. 2, is shown the 3/16-inch round wire handle as it comes from the bending die. This illustration also shows the die for turning back the ends of the handle after it has been inserted in the end of the ash pan. Its operation is as follows: Levers *A*, which are pivoted at points *B* and held together by a light coil spring *C*, are spread apart by turning cam *D*. The wire handle *M* is then inserted in groove *E* and cam *D* turned, so as to allow levers *A* to swing back into place and hold the handle firmly in the upper die; the ends of the handle project about ⅝ inch below the lower surface of the die. The ash pan is then pushed in from the front of the press and lifted up to meet the upper die, holes having been punched in the end of the body to match the ends of the handle. The press is then tripped, and as the ram descends, the ends of the wire handle are forced down into grooves *G* of levers *H*, which are pivoted at point *J* and held up by pins that pass down to a plate on the under side of the lower die. This plate is held in place by a heavy coil spring, as shown. When the down stroke has been completed, levers *H* rest on the body of the lower die and the ends of the wire handle have been carried outward and upward so that they are bent in opposite directions and at right angles to their first positions. The work is removed by turning cam *D*. Holes *K* are drilled to match stud bolts in the ram of the press. The levers *H* are of steel and bronze bushed.

Beaver Dam, Wis. S. W. PALMER

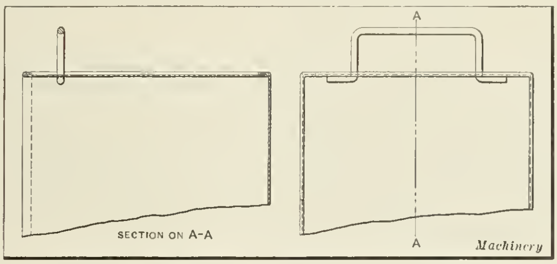


Fig. 1. Part Top View and Cross-section of Ash Pan

HANDY CHART FOR DETERMINING VOLUME OF SPHERE

The accompanying chart will be found handy for determining the volume of any sphere. Column *A* gives the radius of the sphere and column *B* the corresponding volume. By referring to the chart, it will be seen that the volume of a sphere with a radius of 10 inches is about 4200 cubic inches. If the radius is given in millimeters, the volume will be cubic millimeters; if in feet, the volume will be cubic feet.

Inversely, if it is desired to find the radius of a sphere when the volume is known, it is simply necessary to glance across from column *B* to column *A*. For example, the radius of a sphere having a volume of 20,000 cubic centimeters is found, by reference to the chart, to be a trifle less than 17 centimeters.

Attention is called to the fact that when the radius is 50 the volume is close to 500,000, and when the radius is 5 the volume is 500. There are three digits more in 500,000 than in 500, and one digit more in 50 than in 5. Thus it will be understood that the decimal point is shifted three places to the right in column *B* when adding a digit in column *A*. Similarly, if the decimal point is moved one place to the left in the figures in column *A*, the decimal point must be moved three places to the left in column *B*. For example, we can find the volume of a sphere with a radius of 0.2 inch by referring in column *B* to the volume for a sphere of 2-inch radius and moving the decimal point three places to the left; this gives 0.033 cubic inch. These examples could be carried further, but those given are sufficient to indicate that the range of the chart is limitless.

N. G. NEAR

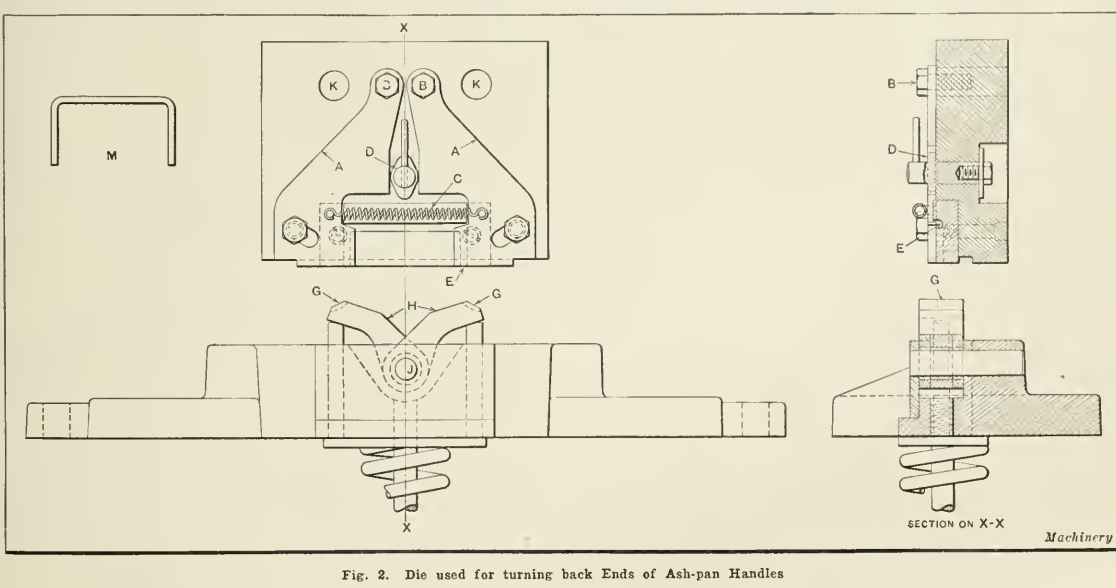


Fig. 2. Die used for turning back Ends of Ash-pan Handles

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

AUTOMATIC SCREW MACHINE STOCK

B. F. E.—Can you tell me what are the physical characteristics of free-cutting screw machine steel stock?

A.—The National-Acme Mfg. Co., Cleveland, Ohio, a large manufacturer of screw machine products, specifies Bessemer screw stock having a tensile strength of 70,000 to 80,000 pounds per square inch.

HAND OF MACHINE PARTS

C. F. T.—Will you kindly give your opinion of the following sentence: "The polishing head carries a taper on the right-hand end of the spindle." Should there be any confusion as to which end of the spindle is meant, making it necessary to say the right-hand end of the spindle when facing the machine?

A.—The hand of machinery parts is fixed with reference to the operator. The parts that are on his right are the right-hand parts, and those on the left, the left-hand parts. Hence the meaning of the sentence given should be perfectly clear.

DRILLING DEEP HOLES IN STEEL DIES

C. J. B.—I would like advice on how to drill holes varying in diameter from 0.120 to 0.385 inch, about 4 inches deep, in steel heading dies. The holes must be straight and smooth, and within limits of $\pm$ 0.001 inch. What kind of drills and reamers should be used and what is the proper lubricant? I have these dies to drill in lots of 100 to 500, and it is essential that the method be fairly rapid and productive of good results.

The question is submitted to readers having had experience in this class of work.

FACING THE ENDS OF SHAFTS BEFORE TURNING

J. U.—Will you kindly decide the following question: A claims that if a shaft is to be turned on centers in a lathe, the ends must be squared; if they are not squared, the shaft will run out after taking facing cuts. B claims that if a shaft is centered properly, it does not matter whether the ends are square or not; the shaft after turning must be true.

A.—The rule is always to face the ends of a shaft after centering and before turning, because an uneven end is likely to cause the shaft to change position slightly on the center when faced off. It is not necessary, however, that the entire end of the shaft be faced; if trued around the center, the shaft will not change position when the ends are faced.

POSITION OF ANVIL AND VISE

G. H. G.—How should a blacksmith's anvil be set—with the horn at the right or left of the blacksmith? How should a machinist's vise be set on the bench in relation to the tool drawer and the workman's allotment of the bench space?

A.—A blacksmith's anvil should be set in relation to the forge so that the horn will be at the blacksmith's left when he turns around to forge a piece. But if he is a left-handed blacksmith, the horn should be on his right hand, of course. A machinist's vise should be set on the left-hand side of the tool drawer, but his allotment of bench space should not stop at the vise. He should have at least two feet of space on the left of the vise in order to handle conveniently heavy pieces that must be held in the vise. The tool drawer on the right is most convenient for a right-handed man, as he can select tools from the drawer and use them without materially changing his position.

DIRECTION OF SPIRAL OF END MILLING CUTTERS

A. F. S.—Will you please advise me regarding the use of spiral end milling cutters up to 1½ inch diameter as to whether a right-hand or a left-hand spiral should be used with a right-hand cutter? Some mechanics tell me to use a right-hand spiral, while others claim that less breakage results from cutters with left-hand spiral flutes.

A.—Theoretically, a right-hand cutter should have right-hand spiral flutes, as the teeth then have positive rake. It is true, however, that the right-hand flutes tend to pull the cutter out of the socket when used for side milling, and cause breakage. But this disadvantage should not be allowed to outweigh the advantage of having the cutter teeth made with positive rake. It is good practice to provide means for holding the cutter firmly in the socket, as has been done by some of the leading milling machine manufacturers who provide a screw collet for the end of the cutter shank (threaded to fit), and means for drawing it firmly into the spindle socket.

SOLVING SPECIAL CASES OF RIGHT TRIANGLES

C. W. M.—Referring to the illustration, *ABC* is a right triangle, right-angled at *C*. If the side *a* and the sum of the other two sides are known, how can the lengths of *c* and *b* be found? Also, if *c* and the sum of *a* and *b* are known, how can the lengths of *a* and *b* be found?

A.—For the first case, let $s = c + b$, then $b = s - c$. But $c^2 = a^2 + b^2$. Substituting the value of *b*, $c^2 = a^2 + s^2 - 2cs + c^2$, or $2cs = s^2 + a^2$. Therefore, $c = \frac{s^2 + a^2}{2s}$. For example, suppose $c + b = 20$ and $a = 5$, then $c = \frac{20^2 + 5^2}{2 \times 20} = 10.625$, and $b = 20 - 10.625 = 9.375$.

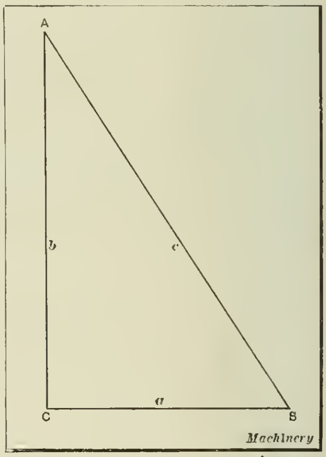


Diagram illustrating Special Solutions of Right Triangles

For the second case, let $a + b = s$, then $a = s - b$. But $c^2 = a^2 + b^2$. Substituting the value of *a*, $c^2 = s^2 - 2sb + b^2 + b^2$. Transposing, combining, and reducing, $b^2 - sb = \frac{c^2 - s^2}{2}$; whence, $b = \frac{1}{2}(s + \sqrt{2c^2 - s^2})$. If the + sign is used, the length of the longer side will be obtained; and if the — sign is used, the length of the shorter side will be found. For example, if $c = 10\frac{5}{8}$ and $a + b = 14\frac{3}{8}$, $b = \frac{1}{2}(14\frac{3}{8} \pm \sqrt{2 \times 10.625^2 - 14.375^2}) = \frac{1}{2}(14.375 \pm 4.375) = 9.375$, or 5; that is, the longer side is 9.375 and the shorter is 5.

J. J.

RATING OF PUNCH PRESSES

C. E. T.—What rules, if any, can be followed in rating punch presses? The ratings given by the various makers do not seem to agree, but inasmuch as the principle of operation is the same in all, there must be some agreement in the actual productive rating of presses built by the principal makers.

A.—The capacity of punch presses is an important matter, but, unfortunately, it is practically impossible to reconcile the ratings given by the various makers with the weight and dimensions of the presses. However, the following suggestions made by a press expert may be found valuable: There is little connection between the number of a press and its tonnage capacity, although some makers have employed the

system of expressing tonnage as the square of the number of the press. A better rule, perhaps, is to compute the tonnage by the weight of the press. In the case of most straight-side or pillar presses the weight of the press in pounds divided by 80 will give the capacity of the press in tons. On overhanging presses of ordinary design the weight of the press should be divided by 100 to 120 to obtain the tonnage. For example, the tonnage of a straight-side press weighing 5600 pounds is $5600 \div 80 = 70$ tons, which is approximately correct. In the case of an overhanging press weighing, say, 3200 pounds, with an average depth of throat of about 7 inches, we have $3200 \div 100 = 32$ tons capacity, which also is close to the correct figure. On small overhanging presses the weight of the flywheel divided by 16 gives the tonnage of the press closely, but on large presses weighing 2500 pounds or more, the weight of the flywheel is divided by 20 in order to get the approximate tonnage. The crank-pin may also be used to determine the capacity of the press, taking the square of the diameter and multiplying it by 3 to 3½. The cross-section of both uprights of the frame of straight-side presses, in square inches, multiplied by one ton per square inch gives a close approximation to the safe working tonnage of the press. Of course the foregoing rules are empirical and their usefulness depends on the presses to which they are applied being made in close conformity to designs that have given general satisfaction in use.

PROBLEM CONCERNING VIRTUAL VELOCITIES

P. G. P.—The illustration shows a flywheel with an axle 2 inches in diameter; as the flywheel turns, it winds up a rope on the axle, and thus raises a weight as shown. If the kinetic energy of the flywheel is 5000 foot-pounds, it will raise a weight of 2500 pounds 2 feet when the diameter of the axle is 2 inches; will it raise the same weight 4 feet if the diameter of the axle is 1 inch?

A.—The flywheel will raise a weight of 2500 pounds 2 feet in each case; the diameter of the axle or drum has nothing to do with the case. According to the law of virtual velocities (see MACHINERY for June, 1916, page 897), the power multiplied by the distance through which it moves is equal to the weight multiplied by the distance through which it moves. This law is really a statement of the law of work and energy. The energy of the flywheel is exactly equal to the work expended in enabling it to store up this energy; hence, the power multiplied by the distance through which it moves = 5000 foot-pounds = the weight multiplied by the distance through which it moves = 2500 × 2. It will thus be seen that it does not matter how the load is raised (neglecting friction and other resistances); all that we are concerned with is the number of pounds that the load weighs and the height through which it is raised. J. J.

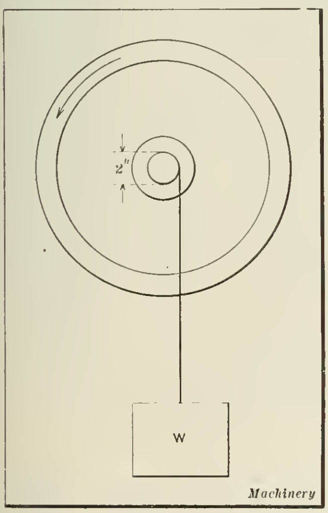


Diagram illustrating Virtual Velocities Problem

FINDING RADIUS OF CIRCLE

F. P. J.—Referring to the illustration, ABC is a right triangle, right-angled at B. With the dimensions given, it is required to find the radius of a circle that will pass through points C and E and be tangent to the side AB. Four of us have tried this and each has obtained a different result.

A.—First calculate the distance DB, which evidently equals $BC \times \cot 23$ degrees $- DE \times \cot 23$ degrees $= (5.1 - 3.8) \cot 23$ degrees $= 1.3 \times 2.355852 = 3.062608$. Through the center O, draw OH parallel and FG perpendicular to BC, and draw OE and OC. Let r be the radius; then $OF = \sqrt{r^2 - FE^2} = \sqrt{r^2 - (3.8 - r)^2} = \sqrt{7.6r - 14.44}$. Whence, $OG = DB - OF = 3.062608 - \sqrt{7.6r - 14.44}$. $CG = 5.1 - r$. Hence, $OC^2 = OG^2 + CG^2 = (3.062608 - \sqrt{7.6r - 14.44})^2 + (5.1 - r)^2 = r^2$. Squaring and transposing and combining terms, $20.949568 - 2.6r = 6.125216\sqrt{7.6r - 14.44}$. Squaring again, transposing, and combining terms, we obtain the quadratic equation $6.76r^2 - 394.076338r + 980.648296 = 0$. This equation may be solved in the regular way, but much more easily by Horner's method; whatever method is used, however, $r = 2.604869$ inches. It is always well, in cases of this kind, to check the work. Had you and your friends done this you would have known which was right. Here, $OF = \sqrt{7.6r - 14.44} = \sqrt{7.6 \times 2.6049 - 14.44} = 2.3145$; $CG = 5.1 - 2.6049 = 2.4951$; and $OG = 3.0626 - 2.3145 = 0.7481$. $OC = r = \sqrt{2.4951^2 + 0.7481^2} = 2.6049$, as before. J. J.

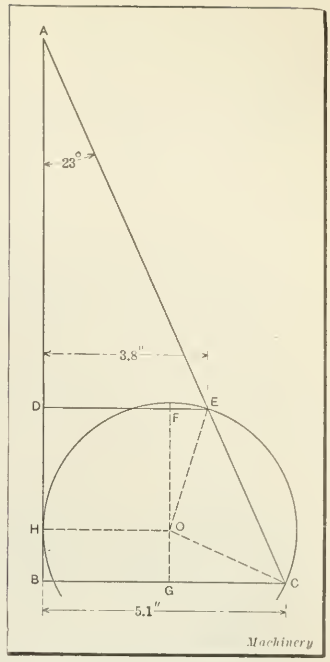


Diagram for finding Radius of Circle

MEASURING FORMING TOOL BY WIRE METHOD

J. F.—A forming tool of the shape indicated in Fig. 1 is to be made. Angles α and β are known, as well as the diameter of the wire, which is $2r$, and dimension b. What is the formula for finding dimension c measured over the wires, in order to insure that dimension b is correct? It is assumed, of course, that the angles are accurate. In a specific example, α equals 35 degrees, β equals 40 degrees, 36 minutes; the diameter of the wires is 3/16 inch; and dimension b is 2 inches.

A.—In order to determine the dimension c measured over the wires, it is necessary first to determine dimension a. It is evident that $2a + 2r + b = c$. In order to determine a, draw construction lines as shown in Fig. 2. Here line AD equals a. The center of the wire is at C. Line CB is at right angles to AB. Line AC, passing through the center of the circle, which is tangent to lines AE and AB, divides angle BAE into two equal parts; hence, angle $BAC = \frac{\alpha + \beta}{2}$. Angle $CAD = \beta - \frac{\alpha + \beta}{2}$, which, simplified, may be written, $\frac{\beta - \alpha}{2}$. Further, $BC = r$.

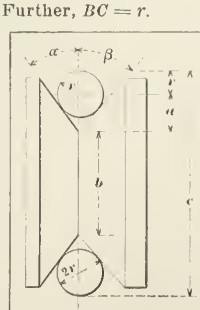


Fig. 1. Forming Tool for which Dimension b is to be determined

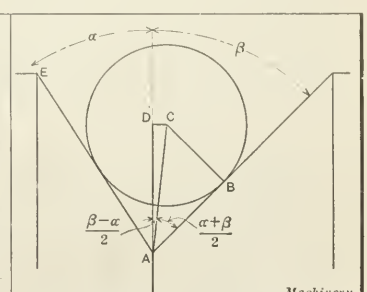


Fig. 2. Diagram showing Method of determining Dimension b in Fig. 1

Now, we find directly by the rules for right-angle triangles:

$$AC = r \div \sin\frac{\alpha+\beta}{2}, \text{ and } AD = AC \times \cos\frac{\beta-\alpha}{2}$$

Having thus found AD, which equals a, the problem is solved. Inserting the given values in the formulas, we have:

$$AC = 3/32 \div \sin 37 \text{ deg., } 48 \text{ min.} = 0.15296$$

$$AD = 0.15296 \times \cos 2 \text{ deg., } 48 \text{ min.} = 0.15278 = a$$

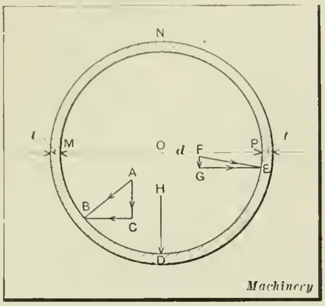
Hence, $c = 2 \times 0.15278 + 3/16 + 2 = 2.4931$.

THICKNESS OF A CYLINDRICAL SHELL

L. W. N.—Will you please explain fully how the formula for finding the thickness of a cylindrical shell that is subjected to internal fluid pressure is derived?

A.—For convenience, assume that the fluid is steam or gas (say compressed air) and that its tension (pressure) is p pounds per square inch. Denote the length of the cylinder by l, the thickness of the shell by t, and the interior diameter by d. The illustration represents a cross-section perpendicular to the axis of the cylinder, and we shall suppose further that it represents a ring 1 inch wide. According to Pascal's law, the pressure at any point is always perpendicular to the surface at that point; consequently, it is always radial, as indicated by the arrows AB, HD, and FE, which represent the pressure p on a unit of area at B, D, and E, respectively. If the pressure is great enough, it will separate one-half of the shell from the other half; suppose it separates the upper half MNP from the lower half MDP. Since the forces acting downward are equal and opposite to those acting upward, it will suffice to determine the downward pressure. At D the unit pressure acts entirely downward; at B it can be resolved into two components, one AC acting downward, and the other CB acting horizontal. As M and P are approached, the downward pressure becomes less and less, and when M (or P) is reached it becomes 0. By methods of the calculus, it is easily shown that the total downward pressure on the strip is $p \times d$, and on the shell it is $p \times d \times l$. This pressure is resisted by the strength of the material of the shell multiplied by the area of the ruptured surface, or $2t \times l \times S$, in which $2t \times l$ is the area in square inches (l being the length in inches) and S is the ultimate strength in pounds per square inch. Therefore, $2tSl = pdl$, or $t = \frac{pd}{2S}$. This formula presupposes that t is small, compared with $r = \frac{d}{2}$, and that l is large, compared with r. The formula may be solved for p, giving $p = \frac{2tS}{d} = \frac{tS}{r}$. If t is greater than $0.1r$, or $\frac{r}{10}$, it is best to use the following formulas: $p = \frac{tS}{r+t}$ and $t = \frac{pr}{S-p}$. It is best to calculate t by the first formula, and then, if it is greater than $0.1r$, recalculate it by the second formula. In practice, S should always be divided by the proper factor of safety before it is substituted in any of the foregoing formulas.

J. J.



Cross-section of a Cylinder

FORMULA FOR RADIUS WHEN CHORD AND LENGTH OF ARC ARE GIVEN

C. W. M.—I should like a formula for finding the radius when the length of the arc and its chord are given. I am unable to find such a formula in any of my reference books.

A.—The writer has never seen such a formula, but one may easily be derived as follows: Let r = radius, C = chord, L = length of arc, and ϕ = central angle, in radians. Then $L = r\phi$, from which $r = \frac{L}{\phi}$, and $\frac{C}{2} = r \times \sin\frac{\phi}{2} = \frac{L}{\phi} \times \sin\frac{\phi}{2}$, or $\sin\frac{\phi}{2} = \frac{C\phi}{2L}$. Now we know from trigonometry that $\sin x = x - \frac{x^3}{6} + \frac{x^5}{120} - \frac{x^7}{5040} + \text{etc.}$ Substituting $\frac{\phi}{2}$ for x in this expression, $\sin\frac{\phi}{2} = \frac{\phi}{2} - \frac{\phi^3}{48} + \frac{\phi^5}{3840} - \frac{\phi^7}{645120} = \frac{C\phi}{2L}$, very nearly. Transposing the right-hand member, clearing of fractions, and dividing through by ϕ, $\phi^6 - 168\phi^4 + 13440\phi^2 - 322560\left(\frac{L-C}{L}\right) = 0$. From this equation, ϕ may be found by Horner's method; then, knowing ϕ, $r = \frac{L}{\phi}$. This equation gives exact values for ϕ for all angles. For a semicircle, $L = 3.1416$ to a radius 1, and $\phi = 3.1413$, as calculated by the formula. For angles not greater than 90 degrees, a simpler expression may be obtained by dropping the term ϕ^6 and dividing through by -168, the coefficient of ϕ^4; the equation then becomes $\phi^4 - 80\phi^2 + 1920\left(\frac{L-C}{L}\right) = 0$. This last equation may be solved as a quadratic, and we obtain $\phi = \sqrt{40 - \sqrt{1600 - 1920\left(\frac{L-C}{L}\right)}}$. For 90 degrees and a radius 1, $L = 1.5708$ and $\phi = 1.5712$, as calculated by the formula. For angles considerably greater than 90 degrees, the last formula does not give very close results. For example, for 120 degrees, $L = 2.0944$ and $\phi = 2.0960$; for 180 degrees, $L = 3.1416$ and $\phi = 3.1562$.

J. J.

MOMENT OF INERTIA OF A SECTION

G. F. L.—Will you please tell me how to find the moment of inertia of a section like the one shown in the illustration?

A.—We assume that you wish the moment of inertia about the axis X'–X, which passes through the center of gravity of the rectangle $ABCD$ and is perpendicular to the long side AD. The following principle is demonstrated in works on mechanics: The moment of inertia of a section about any axis is equal to the moment of inertia about a parallel axis through the center of gravity plus the product of the area of the section by the square of the distance between the axes. Let I = the required moment of inertia; I_1 = moment of inertia about a parallel axis through the center of gravity; A = area of section, and h = perpendicular distance between the axes. Then $I = I_1 + Ah^2$. If the given area is divided into sections of such shape that their areas, A_1, A_2, A_3, etc., the distances of their centers of gravity from the given axis, h_1, h_2, h_3, etc., and their moments of inertia, I_1, I_2, I_3, etc., may be calculated, then $I = I_1 + A_1h^2_1 + I_2 + A_2h^2_2 + I_3 + A_3h^2_3 +$ etc. It is possible to proceed in several ways. Thus, assume that the given section is made up of the following: two rectangles 1 inch by 10 inches, two rectangles 5 inches by 1 inch, one rectangle ½ inch by 8 inches, and two rectangles 2¼ inches by ½ inch. For the first and third sets, the centers of gravity lie on the axis X'–X, and h_1 and h_3 are both equal

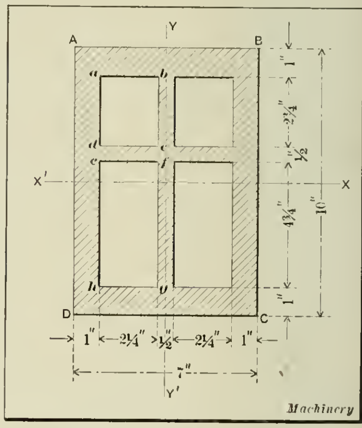


Diagram illustrating Method of finding Moment of Inertia of a Section

to 0; for the second set, $h_2 = 4\frac{1}{2}$ inches; and for the fourth set, $h_4 = 1$ inch. Since the moment of inertia of a rectangle is $\frac{bd^3}{12}$, when the axis passes through the center of gravity parallel to the base, and b is the breadth AB and d is the depth AD,

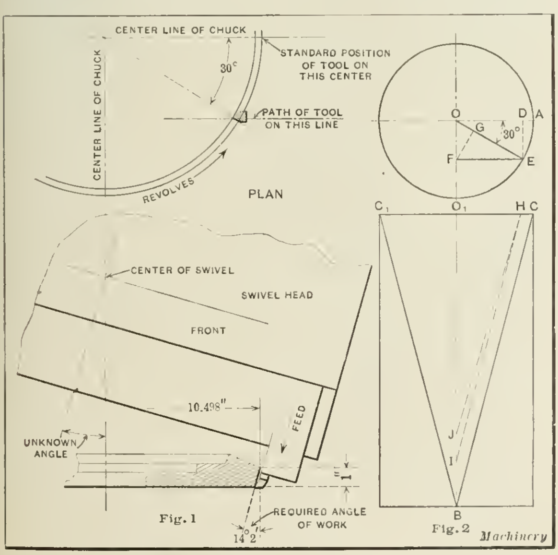
$$I = \frac{1 \times 10^3}{12} \times 2 + \left[\frac{5 \times 1^3}{12} + 5 \times 1 \times (4\tfrac{1}{2})^2\right] \times 2 + \frac{\frac{1}{2} \times 8^3}{12} + \left[\frac{2\frac{1}{4} \times (\frac{1}{2})^3}{12} + 2\tfrac{1}{4} \times \tfrac{1}{2} \times 1^2\right] \times 2 = 393.63.$$

Another method is to calculate the moment of inertia of the rectangle $ABCD$ and then subtract the moments of inertia of twice the rectangle $abcd$ and twice the rectangle $cfgh$, all taken with reference to the axis X′–X. Either method will give the same result. If I is calculated for the axis Y′–Y, what was the breadth of the rectangle becomes the depth, and it will be found that I for Y′–Y is much less than it is for X′–X. It is for this reason that a beam is stronger when the long side is vertical. J. J.

CUTTING A BEVEL WHEN TOOL IS AHEAD OF CENTER

J. W. D.—We have a bevel gear, 10.498 inches outside diameter, with an angle of 14 degrees, 2 minutes from the vertical to be turned on a vertical boring mill having a swivel head. The arrangement of the head is such that to turn this angle, it is necessary to place the cutting tool 30 degrees ahead of center. At what angle must the swivel be set to cut 14 degrees, 2 minutes? Will we get a true straight line on this angle or will it be slightly concave?

A.—The conditions are represented in Fig. 1. Referring to Fig. 2, if the tool were located at A and fed along the line OA at an angle of 14 degrees, 2 minutes to the vertical, it would generate a conical surface, which would be a part of the cone CBC_1, and the path of the tool point would be along the line CB (an element of the cone) in a vertical plane. The tool point, however, is located at E, 30 degrees from A; it moves along the line EF, and does not pass through the axis of the cone. The projection of the path on a vertical plane, the trace of which is OA, is the line HI, which is parallel to CB. The surface so generated will not be conical, but a warped surface, the mathematical name for which is a hyperbolic-paraboloid, and it can always be generated by the movement of a straight line. If a straightedge is laid on this surface extending from C toward B, it will touch the surface in only two points. The only way in which a conical surface can be turned is to cause the tool point to move in the line OE. But, as the vertical movement of the tool is only 1 inch, the difference between the warped surface and the true cone can be neglected in practice. To get the required angle, proceed as follows: $OA = 10.498 \div 2 = 5.249$, the radius. It is now necessary to find what angle in the plane EF will project into an angle of 14 degrees, 2 minutes in the plane OE. $OD = OE \times \cos 30$ degrees $= 5.249 \times 0.86603 = 4.5458 = EF = O_1H$. $EG = EF \times \cos 30$ degrees $= 4.5458 \times 0.86603 = 3.9368$. The projection of the path of the tool point on the plane OE will be along a line in the plane EF, the projection of which on OE is HJ. The distance $O_1J = EG \times \cot 14$ degrees, 2 minutes $= 3.9368 \times 4.0009 = 15.751$. The required angle in the plane EF is now readily determined. Denoting it by ϕ, $\tan \phi = \frac{EF}{O_1J} = \frac{4.5458}{15.751} = 0.28860$, which corresponds to an angle of 16 degrees, 6 minutes the angle to which the swivel should be set. J. J.



Figs. 1 and 2. Bevel-cutting Problem

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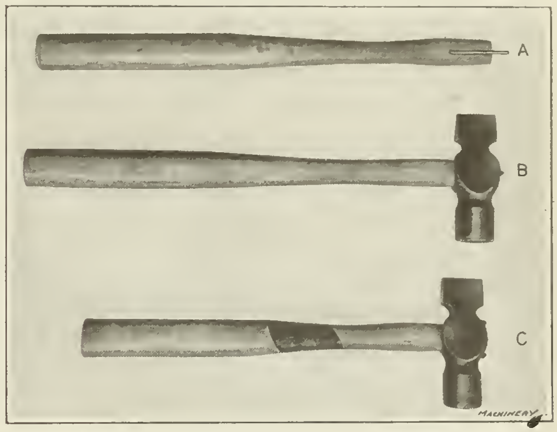
METHOD OF FASTENING HAMMER HEADS

J. H. De Groodt, instructor in shop work at the College of the City of New York, has developed an ingenious device for fastening the head of a hammer securely to the handle. This



Method of fastening Heads securely to Hammer Handles

will best be understood by referring to the illustration of handle A without a head, where it will be seen that the method consists of drilling a hole through the handle in which are placed two nails with the heads cut off and the ends bent over at right angles to enter the hole. Grooves are cut at each side of the handle, in which the nails lie flush with the surface and enable the end of the handle to be inserted in the hammer head in the usual way. The ends of these nails project out beyond the head of the hammer and are bent over, thus securing the hammer head firmly in place. At B the nails are placed in the handle as shown at A; and at C they are placed at the top and bottom of the handle, instead of at the sides. E. K. H.

* * *

Owing to the shortage of leather, paper belting is now being used to some extent in Austria-Hungary; it is made chiefly in Bohemia and northern Hungary. The belting is woven from paper cord, which is being used almost entirely in that region. The paper cord is ordinary wood-pulp paper, cut into reels, which is run by means of spinning machines through a paraffin bath and then into strands which are twisted into cordage or twine. Pulp obtained from fir or pine trees is the most satisfactory for this purpose. In order to increase the tensile strength of the cords hemp threads or wire is frequently added to the pulp. The resistance of paper belting to traction is said to vary from 22 to 220 pounds, depending on its quality. When moist the belting loses practically all its tensile strength, and when thoroughly wet will not resist even slight tension. However, the belting may be strengthened by various processes, according to the quality of the cord and to the weaving texture, but it does not attain the strength of leather belting. The abrasion on the cord is much greater than on leather and considerably diminishes its durability.

AMERICA IN WAR

The strength of a country in war is measured by its industrial resources. The ability merely to make guns, shells, rifles and cartridges is by no means the ultimate measure. A country, to be successful in modern war, must be able to coordinate and direct all its industrial resources for the one great purpose of delivering irresistible blows. Germany is united for offensive and defensive purposes. Its industries are under governmental control and are so directed that the maximum productive capacity required for war needs is obtained. We shall be strong in proportion to our capacity to marshal our industrial activities and direct them toward the accomplishment of the purpose to which we are committed. If there is lack of coordination, there will be waste, confusion and futility of purpose. The advisory committee of the Council of National Defense has taken a census of over 27,000 plants, large and small, engaged in the manufacture of the necessities and luxuries of life. These data have been indexed and filed for reference in Washington, the purpose being in an emergency like this to apportion to selected plants the production of machines and supplies for which they are best fitted by reason of equipment, organization and location. The compilation of these data during the past two years has, in a measure, prepared manufacturers and their workmen for this great emergency when individual ownership must surrender to national needs.

Patriotism should be revealed in a practical way. One of the most valuable services that a citizen can render to his country is to produce the things required for subsistence or war in a time like this. Enlisting and training an army are the visible activities that stir the nation's pulses. But these military duties alone do not produce shells, clothing or food, nor provide for transport. These are the problems of the engineer, and require careful planning, investigation and direction, and hard work. The needs of armies are as varied as the needs of humanity in time of peace. There is scarcely a raw or a manufactured product that will not be needed in one way or another; hence, it is apparent that the data secured by the work of the Council of National Defense should, if properly used, be of great value to those who must direct the industrial energies.

The consensus of opinion seems to be that the United States can take but a small part immediately in waging war in Europe because of the lack of shipping to transport supplies. It is estimated that not less than eight tons of shipping will be required to maintain every American soldier in France. An army of 500,000 soldiers on foreign soil, then, would require the use of 4,000,000 tons of shipping to supply their needs alone. The important part that we can take is that of furnishing food and manufactured products at reasonable prices. War has been made the excuse for extortion, and we are now suffering from the effects of inflated prices on every side. Governmental authorities must lay a heavy hand on the bloodsuckers who would fatten on the desperate needs of the peoples at war for principles. Manufacturers and their engineers should endeavor with all their might to restrict costs and limit profits. Their workmen will then in general be willing to work also for the common good and forget for the time to demand higher wages and shorter hours.

Thanks to the contracts for munitions that came to the United States in the early days of the war, we are by no means without experience. It is estimated that the daily productive capacity of the plants making shells and that have filled shell contracts is equivalent to not less than 300,000 three-inch shells daily. The great rifle factories at Bridgeport, Ilion, Eddystone and Chicopee, which did not at first succeed in organizing on an efficient basis for the manufacture of military rifles, are now on a sound footing; the productive capacity of all the plants now making military rifles in the United States is about 15,000 rifles daily.

When Great Britain declared war in August, 1914, it was a great commercial and industrial nation, but its plants were inadequately organized and there was no common purpose. Manufacturing had been carried on without a proper and full comprehension of the value of gages, jigs and fixtures and the importance of interchangeability of parts made in large quantities. The making of the thousands of gages required for the manufacture of shells alone was an enormous task, and few outside of the munitions work realized the importance of gage manufacture for this one branch of military activity.

The United States government has two armories, one at Springfield, Mass., and the other at Rock Island, Ill., equipped for the manufacture of United States service rifles. These plants, when working one full eight-hour shift daily, turn out about 300 rifles per day each, or a total of about 180,000 a year. To equip an army of one million men with one rifle each would require nearly six years of ordinary activity. Even if we now have one million rifles available, the productive capacity must be greatly increased, as it is necessary to provide more than one rifle for each soldier. The experience of the nations now at war is that a modern rifle has to be replaced in less than three months of active use.

This brings us to a consideration of the assistance that can be rendered by private plants. They can be made to turn out supplies quickly if properly tooled and organized, but they will be very slow in producing rifles, for example, unless provided with tools, gages, fixtures and detailed instructions. The manufacture of sets of these tools and fixtures is in itself a great undertaking and should receive the first attention of the munitions board recently appointed.

Generals and soldiers are helpless without engineers, mechanics and toolmakers. Fortunately, we have the best in the world. America is the home of mechanical ability and highly specialized manufacture. The interchangeable system has reached its highest development here, and its advantages are most marked when large quantities of mechanical products are required. The machine shop with its complement of machine tools and equipment and corps of skilled mechanics and toolmakers is the basis of industry. On the machine shop depends all manufacturing enterprise, whether it be devoted to peace or war. American mechanics are renowned for their skill, ingenuity and productive capacity. They are intelligent, and the technical press, by spreading mechanical information and facilitating the exchange of ideas, has played no small part in promoting the development of mechanical ability. The spread of mechanical knowledge must be accelerated in these troubled times. Censorship, if we must have it, should not be so stupidly directed as to interfere with the assistance that can be rendered in making the nation's industry most efficient.

The articles on the manufacture of military rifles that appeared in MACHINERY a year ago gave the first published analysis of the operations on a firearm accompanied by a description of the means and methods to be employed. This article is a sample of the kind of data that should be compiled by government experts for every kind of material required in large quantities. The manufacturing plant as ordinarily organized, having mechanics, toolmakers and other skilled workmen, should be able, with the aid of detailed specifications and the required equipment of tools, to reorganize and begin the manufacture of parts that will pass inspection in a few days. It is claimed that some German plants making products like ball bearings were changed over in twenty-four hours to the manufacture of fuses. This lightning change was made possible by the fact that all preparations had been made beforehand, the tools and equipment were ready, the plans and specifications were on file, and the department heads had been told just what should be done when the war order was received.

The mass of information and data published in the last three years on the manufacture of shrapnel, high-explosive shells, fuses, rifles and other munitions should be of even greater value now than heretofore. This brings us again to a consideration of what has been said in regard to industrial strength and the importance of spreading knowledge of mechanical practice. The many practical articles published during the past twenty years have promoted higher mechanical efficiency and have contributed in no small way to national strength. The man who by reason of intelligence, experience and skill is able to turn out a well finished piece in half the time required by another is twice as strong industrially. The mechanic may be serving the nation more effectively at his daily task than as a soldier in the field.

Technically trained engineers who would serve the country best should carefully compare their relative effectiveness in the army and in industry. Unless a young engineer can be sure that his ability will be utilized in army or navy service, he should by all means be employed in industry. It is to be hoped that our military authorities will not commit the blunder of Great Britain in sending skilled men into the trenches, but will recognize the importance of segregating those who by experience, education and skill are able to direct and produce in industrial employment; they should be regarded as industrial soldiers "doing their bit" most effectively at the forge or lathe.

Automobile manufacturers, who have made America the greatest producer of motor cars in the world, are prepared to take an active part in this national emergency. Means of transportation will be at a premium, and the maker of motor cars will be doing his part if he continues to turn out dependable means of transport. The manufacturers of internal combustion engines of specialized designs will produce aeroplane engines. The aeroplane is the eye of the modern army. Observations made by aviators are absolutely necessary for directing the fire of big guns. Without aeroplanes the army is blind and its efforts are largely futile. The United States may require fleets of aeroplanes which, thanks to our industrial development, can be rapidly and efficiently constructed in plants that have been devoted to the manufacture of motor cars and internal combustion engines. Examples might be multiplied to show the effective part that will be played by the manufacturing industries in war time.

It is the duty of every mechanic, as well as of every manufacturer, to direct his energy and skill to produce that which is required. It is no time for shirking, strikes or interferences with that which is virtually necessary for national security. All men who love liberty and justice should join in this great world battle for democracy—a battle against autocracy which, if successful, will make future wars unnecessary, and in fact improbable. F. E. R.

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INSPECTING FORGINGS FOR HIGH-EXPLOSIVE SHELLS

BY F. E. MERRIAM [1]

The forgings for Russian 3-inch high-explosive shells are rather difficult of manufacture on account of their length and the comparatively small inside diameter of the pierced hole. They therefore require a careful inspection in order that the defective pieces may be found before they pass to the machining operations. The severity of this inspection depends, to a considerable degree, on whether the forging manufacturer or an independent concern is to do the finishing. If the forging manufacturer also does the machining, it will be desirable for him to attempt to finish forgings that an independent concern cannot afford to touch except under special arrangements. The inspection methods described here are those used in a shop in the Middle West, where an independent concern was doing the finishing.

From Fig. 1, it is evident that the punches, or plungers, are long and slender, especially as they must allow sufficient length for a stripper, and therefore are likely to bend and produce eccentric forgings. Since eccentricity is the most common defect, the first inspection has as its object the elimination of all such forgings, the same as in rough-turning. The most common method of turning is to revolve the forgings as true as possible with the axis of the pierced hole, so that the eccentric portion will be removed in the rough-turning operation. Fig. 2 shows the eccentricity testing device, which is simply an expanding mandrel with fingers, or points, set to as small a diameter as is feasible, allowing the forgings to be cleaned up all over. The gage shown in Fig. 3 is sometimes used for determining the eccentricity, and works on the principle that if the inside diameter is correct, and the wall thickness not less than minimum, the shell will machine properly, as far as turning is concerned. As indicated, the measurement is taken as close to the bottom of the forging as the fillet will allow. This gage, however, considers only one cause of eccentricity, namely, improper relation between the axis of the pierced hole and the outside; but the trouble may be due to the forging not being straight. As shown in Fig. 4, there may be a sufficient bend in the forging between the gaging point and the closed end, which this gage cannot detect, to cause failure in the turning operation. This defect is so common that the wall gage is unsafe except when used in conjunction with a straightedge. Another inherent defect of the wall gage is that, by itself, it gives no consideration whatever to the inside diameter. Although a forging may have sufficient wall thickness, because the inside diameter is near the minimum, it cannot be machined if centered true with the axis. To eliminate this difficulty, it is necessary to use a gage of the minimum allowable inside dimensions; Fig. 5 illustrates this condition. On account of these inherent defects, this method of determining eccentricity is no longer used in the shop mentioned, the mandrel being used instead.

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The next step in the inspection is an examination of the bottom inside for scale. This is done by setting the forgings open end up and examining them with a properly shaded electric light. Several defects are sometimes found at this time; most of them are due to improper scaling of the billet previous to the piercing operation, or to the introduction of coal dust or some other foreign matter to facilitate the withdrawal of the punches. This foreign matter usually takes the form of a scale-like substance and varies from a few thousandths to a quarter inch in thickness. This scale, of course, prevents the proper gaging of the shell by giving the gages locating from the bottom the wrong position in the forging. For example, all the inside-diameter gages locate from this point, and since the forging is tapered, the presence of undue scale may make it appear to be too large inside and cause it to be rejected. This condition may also cause the wall gage to reject pieces in the same way. But the most serious effect is upon the machining operations, for the scale is very destructive to the tools. Furthermore, the scale may be the cause of failure to finish the bottom inside, especially when the outside of the base is finished previous to the boring operation, because the point of cut-off is then determined from the inside, and when a considerable quantity of scale is present so much stock will be removed from the outside that there will not be enough left for finishing the inside and the shell becomes scrap. Where it is the practice to bore previous to facing the closed end, this difficulty is largely eliminated, but the effect upon the boring tools is the same. During this examination, it is necessary to look for scale on the walls as well as for other defects, such as gas pockets.

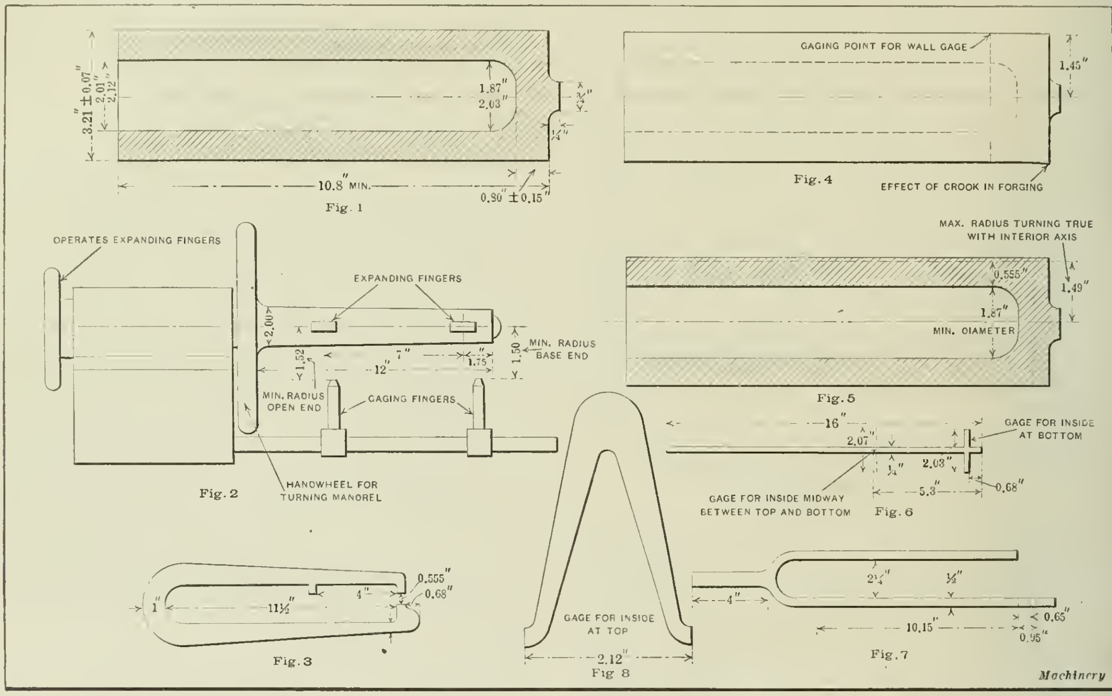
Following this inspection comes the measurement of the inside at three points, namely, 0.68 inch from the bottom, half way between the top and bottom, and at the top, both maximum and minimum diameters. The gages for this purpose, shown in Fig. 6, are simply plain diameter gages. It might seem that the gages for measuring half way between the top and bottom might safely be eliminated, but experience shows that to do so would result many times in the acceptance of forgings too large at this point. Occasionally a forging has been found that is as much as 3/32 inch too large at this point but correct as to the top and bottom diameters. The same condition also obtains at times at the gaging point near the bottom. The minimum gages are necessary, because a small plunger is sometimes used by mistake, thus making the pierced hole too small and creating trouble by not allowing the forging to slip on the eccentricity gage and the machining fixtures. Sometimes a forging has ridges on the inside, caused by scoring of the plungers; these produce the same effect as a small punch, as far as gaging and machining are concerned.

The measurement for length and bottom thickness comes next, and is one of the most important items of the inspection. The gage for this is shown in Fig. 7, and when used it is necessary to watch for a suitable bottom thickness and length over-all. Aside from matters of dimension, it is necessary to see that the bottom is of regular form, that the projection for the center is sufficiently long, and that there is not excessive scale or pitting on the outside. Defects due to scale can often be corrected by scaling, and sometimes by chipping, sufficiently to allow the eccentricity test to be made at that point.

No separate test is necessary, of course, for the wall thickness at the open end, since the eccentricity and the measurement of the inside diameter at this point, with the gage shown in Fig. 8, determine if the forging is satisfactory in this particular. A number of the other tests, such as for the length and bottom thickness, could be made at the same time as the eccentricity test, but it has been found more desirable to handle the work as outlined, since expanding mandrels are expensive and for these tests much slower than the simpler form of gage.

The surface inspection for seams, excessive scale, pits, etc., that is made at the same time as the gaging is an important part of the inspection, because a seam that is not discovered until the shell is finished will cause rejection with loss to all concerned. The examination for excessive scale is also equally important, because it often conceals pits, which may not turn out in the finishing and thus be the cause of final rejection. The only way to discover such defects is by a visual inspection, it usually being found that a porous open scale covers pits. Seams are sometimes so fine, of course, as to be impossible of discovery until the shell is finished, but most of them can be detected in the forge shop if a careful search is carried out.

The inspection of forgings is not as simple as many appear to believe, for there are many new things constantly arising that call for a knowledge of more than forge work and drawings. The eccentricity test is undoubtedly the most important, since failure to turn has been the cause of more rejections than any other one thing. The rejection of a forging on this test, however, does not necessarily mean that it cannot be machined, but it does indicate that it cannot be machined unless unusual precautions are taken. If the forging manufacturer is machining his own forgings, he will find it profitable to use special methods on forgings rejected on this test, since he can thereby save many of them. Oftentimes this work will call for centering eccentrically with the inside or rough-turning to nearly the finished size, but this is always more desirable than scrapping the forging. If there are but a few forgings to be machined, the inspection methods are not of great importance, but when the quantity runs into the hundreds of thousands, it becomes quite as important as any of the other operations and very necessary if production costs are to be kept low.



Figs. 1 to 8. Forging for High-explosive Shell and Gages testing Dimensions

CAUTION TO EMPLOYES OF FOREIGN BIRTH

In view of complications that might otherwise develop with workmen of foreign birth, J. H. Williams & Co., manufacturers of drop-forgings, having factories in Brooklyn and Buffalo, have issued the following cautionary statement to their employes, which is to be commended for fairness and straightforwardness. If other manufacturers generally deal with their employes in the same frank and democratic spirit, national feelings and prejudices engendered by the war will be largely submerged in manufacturing plants.

In the present crisis in our relations with the German government it is the purpose of this company to treat all of its employes alike, regardless of nationality of birth, or descent. The company expects from all in its employ the same loyalty that has been proved so often in the past, and takes it for granted that this loyalty will be extended in even greater measure to the policies of the United States government.

We cannot do otherwise than endorse the suggestion of the President that we all, in our various relations with each other, allow no accident of heredity to influence our feelings at this time toward those who are loyal American citizens.

J. H. Williams & Co.

J. H. Williams, President

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NEW ENGINEERING SOCIETY ORGANIZATION

A new engineering society was organized at a convention held in El Paso, Texas, March 8-10, with more than one hundred charter members, which will be known as the Southwestern Society of Engineers. Membership is open to civil, mechanical, mining, electrical, or chemical engineers, architects and other persons belonging to a technical profession, who are not less than twenty-seven years of age, and who have been in active practice of their profession for at least six years. Provision is also made for associate, honorary, and affiliated members. The president is Dean A. F. Barnes, School of Engineering, New Mexico College of Agriculture and Mechanic Arts, College Station, New Mexico; secretary, Forrest E. Baker, El Paso, Texas; vice-presidents, Dean G. M. Butler, College of Mines and Engineering, University of Arizona, Tucson, Ariz., and Dean S. H. Worrell, Texas College of Mines, El Paso, Texas.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

HEALD ROTARY SURFACE GRINDER

Simplicity of design and adoption of a unit principle of construction are the two outstanding features of this machine. Five units comprise the entire mechanism, and any of these can be easily removed if necessary. Provision is made for grinding concave and convex surfaces in addition to flat surfaces, making the machine suitable for handling a wide range of work.

A new size of rotary surface grinding machine has recently been brought out by the Heald Machine Co., 20 New Bond St., Worcester, Mass., for grinding rings, washers, thrust collars and similar parts that have flat surfaces to be finished by grinding and that can be held on a magnetic chuck. The most noticeable features of this 12-inch rotary surface grinder are the simplicity and compactness of its design and the fact that the machine is built on the unit principle. The entire mechanism consists of five units, *viz.*, the driving shaft bracket, idler pulley bracket, speed and feed box, wheel-spindle ram, and work-spindle knee, all of which are self-contained units which may be easily attached to or removed from the machine. In this connection, it may be mentioned that the unit type of construction lends itself well to the application of either belt or motor drive, it being merely necessary to assemble a pulley drive bracket or a motor drive bracket on the machine, according to the requirements of different cases.

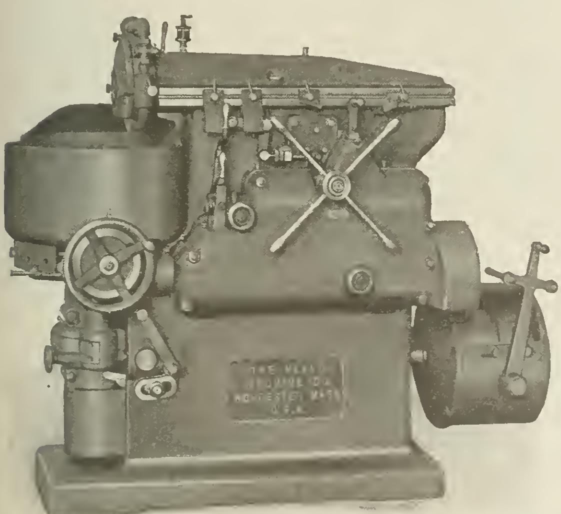


Fig. 1. Heald 12-inch Rotary Surface Grinding Machine

In order to explain the features of design of this grinder, there is probably no better way than to follow the transmission of power from the main driving pulley to different members of the machine. The main driving shaft bracket is shown in Fig. 3, from which it will be seen that the tight and loose pulleys *A* and *B* are located at the left-hand end. Loose pulley *B* is of smaller diameter than tight pulley *A*, so that the belt tension is relaxed while the belt is not driving the machine. Power for driving the wheel-spindle is taken from pulley *C* by a belt, the tension of which is kept uniform by a special form of idler pulley illustrated in detail in Fig. 4. Reference to this illustration will show that the pulley is supported by a swinging arm which holds it in contact with the belt through the action of a torsion spring. The strength of this spring is adjusted to maintain exactly the required belt tension, and allows for any unusual demand upon the drive. It will be seen that the idler pulley is supported on ball bearings.

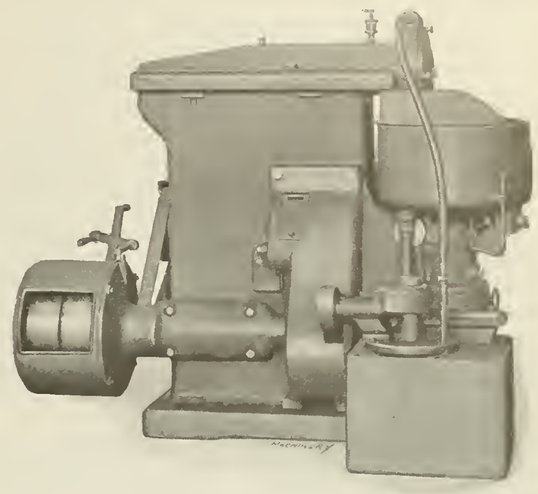


Fig. 2. Opposite Side of Heald Rotary Surface Grinder shown in Fig. 1

At the extreme right-hand end of the main driving shaft is a small pulley *D*, Fig. 3, which transmits power to the pump; and about midway along the shaft there is a third pulley *E*, from which power is transmitted to the feed and speed box located at the opposite side of the machine. Two views of the speed and feed box are shown in Fig. 5, and in this illustration it will be noticed that connection is made with pulley *E* on the main driving shaft at the back of the machine by a belt running over pulley *F*. The most important feature of design of the speed and feed box is that changes of both speed and feed are secured by two cones of gears which mesh with a common cone of gears keyed to shaft *G*. Any of the available rates of speed or feed is obtained by clutching the proper gear to the speed shaft or feed shaft, as the case may be, by means of diving keys *H* which are actuated by knobs *I* and *J* at the front of the speed-box. When so desired, the drives of both the speed and feed gears may be disconnected by throwing out keys *H*.

From the speed and feed box power for driving the work-spindle is transmitted by bevel pinion *L* through a suitable ar-

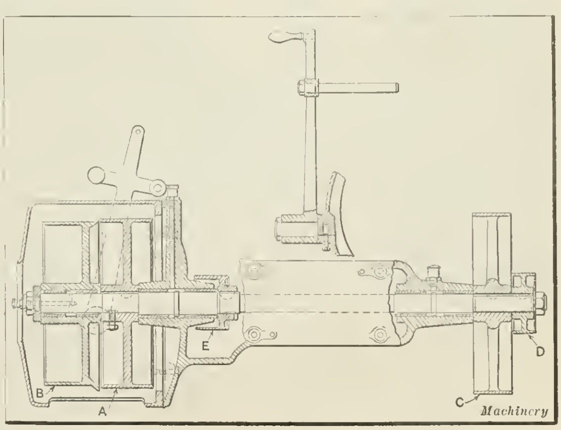


Fig. 3. Main Driving Shaft Bracket, showing Connections to drive Wheel-spindle, Pump, and Speed and Feed Box

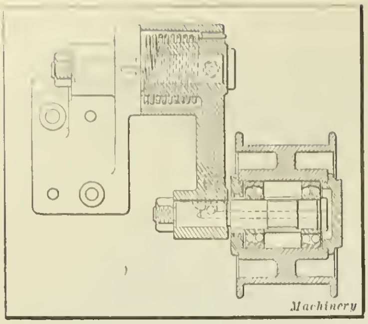


Fig. 4. Idler Pulley for maintaining Constant Tension on Wheel-spindle Driving Belt

rangement of gearing and shafts to a pinion that meshes with a spur gear *M*, Fig. 7, keyed to the vertical work-spindle. It will be seen that the lower end of the work-spindle is held by a radial ball bearing and there is a taper bearing at the top which keeps the spindle concentric and compensates for wear. Vertical feed of the work-spindle is automatically controlled by dogs on the wheel ram, which actuate a ratchet and pawl shown at *N*. These stops may be set to obtain any desired rate of feed, and an adjustable shield on the ratchet provides for disengaging the feed at any desired point. From the ratchet power is transmitted through shafts and gearing to pinion *O* that meshes with a combination gear and nut carried on the feed-screw. It will be evident from the illustration that rotation of the nut around the feed-screw provides for feeding the work up to the grinding wheel. A ball bearing under the nut supports the downward thrust of the work-spindle.

Referring again to Fig. 5, which shows the arrangement of gearing in the speed and feed box, we are now in a position to take up the manner in which power is transmitted to provide reciprocating motion for the wheel-spindle ram. The cone of gears which provides the changes in feed is carried on shaft *P*, which supports two bevel pinions between which is clutch *Q*. On the wheel-spindle ram there are adjustable stops that engage lever *R* at each end of the stroke, which results in throwing clutch *Q* into engagement with the forward and reverse bevel pinions on shaft *P*, thus providing the reciprocating motion of the wheel ram. These bevel pinions both mesh with a bevel gear carried on a cross-shaft, from which motion is transmitted through a vertical shaft to worm-wheel *S*, which meshes with a fixed worm on the wheel ram and results in forward or reverse traverse of the ram, according to the bevel pinion on shaft *P* that is engaged by the clutch *Q*.

Provision is made for grinding "convex" or "concave" tapers by setting the work-spindle bracket either to the right or left of the neutral position in which flat work is ground. Referring to Fig. 7, it will be seen that a scale *T* is provided to

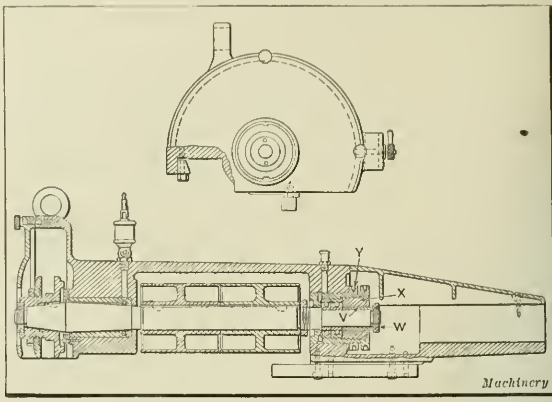


Fig. 6. Sectional View through Wheel-slide, showing Improved Type of Spindle Bearing Construction

facilitate making this setting; and the work-spindle knee is swung about shaft *V*, on which is mounted the driving pinion that transmits power to this section of the machine. In this way, the angular setting may be made without interfering with the transmission power.

From Figs. 1 and 2 it will be seen that all working parts are covered by guards which provide for the safety of the operator and also protect delicate parts of the mechanism from damage. In conformity with the best practice of machine design, the control of all parts of the mechanism is centralized so that the operator has mplete control of all movements without being required to leave his position at the front of the machine. Another feature that adds to the efficiency of operation is the fact that the handles of all handwheels are made separate from

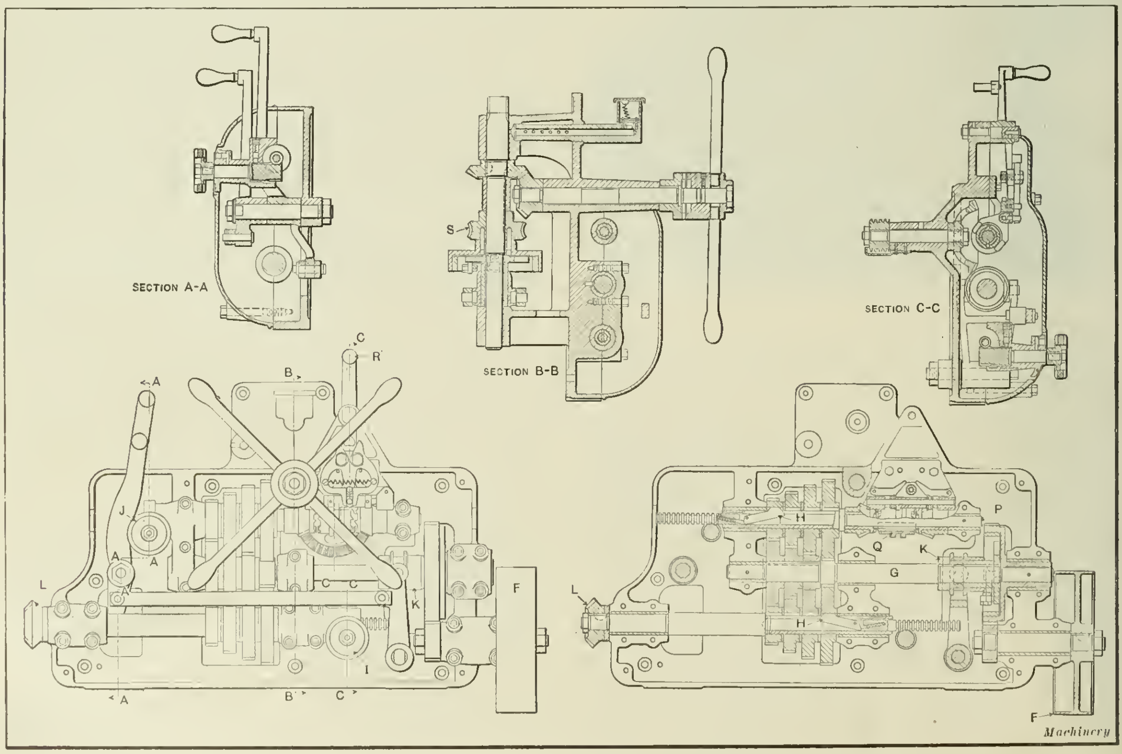


Fig. 5. Arrangement of Gearing in Speed and Feed Box, and Transmission to Wheel-spindle Slide

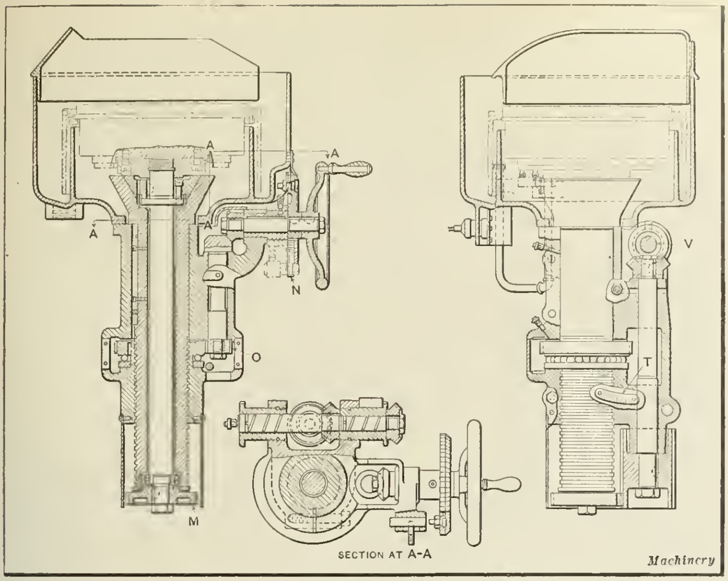


Fig. 7. Sectional View of Work-spindle Knee, showing Feed Mechanism and Means for grinding Tapered Work

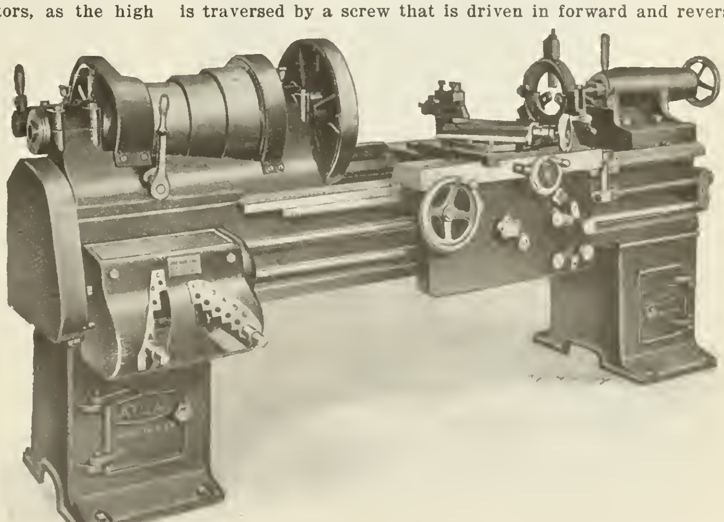
the studs which support them, so that the handle remains stationary in the operator's hand while the wheel is turned. This may appear to be an unimportant matter, but those who have had experience will realize that the constant turning of a handle in the hand is a source of fatigue, and results in reducing production.

Attention is called to the design of the wheel-spindle illustrated in Fig. 6. It will be seen that a plain bearing is used to support the front end of the spindle, but this bearing is tapered and made in a single piece, as the experience of the Heald Machine Co. has shown that better results are obtained in this way than by employing a split bearing. At the rear end of the spindle there is a double ball bearing, the inner races of which are clamped to the spindle by means of sleeve V and binding nut W that force the races up against a shoulder turned on the end of the spindle. Similarly, nut X adjusts the position of the outer races in the proper relation to the inner races and balls. When it becomes necessary to compensate for wear in the taper front-spindle bearing, such adjustment is made by tightening nut Y, which draws the entire spindle back into the taper bearing. Running tests made with this bearing in the shops of the Heald Machine Co. are said to have shown exceptionally satisfactory results, and the importance of efficient operation at this point will be conceded by all experienced grinding machine operators, as the high speed at which grinder spindles are run makes the design of the spindle and spindle bearings a matter of importance.

The principal dimensions are as follows: diameter of magnetic chuck, 12 inches (8- or 10-inch chucks can also be used if desired); size of grinding wheel, 12 inches diameter, 1 inch face, 3½ inches hole; greatest distance from top of chuck to center of wheel, 9½ inches; vertical adjustment of chuck, 5 inches; largest swing inside water pan, 15 inches.

"ATLAS" ENGINE LATHE

The Taylor Machine Co., 7804 Carnegie Ave., Cleveland, Ohio, is now building a 20-inch "Atlas" engine lathe equipped with a double back-geared drive, quick-change gears, and other features which will be apparent by reference to the accompanying illustration. Machines of this type are built with eight-, ten- and twelve-foot beds, furnished with heavy double-wall cross girths spaced two feet apart, which provide a rigid construction capable of resisting severe stresses. There are two ways on the bed, and a 20 per cent steel mixture is used, which provides a harder metal than that in the carriage bearings, so that any wear which takes place will be confined to the carriage, where adjustment can be made. The high-carbon steel feed rack is pinned and bolted to the bed.



"Atlas" Engine Lathe built by Taylor Machine Co.

The compound rest has its swivel made completely circular and graduated in degrees, the rest being clamped to the cross-slide by means of heavy bolts. Full-length tapered gibs with end screw adjustment are provided on both cross and compound slides, and are placed on the side where they will not receive the thrust of the tool. The headstock is of the closed type and is designed to meet the requirements of heavy work. The spindle is turned from 50-point carbon steel and is carried by phosphor-bronze bearings. The tailstock spindle is clamped by means of a double binder which is so constructed as to clamp the spindle in any position without affecting its alignment. Sight-feed oil cups are provided on the front spindle bearing and all other bearings are furnished with Brown & Sharpe oil plugs. There is a thrust bearing on the spindle which consists of bronze and hardened steel collars. A one-piece apron construction is employed in which all bearings are cast integral; and all gears are furnished with bearings at both ends. The lead-screw is turned from 40-point carbon steel and is 1½ inch in diameter with a 4-pitch thread.

"HY-GRADE" CYLINDER GRINDER

To meet the requirements of garages, repair shops, etc., which are called upon to handle cylinder grinding, the Hy-Grade Machine Co., 5606 Curtis Ave., Cleveland, Ohio, is now building a cylinder grinding machine. The upright frame and lower surface table are cast integral; and the vertical ways and bottom surface are carefully machined and scraped perfectly square to insure accurate alignment. The cylinder to be ground is mounted on a plate which may be adjusted to bring the different bores into the grinding position, this plate being carried on ways that extend the full length of the machine. The spindle is carried in a movable head and may be eccentrically adjusted to travel around the bore of the cylinder while rotating on its own axis. This spindle is driven by a belt extending back through the ways upon which the head is traversed by a screw that is driven in forward and reverse

directions by bevel gears. Up and down feed is controlled by a rod with adjustable stops that govern the clutch between the two bevel gears. Revolution of the spindle is controlled by a clutch on a splined shaft driven by spur gears. The fine eccentric feed is operated by a worm or screw furnished with a graduated dial.

All operating levers are located at the front of the machine where they are convenient for the operator. Counterweights relieve the machine of all strain and tendency toward excessive wear. All sizes of automobile cylinders may be ground, and it is claimed that the machine is capable of attaining a high rate of production and doing accurate work. The spindle head is equipped with adjustable bronze bearings, and the spindle is carried by double-row ball bearings and adjustable bronze bearings which are furnished with leak-proof oil retainers. The principal dimensions of the machine are as follows: height, 6 feet; total travel of spindle head, 22 inches; length of grinding spindle, 16 inches; size of movable plate that supports the work, 16 by 22 inches by 2½ inches thick; working space under machine, 18 by 22 inches; and floor space occupied, 28 by 32 inches.

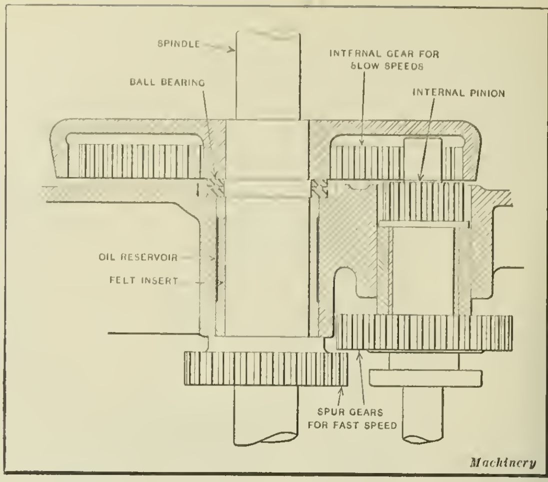


Fig. 2. Selective Internal and External Geared Drive to Spindle

AMERICAN RADIAL DRILLING MACHINE

In working out the design of a six-foot radial drilling machine which has recently been placed on the market by the American Tool Works Co., Cincinnati, Ohio, provision has been made for the performance of boring operations in addition to drilling and tapping, and on this account the machine has been termed a "triple-purpose" radial drilling machine. This result is accomplished by providing a quadruple geared head, affording four distinct speeds, which, in turn, are divided into two separate ranges of two speeds each—one for heavy tapping and boring, and the other for high-speed drilling and light tapping. The boring and tapping range, in conjunction with the eight gear-box speeds, comprise sixteen speeds ranging from 15 to 81 revolutions per minute, which are obtained through an internal gear drive on the spindle, while the high-speed drilling range consists of sixteen speeds from 94 to 500 revolutions per minute, secured through an external gear. These internal and external gear drives are non-interfering, and the thirty-two spindle speeds are in geometrical progression. A clear idea of the arrangement of the external and internal geared drive to the spindle will be gathered by reference to Fig. 2. At first thought it would seem that in supplying such a wide spindle speed range as 15 to 500 revolutions per minute, excessive gear velocities would be encountered, and this would be unavoidable were it not for the use of the double-spindle gear drive; but with this drive no gear runs faster than 1000 feet per minute, which is quite conservative. The head mechanism is fully enclosed inside of one large casting or housing, which not only prevents all possibility of accident from exposed running parts, but also presents a neat and finished appearance.

One important feature of this machine is found in the tapping mechanism, which is completely enclosed and runs in oil. Particular attention is called to the fact that with the added facilities furnished by this machine, there has been no complication of the mechanism or method of operation. For instance, thirty-two spindle speeds are obtained with only fifteen gears in the speed-changing mechanism. As to the convenience of operation, a study of the illustrations will be sufficient to give an idea of the way in which this has been provided for in the arrangement of all operating members. The different levers on the head are located so the operator can reach them easily, and two head-moving handwheels are provided, one on each side, so that either is available for instant use. Two levers are furnished for raising or lowering the spindle, and only one dial is used for the eight feeds. A conical roller bearing interposed between the column and sleeve make the arm easy to swing, this result being further facilitated by a ball bearing at the top which takes the radial thrust of the sleeve.

Thorough lubrication is a point of exceptional importance in radial drilling machines because of the number of vertical bearings and high velocity of the shafts. On this account oil ducts from the bearings are brought to centralized locations on the head and cap, into which oil may be introduced. This method insures an oil supply for every pipe and bearing. To further provide for efficient lubrication, a special bearing design has been worked out, this being of the type shown in Fig. 3. Oil is led into the annular chamber formed in the bronze bushing, which contains a large supply of lubricant, which, in turn, is fed to the bearing by means of a strip of felt inserted in a slot cut lengthwise in the bushing. This construction insures a continuous and uniform supply of clean oil for the bearing, and prevents waste from oil flooding and running out of the bearing before performing its function. To avoid possible accidents through falling of the counter-

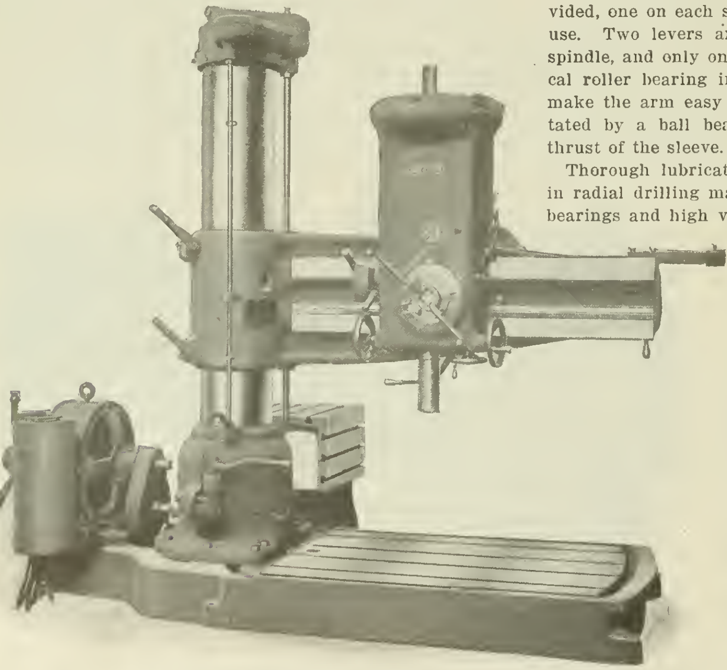


Fig. 1. American "Triple-purpose" Radial Drilling, Tapping and Boring Machine

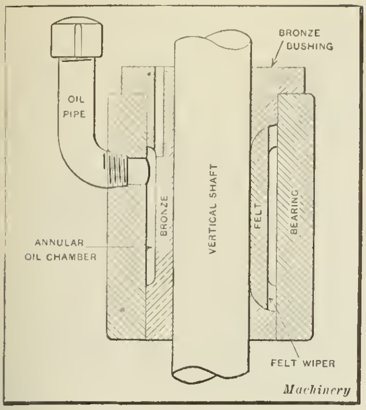


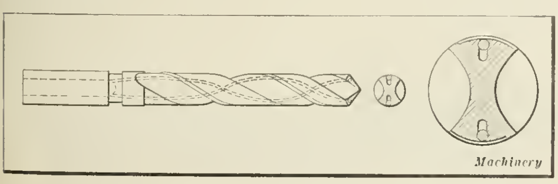
Fig. 3. Special Type of Bearing with Provision for Constant Lubrication

shaft, the weight on this machine is completely enclosed and provided with a safety stop which operates automatically in event of the supporting chain breaking; in this way the possibility of accident has been eliminated.

Eight changes of feed are provided, these being in geometrical progression and ranging from 0.005 to 0.040 inch per revolution. The feed mechanism is direct-reading, and only one dial is required for its operation. Thorough protection is provided for the feed mechanism to guard against sudden shocks or excessive strains, this result being obtained by means of a friction that constitutes the connection between the mechanism and the spindle, and acts as a "slipping point." This friction is of an improved expanding band type, and is quickly adjustable for the desired tension. The feed worm-wheel runs in an oil bath, insuring a minimum of wear between the worm-wheel and worm. Eight changes of speed are furnished by a cone and tumbler type gear-box, which has an automatic silent clutch auxiliary drive that keeps the shafts and gears running while speed changes are being made. This is the means of eliminating much of the shock caused by engagement of gears. It is impossible to elevate the arm until the binding levers have been loosened, and the arm cannot be elevated or lowered beyond certain fixed points. Whenever the elevating mechanism is engaged there is ordinarily a noticeable shock caused by meshing of the gears, but this shock is absorbed by the friction mechanism, so that it does no damage. This elevating mechanism is controlled by a lever that is inoperative until raised from its bearings, thereby guarding against breakage through careless handling. An automatic knock-out is also provided for the elevating shaft, which automatically disengages the mechanism at the extreme upward or downward movement of the arm, thus preventing damage from this source.

LINCOLN-WILLIAMS OIL-TUBE DRILL

The Lincoln-Williams Twist Drill Co., Taunton, Mass., has developed a new type of oil-tube drill, which is now ready for the market. Oil-tube drills of the type in which the tubes are soldered in place have often been found unsatisfactory, having given more or less trouble from the tubes working loose, and interfering with efficient drilling. In the Lincoln-Williams type of oil-tube drill, which is illustrated in the diagram presented herewith, the oil-tube is cut into the solid metal and the outer wall of the tube is formed by an inserted piece of drill rod which is dovetailed into place. This rod cannot work loose or come out, and the resulting oil hole formed from the solid metal and closed by the drill rod is in every way equal to that in the usual type of oil-tube drill. The oil-tube channels run back into the shank of the drill, where a connection by cross-holes is made to a central hole that runs out at the end of the shank, thus providing an entrance for cutting lubricant.

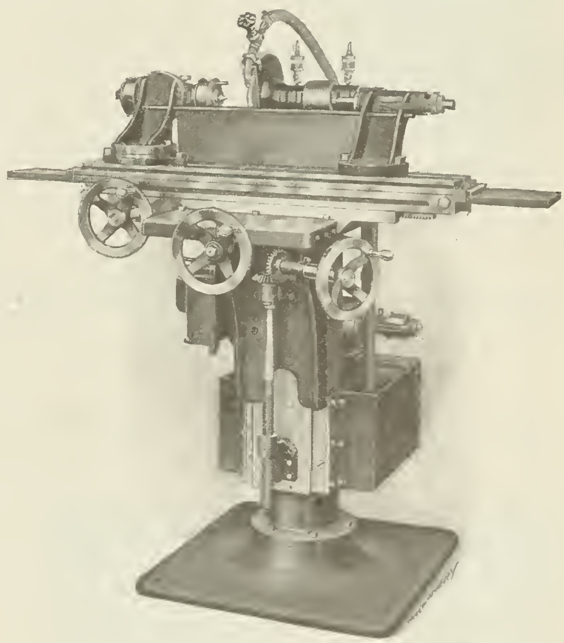


Oil-tube Drill made by Lincoln-Williams Twist Drill Co.

"CONNECTICUT" UNIVERSAL GRINDER

The Middlesex Machine Works, Middletown, Conn., are now building a machine known as the "Connecticut" universal grinder, which is shown in the accompanying illustration. The most important feature of design is the column construction which allows the table to swing completely around on bearings of liberal size, so that this grinder is a full universal machine. The head is fastened to the column, and any position can be obtained without twisting the belt. Another important feature is the ease and rapidity with which the grinder can be changed over from cylindrical wet grinding to surface grinding. This is particularly important in tool-room work or in manufacturing shops where the grinder is used for a variety of work. An internal grinding attachment can also be applied in a few moments to adapt the machine for those operations for which such an attachment is required.

The universal headstock has a No. 10 Brown & Sharpe taper in the removable sleeve, making it possible to use regular milling machine arbors, collets, etc.; and all kinds of cutter grinding can be done without requiring the use of extra fittings. The universal headstock is also provided with a drawback attachment made to receive special collets that may be used for grinding small cylindrical parts. The spindle is made with a 15-degree taper on each end, and two flange bushings are made to fit on the ends of the spindle. These make it possible to change wheels and maintain their true relation to the work, eliminating the necessity of truing the wheel. A



"Connecticut" Universal Grinder built by Middlesex Machine Works

water supply is available for wet grinding. This machine is adapted for taking very heavy cuts when roughing, and also for taking the lightest cuts where accuracy and a high finish are necessary, the claim being made that the machine operates with uniform efficiency under all conditions.

It will be noted that the table has no overhang, because it is supported for its entire length by the longitudinal slide, which is heavily braced and held in its turn by two generous bearings on the column. With this rigid support for the work, a remarkable degree of accuracy can be obtained. The top platen rests for its full length upon the longitudinal slide upon which it swivels, and is provided with a screw adjustment for aligning the centers accurately. The ends are graduated to facilitate setting for handling tapered work, one end being graduated to read tapers in inches per foot and the other end in degrees. The longitudinal movement is operated by a rack and pinion and the cross movement by a feed-screw furnished with micrometer adjustment.

The principal dimensions of this machine are as follows: diameter of spindle, 1½ inch; length of front bearing, 4½ inches; length of rear bearing, 3¼ inches; longitudinal movement of table, 20 inches; vertical movement of table, 13 inches; transverse movement of table, 8½ inches; capacity for handling work on centers, 24 inches in length by 12 inches in diameter; working surface of table, 5⅞ by 34 inches; maximum distance between spindle and table, 9 inches; height from floor to center of spindle, 45 inches; diameter of column, 7 inches; width of driving belt, 2½ inches; and net weight of machine, including attachments and countershaft, 1200 pounds.

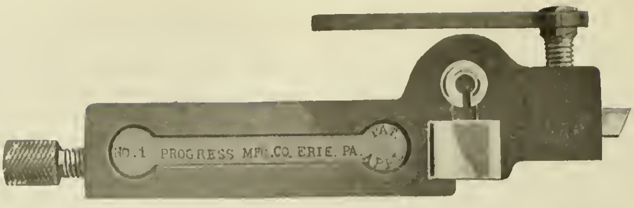


Fig. 1. Progress Spring Tool-holder for Performance of Threading and Forming Operations

"PROGRESS" SPRING TOOL-HOLDER

Most mechanics are familiar with the advantages obtained through the use of the so-called gooseneck or spring-tool that is commonly used for threading and forming operations. It is a matter of general knowledge that such a tool does not dig in and tear the work, which is likely to occur when a straight tool is used for these operations. With the view of overcoming such troubles and also to take advantage of the economy of a tool-holder, the Progress Mfg. Co., Erie, Pa., is now making the spring tool-holder illustrated and described herewith. Cutters used in this tool-holder can be made of 5/16-inch square or round stock. A spring bushing is placed in the gooseneck to stiffen the tool and afford additional spring when cutting coarse threads or performing heavy forming operations. A spring is placed through the shank of the holder, and this can be tightened by a knurled set-screw; the spring bears against the lower part of the gooseneck and is used when roughing out a thread or performing similar operations, after which the spring is released for finishing the work. Any forming cutter can be used in the tool-holder to advantage.

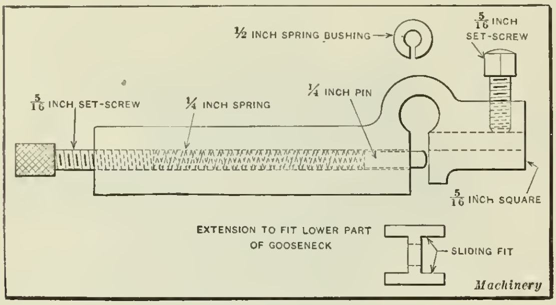
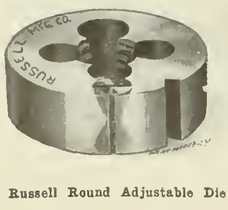


Fig. 2. Arrangement of Spring Bushing, Spring Support for Gooseneck and Sliding Extension to fit into Slot

RUSSELL ROUND ADJUSTABLE DIE

One of the latest products of the Russell Mfg. Co., Greenfield, Mass., is a round adjustable die, which is shown in the accompanying illustration. Dies of this type may be adjusted while in the holders by means of a taper-headed screw which engages a cone-shaped nut at the opposite side of the die. The taper head of the screw bears against a countersunk recess at the front face of the die, while the conical nut bears against a similar recess in the back face. It will be evident that this causes the die to open evenly and avoids the possibility of trouble through a twisting action. These new Russell round adjustable dies will fit any make of holder, as the slot running across the entire edge will engage with the set-screw no matter where the latter may be located.

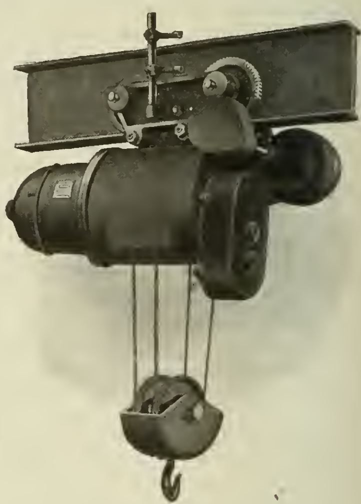


Russell Round Adjustable Die

"AMERICAN" ELECTRIC HOIST

The "American" electric hoist shown in the accompanying illustration has recently been placed on the market by the Barber-Foster Engineering Co., 605-607 Swetland Bldg., Cleveland, Ohio. These hoists are made in different types, which include a plain trolley hoist built in sizes from ¼ to 2 tons capacity, a geared trolley and hand chain hoist built in capacities from 2 to 10 tons, and a motor-driven trolley hoist for remote control, which is also built in capacities from 2 to 10 tons. Each type of hoist is completely enclosed, making it suitable for outdoor service or where exposed to dust, dirt, acid fumes, etc. All gears are cut from solid heat-treated steel blanks and the shafts are hardened and ground at the bearings. The mechanical brake is of a simple double-friction disk type, and Hyatt roller bearings are used to increase transmission efficiency. The motor and controller are of a standard design especially adapted for heavy-duty hoisting service; and the hoists may be provided for use in connection with either alternating or direct current.

Cast iron is used for the hoist frame, which is cylindrical in form and so constructed that it entirely encloses all the mechanism, including the drum and brakes. By locating the drum centrally within the frame, only a very small opening is required for the rope to pass through, so that not even the drum is exposed. The section of the frame containing the gearing and mechanical brake is separated from the drum by a cast-iron partition and is packed with grease. The drum is made of cast iron and machined with grooves to receive the full amount of rope for a given lift without overlapping. Attention is called to the fact that the drum gear is keyed to the end of the drum and not to the drum shaft. A mechanical load brake automatically stops and holds the load when the motor is stopped, and this brake is not released until the motor starts revolving in the lowering direction.



"American" Electric Hoist built by Barber-Foster Engineering Co.

Through the use of roller bearings and by having the gears run in grease there is little need of lubrication, although the bearings are provided with means for lubricating with oil. The trolley consists of two castings securely connected to lugs on the frame by through bolts which are of ample size. By simply removing these bolts the hoist is detached and each trolley frame with its wheels may then be easily removed from the I-beam. These wheels are single-flanged with tapered treads, and they are equipped with Hyatt roller bearings. An automatic limit stop is provided to prevent over-travel of the block in the hoisting direction due to neglect of the hoist operator. This stop is actuated by direct contact of the block.

MOCCASIN SELF-OILING BUSHINGS

For use as a bearing for loose pulleys and for similar applications where it is desirable to have the combination of an efficient bearing metal and an automatic lubricating system, the Moccasin Bushing Co., Chattanooga, Tenn., has placed on the market a line of self-oiling bushings which form the subject of the following description. Probably the best idea of how these bushings are used will be gathered from Fig. 2, which shows a Moccasin bushing in a loose pulley that is provided with an oil reservoir in the hub. The principle on which lubrication of this bushing is effected is the same as that by which oil is drawn up through a lamp wick, *i. e.*, capillary attraction. These bushings may be used in any machine member furnished with an oil cavity from which lubricant may be drawn by the capillary feeders in the bushing, which carry oil to the bearing. These capillary feeders pass transversely through the bushing to the bearing surface, where the oil is deposited in a continuous film. The feeders are especially prepared so that they cannot glaze or clog, and they have great power to hold oil and give it off as required. A special metal mixture is employed in making the bushings, which has ample strength without too much hardness. A further claim made for these bushings is that they obviate waste of oil, which is an important factor in many places. This saving, in addition to increased transmission efficiency, makes these bushings the means of effecting a considerable saving.

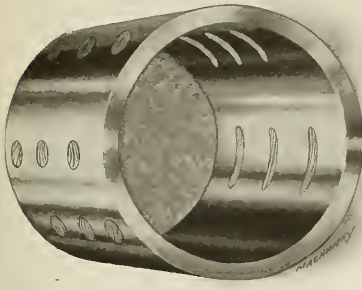


Fig. 1. Moccasin Self-oiling Bronze Bushing

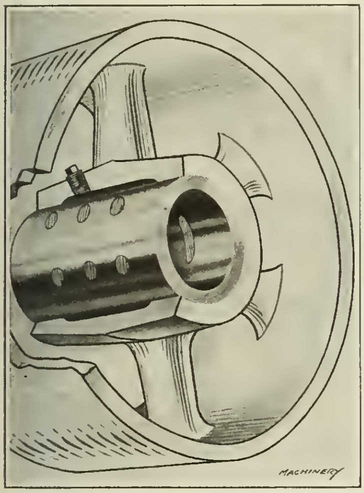


Fig. 2. Application of Moccasin Bushing in Loose Pulley

GALE-SAWYER ELECTRICALLY WELDED TOOLS

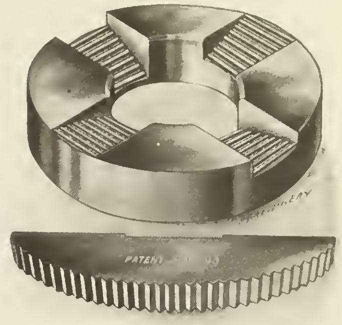
The accompanying illustration shows an end-mill made by the Gale-Sawyer Co., 33-37 Wormwood St., Boston, Mass. This tool has been electrically welded just above the cutting point, and by a series of special heat-treatments before and after welding, the steel is so united that it is claimed to be capable of withstanding a greater strain at the welded joint than in any other portion of the tool. After fitting the welding surfaces together, the steel is heat-treated in preparation for welding, the welding being done on a butt-welding machine which applies different temperatures for the carbon and high-speed steel.

Gale-Sawyer Electrically Welded End-mill

After welding and before the weld has been allowed to cool, the entire tool is heat-treated to relieve all strain, and it is then put through a special annealing process to bring both the high-speed and carbon steel to a workable point, after which the tool is finished in the usual way. In order to protect carbon steel from being destroyed at the high temperature necessary to harden high-speed steel, special furnaces have been built which provide for hardening the high-speed steel to any degree without damaging the carbon steel shank, which may be left entirely soft or hardened according to requirements of the customer.

DU BOIS TOOLPOST COLLAR AND SHOE

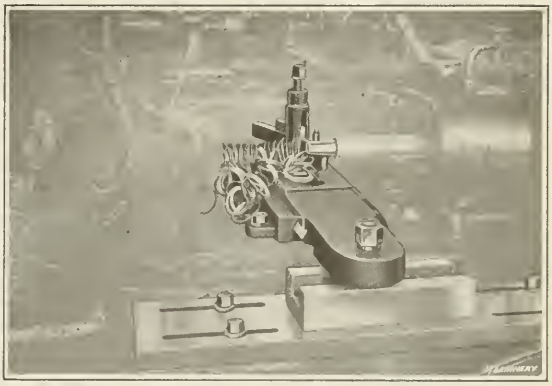
A positive lock toolpost collar and shoe, which is of simple design and suitable for attachment to any standard toolpost without making alteration, has recently been developed and placed on the market by the Du Bois Machine Shop, Inc., 118 Hudson Ave., Albany, N. Y. The positive lock washer is a flat piece with recesses cut in it to suit the adjusting shoe. The adjusting "radius surfaces" on the collar and shoe are corrugated to afford a positive lock when the device is in use. This corrugation does away with the need of depending upon friction to hold the tool. The recesses cut in the washer or collar are of different heights to allow the tool to be set level at different heights. It is claimed that with this collar and shoe it is unnecessary to apply as great a strain on the clamp screw in order to secure the tool. Both the collar and shoe are drop-forgings made from a suitable grade of steel. These collars and shoes are made in different sizes to suit toolposts of different lathes.



Du Bois Positive Lock Toolpost Collar and Shoe

TAPER-TURNING ATTACHMENT FOR TURRET LATHE

The taper-turning attachment shown in the illustration is intended for use on any turret lathe for turning accurate tapers, especially long tapers that cannot be adequately taken care of by forming tools. The turning slide is bolted to the turret and the brackets that support the guide controlling its movement are bolted to the rear of the lathe. The attachment does not interfere with the general operation of the turret lathe, and when the taper is to be turned it is indexed to bring the taper-turning attachment into position; as the turret is



Taper-turning Attachment made by Matthew Harrison for Use on Turret Lathes

fed forward a roller stud attached to the turning slide engages the hardened steel guide-block adjustably mounted on the bracket at the rear. This guide-block may be swiveled and set to give any degree of taper. The operation of this device is exceedingly simple. As soon as the roller stud on the bottom of the slide of the turning attachment enters the guide-block, the slide is advanced or withdrawn, according to the inclination of the guide-block. At the end of the taper-turning operation the attachment is merely swung out of the way by the indexing until it is required for the next part that is to be machined. This attachment is built by Matthew Harrison, 61 Albemarle Ave., Springfield, Mass.

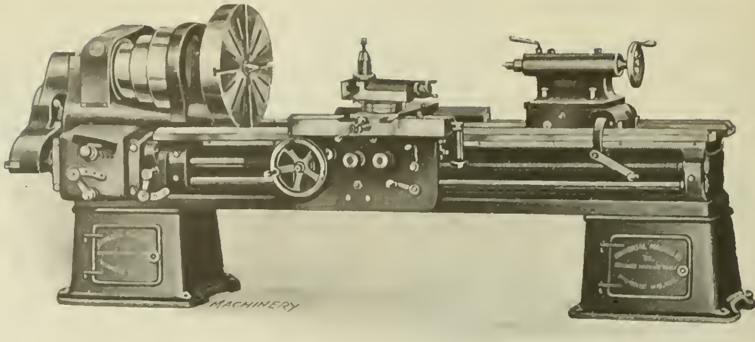


Fig. 3. Universal Machinery Co.'s 24-inch Engine Lathe with Quick-change Gear

"UNIVERSAL" LATHES

The Universal Machinery Co., 770-790 30th St., Milwaukee, Wis., is now building the high-speed all-geared manufacturing lathe shown in Fig. 1. The machine was especially designed to meet requirements in shops where the work is of a kind that calls for machining at high speed; and it is interesting to note that this lathe is sold under a guarantee that it will give satisfactory service when operated under spindle speeds up to 2000 revolutions per minute. The lathe is particularly suitable for use in the production of small parts where it is required to perform drilling operations and turning and boring operations on small diameters. It will be seen that the headstock is of the all-geared type with single-pulley drive, and where an individual electric motor is used, one good arrangement is to mount the motor at the back of the machine as shown.

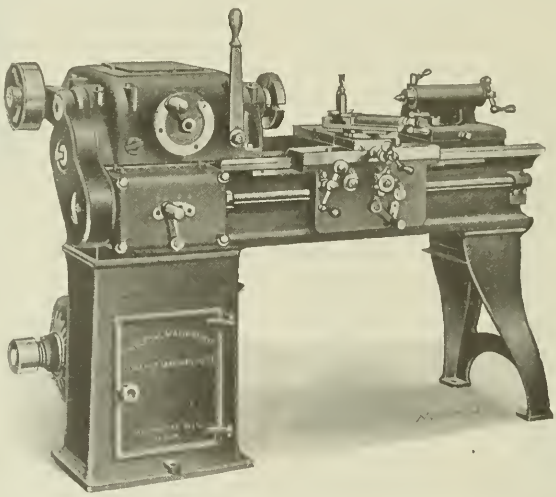


Fig. 1. High-speed All-geared Manufacturing Lathe built by Universal Machinery Co.

Eight geared speeds are obtained by means of a "radius plate" with four holes, which will be seen at the front of the head. These speeds may be arranged to give four forward and four reverse speeds, or eight forward speeds; and a set of frictions operated through the vertical lever at the front of the head controls starting, stopping and reversing of the spindle if the head is arranged for four forward and four reverse speeds, or starting and stopping the spindle if the machine is arranged for eight forward speeds. This allows the motor or countershaft to run constantly, thus giving the operator full control of the lathe at all times. Another feature is that when the motor or countershaft is running and the spindle is at rest, the only revolving parts are the main driving shaft and the two friction gears. The drive is said to be so sensitive that a half revolution of the spindle can be obtained when the spindle is running at 2000 revolutions per minute. All bearings are oiled through a double oiling system, *i. e.*, the combination of a splash system and felt wipers in each bearing. The oil reservoir is filled with 2½ gallons of oil, which is sufficient to take care of all oiling of the headstock, gears and bearings for a considerable length of time.

Longitudinal feed for the carriage is obtained and controlled through the all-geared feed-box, four mechanical changes of feed being obtained through a single lever, which will be seen at the front of the box. The tailstock is of the standard set-over type, allowing the compound rest to be swiveled at right angles to the carriage. When required, the lathe can be furnished with a turret toolpost, a turret on the carriage or a turret on the shears; and when the turret on the shears is employed, it may be furnished with or without power feed. When motor drive is employed, electrical apparatus, such as the controller or starting box, switches and cutouts, are placed in the cabinet leg, where they are out of the way of oil, dirt and chips; and the handle on the controller or starting box extends through a slot in the door, so that the operator has full control of his machine at all times. A taper attachment can be furnished for the lathe when it is to be employed on work requiring such equipment, and special fixtures can be designed to meet the requirements of manufacturing operations.

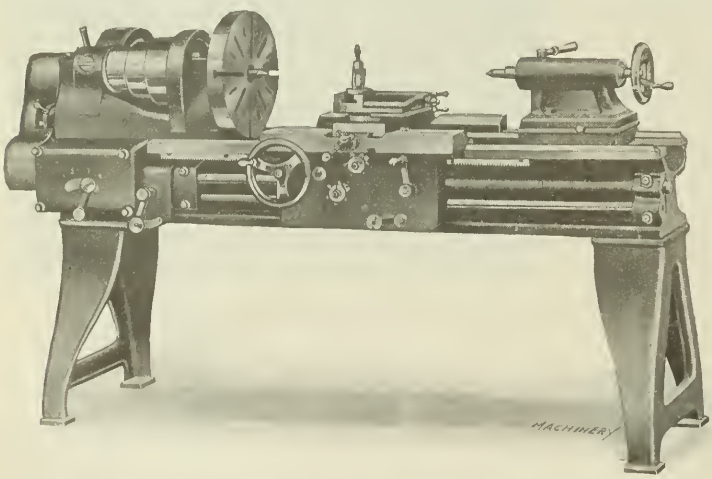


Fig. 2. Universal Machinery Co.'s 16-inch Engine Lathe with Semi-quick-change Gear

The Universal Machinery Co. is also building a line of "Advance" engine lathes, which are made in 16-, 18-, 22- and 24-inch swings. Each size of machine is built in semi-quick-change and quick-change types, both of which are driven by a three-step cone pulley

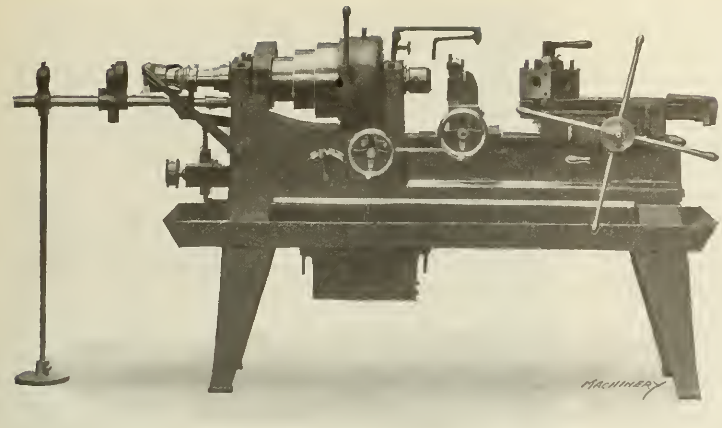


Fig. 4. Hand Screw Machine built by Universal Machinery Co.

and double back-gears. The general features of all the machines are similar, but the 16- and 18-inch machines are furnished with the usual form of legs, while the 22- and 24-inch machines have cabinet legs with liberal sized cupboards for the storage of tools, etc. Fig. 2 shows a 16-inch lathe of the semi-quick-change gear type, while Fig. 3 shows the 24-inch machine with quick-change gear mechanism. It will be noticed that these illustrations also show machines with the two styles of legs, and a good idea of features of the "Advance" lathes built by the Universal Machinery Co. will be gathered by making a study of these pictures, which clearly show general features of the two designs of engine lathes to which reference has already been made.

The dimensions of both the semi-quick-change and quick-change gear lathes of each size are the same, and an idea of the way in which these machines are built will be obtained from the dimensions of the smallest and largest machines of the line, *i. e.*, the 16-inch and the 24-inch lathes. For the 16-inch machines, the principal dimensions are as follows: swing over bed, 16½ inches; swing over carriage, 9⅜ inches; length of carriage bearing, 23½ inches; length of tailstock bearing, 10⅝ inches; dimensions of headstock cone pulley, 9¼, 8 and 6¾ inches by 3 inches face width; distance between centers for six-foot bed, 3 feet; size of front spindle bearing, 2 11/16 by 4 1/2 inches; size of rear spindle bearing, 1 15/16 by 3 1/4 inches; diameter of spindle nose, 2 3/8 inches; size of hole through spindle with No. 4 Morse taper, 1 3/8 inch diameter; range for thread cutting, 3 to 45 threads per inch; ratio of double back-gears, 4.4 to 1 and 9 to 1; and weight of machine with six-foot bed, 2000 pounds.

The principal dimensions of the 24-inch lathes are as follows: swing over bed, 24½ inches; swing over carriage, 15¾ inches; length of carriage bearing, 30 inches; length of tailstock bearing, 14 inches; dimensions of headstock cone pulley, 9¼, 12⅛ and 15 inches in diameter by 4 inches face width; distance between centers for six-foot bed, 3 feet, 10 inches; size of front spindle bearing, 3¾ inches by 7 5/16 inches; size of rear spindle bearing, 3 by 5 inches; diameter of hole through spindle with No. 6 Morse taper, 2⅛ inches; diameter of spindle nose, 3½ inches; size of lathe tool, ¾ by 1⅝ inch; ratio of double back-gears, 3.45 to 1 and 12 to 1; and weight of machine with eight-foot bed, 5190 pounds.

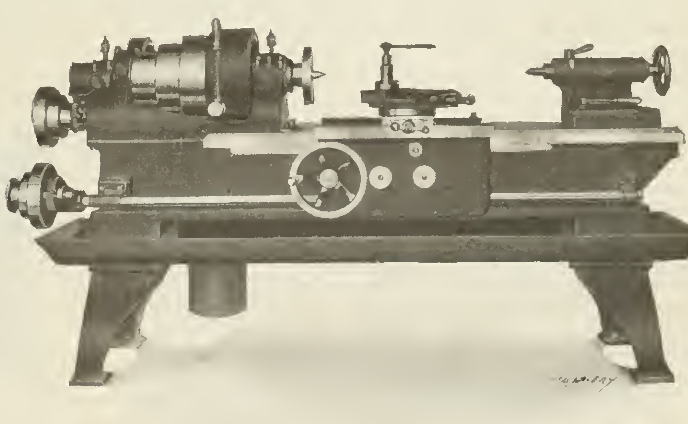
In Fig. 4 is shown the 1½-inch "Advance" hand screw machine which is another product of the Universal Machinery Co. A study of the illustration will make it apparent that this machine follows established practice in the design of hand screw machines, and on that account a description is not called for, as the picture will be sufficient to give any mechanic a good idea of the machine.

FULTON MANUFACTURING LATHES

A recent product of the Fulton Machine Tool Co., 1438 Bryan Place, Chicago, Ill., is the heavy-duty manufacturing lathe illustrated and described herewith. This machine swings 18¼ inches and is usually built with a seven-foot bed. It was designed for use in shops requiring a simple high-power lathe for plain turning, boring and facing. The simplicity of the machine makes it particularly well adapted for work of this kind, and the range extends from very small parts up to the largest pieces that can be handled on an 18-inch lathe. As regularly built, the machine is equipped with a three-step cone pulley and single back-gears, but it can also be furnished with a friction head, by means of which the spindle is started and stopped with a powerful friction clutch operating in the largest step of the cone pulley. A hand-lever on the front of the headstock operates the friction and also applies a brake which instantly stops the spindle. The advantage of this arrangement is apparent, as it permits quick removal and replacing of work and quick stopping of the work to make measurements. Another special feature that may be furnished is a quick-acting tailstock; various types of rests may also be provided, as well as a taper attachment.

The headstock spindle is machined from a crucible steel forging, and is carried in phosphor-bronze bearings provided with ample facilities for lubrication. The front spindle bearing is 3 inches in diameter by 6¼ inches long. It will be seen that the tailstock is of the cut-away type, with two heavy bolts for clamping it to the bed. This tailstock can be set over for turning tapers, and it is furnished with a spindle 2⅜ inches in diameter by 9 inches long. The lathe is usually equipped with a special plain rest 7 inches wide, but it may be equipped with a compound rest or with a front and back plain rest. The apron is designed to provide front and rear bearings for all studs. This lathe has power, cross and longitudinal feeds, each of which is driven by an independent friction. The feed cones are of large diameter and carry a belt 1½ inch wide, which, in connection with a worm and worm-wheel in the apron, provides ample power for taking heavy cuts. Provision is made for adjusting the lower cone to obtain the desired belt tension.

The principal dimensions of this machine are as follows: swing over bed, 18¼ inches; swing over plain rest, 10½ inches; swing over compound rest, 12½ inches; length of bed, 7 feet; distance between centers with plain head, 38 inches; distance between centers with friction head, 36 inches; diameter of hole through spindle, 1 13/32 inch; diameter of spindle nose, 2⅝ inches; size of tool, ¾ by 1½ inch; length of carriage on bed, 24 inches; dimensions of cone pulley, 7¾, 10



Fulton 18-inch Heavy-duty Manufacturing Lathe

and 12¼ inches in diameter by 3½ inches face width; number of changes of spindle speed, twelve; range of spindle speeds, 23 to 303 R. P. M.; number of feed changes, six; range of feeds, 0.009 to 0.070 inch per revolution of the spindle; size of countershaft pulley, 14 inches in diameter by 4¼ inches face width; and weight of machine crated for shipment, 2650 pounds.

WESTINGHOUSE AUTO STARTERS

The three types of auto starters here shown have been developed by the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., for use in connection with the operation of large squirrel-cage induction motors up to 650 horsepower. They serve to provide ample protection to motor, machinery, line and operator, by preventing excessive strain on the motor and disturbance to the line, reducing the line voltage and current in starting. Both motor and starter are protected against overloads and short-circuits. In special cases, where the power delivered to the motor is of high kilovolt-ampere capacity, the destruction of motor and starter is prevented by the provision of heavy breaking capacity. Resistance can also be furnished to prevent the opening of the circuit when changing from starting to running position, which causes disturbances that may be injurious to both motor and starter.

These starters are extremely durable, and possess large, substantial contacts capable of breaking heavy currents frequently. The switching mechanism is simple and strong. The effect of arcing has been reduced to a minimum by immersing all contacts in oil and by the use of either auxiliary arcing tips or large contact area on the main contacts. Where arcing occurs, the contacts are provided with removable tips, which may be renewed readily with a pair of pliers. The starting current may be adjusted to the service by taps on an auto transformer, which provides either three or eight starting voltages, according to the capacity of the transformer. Absolute safety to the operator is assured by excellent insulation in the switch and by a liberal margin of safety above the actual requirements. Safety to the apparatus is assured by overload relays, which cause the switch to open at a predetermined overload, and by a low-voltage relay, which opens the switch when the voltage fails.

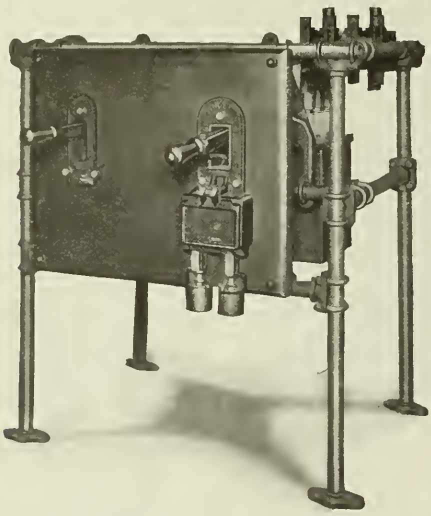


Fig. 1. Westinghouse Auto Starter—Types QF and QF-1

The three types of starters provide a range of capacities that will cover the majority of cases. The type Q starter is for use on two- and three-phase circuits of from 220 to 2200 volts, 25 to 60 cycles. The types QF and QF-1 are for use with motors of larger capacity or higher voltage than can be started by the type Q starters. They differ from the latter mainly in their ability to handle larger currents and in having larger kilovolt-ampere breaking capacity, and in certain sizes a preventive resistance. They also have two handles—one for starting and the other for running.

Fig. 2. Switches of Westinghouse Auto Starter

In starting a motor with the type Q auto starter, the switch handle is moved from the "off" to the "full up" position and held there until the motor has ceased to gain speed. It is then moved downward, as far as it will go, to the "running" position, where it will remain. The handle will not remain in the "starting" position unless held, and it is impossible to move the handle directly from the off to the running position without first passing to the starting position. Where a type QF or QF-1 auto starter is employed having no preventive resistance, it is necessary to move the starting handle down as far as it will go and hold it there until the motor has ceased to gain speed. That handle is then released, and before it has fully returned to the off position the running handle is moved down as far as it will go, where it will remain latched. If a preventive resistance is used, the starting handle is held down until the motor no longer gains speed; then the running switch is closed and the starting switch released.

Overload and low-voltage protection is furnished for all types, protecting the motor from overloads and from the effects of failure of the supply voltage. The overload relay operates very slowly on slight overloads and almost instantaneously on short-circuits. Consequently, the motor circuit is not opened for a momentary overload, such as during the moment of acceleration when the switch is changed from starting to running position. The low-voltage relay operates whether the voltage fails quickly or slowly, affording full protection.

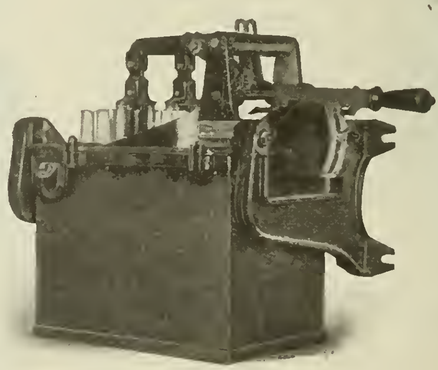


Fig. 3. Westinghouse Auto Starter—Type Q

NATIONAL CALLING SYSTEM

In manufacturing plants where the duties of certain executives require them to spend considerable time in the factory, and where it is frequently necessary to communicate with these men, some means must be provided for getting in touch with them. For this purpose the National Scale Co., 6 Mechanic St., Chicopee Falls, Mass., is now building a calling system that forms the subject of this article.

Primarily, this consists of an operating instrument which is placed beside the main telephone switchboard and taken care of by the same operator who has charge of the board. This instrument is connected by wiring to a line of signals, which may be either bells, horns, buzzers, lights or other electrical devices which it may be desired to use. These signals are distributed throughout the factory in such a way that each department is taken care of by one or more signals; and each man has a different signal. As a result, any executive who is going through the shop will instantly have his attention attracted by one of these devices giving his signal if the

Instrument placed by Telephone Switchboard and used to operate Bells, Buzzers, Horns, Signal Lights, etc., to call a Man to Telephone

switchboard operator desires to get him on the telephone. A great part of the high efficiency and productive capacity of the American business man is due to his faculty of utilizing his business day to the greatest possible advantage, and such utilization would be impossible were it not for the mechanical devices developed to facilitate the conduct of business transactions, of which the calling system is a typical example.

MERIDEN SENSITIVE TAPPING MACHINE

This sensitive tapping machine, a recent product of the Meriden Machine Tool Co., Meriden, Conn., is designed for tapping up to and including 1/4-inch holes. Its great field of usefulness is found in electrical manufacturing, gun work, or any similar light tapping work on parts that are manufactured in large quantities. The machine is constructed along simple lines. The main tapping spindle is provided with two cones, which engage with a third cone carried by the main driving spindle. Power is transmitted to the tapping spindle by frictional contact of the two driven cones with the driving cone. The tap-carrying spindle has a free longitudinal movement, and when pressure is brought upon the end of the tap as a piece of work is moved toward it, the forward cone is brought into contact with the driving cone, causing the tap to rotate and do the tapping. As soon as the desired depth

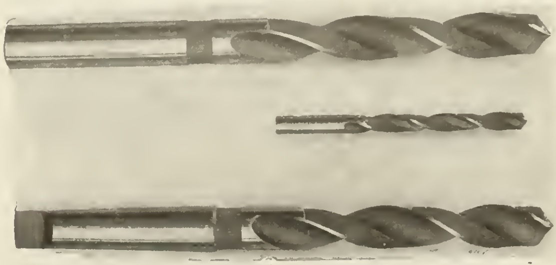
Sensitive Tapping Machine made by Meriden Machine Tool Co.

of tapping is reached, the natural tendency is to pull the work away from the tap, which slides the rear driven cone into contact with the driving cone, causing the tap to back out.

The two driven cones are made of cast iron, while the driving cone is cast iron faced with leather, which increases the effectiveness of the friction drive. The driving shaft is provided with a ball bearing thrust collar to overcome the thrust caused by the cones while in contact. The machine is provided with a fixture holding member that slides on V-shaped ways. To this member may be attached any work-holding fixture. It is provided with an adjustable stop rod that limits the travel of the work toward the tap. The machine may be furnished with or without the pedestal. The weight of the machine alone is approximately 100 pounds, and combined with the pedestal approximately 180 pounds.

"COLTON-DETROIT" TWIST DRILLS

Arthur Colton Co., Detroit, Mich., is now manufacturing the "Colton-Detroit" twist drills here illustrated and described. These are hammered high-speed drills designed for severe service; and they are claimed to be absolutely uniform in quality and uniformly hardened. Wide grooves in the drill provide adequate chip clearance which prevents tendency toward clogging. Another important feature is that on the taper shank drills the shanks are exceptionally large so that ample strength is provided. The drills are ground at the point with cutting edges of equal length, that make a uniform angle with the longitudinal axis of the drill, 59 degrees being considered the best angle for this purpose. The lip clearance or backing-off of the cutting edges for regular shop work is made 12 degrees at the periphery, but as the center of the drill



"Colton-Detroit" Twist Drills with Straight and Taper Shanks

is approached this angle is increased until the line across the center of the web makes an angle of 135 degrees with the cutting edges. For heavier feeds or drilling soft metal, the angle of the lip clearance may be increased to 15 degrees at the periphery, but in such a case it is important that the angle at the center be given a corresponding increase. For drilling extremely hard material where lighter feed is used, the point should be ground at an angle of 68 degrees, while the angle of lip clearance is decreased to 9 degrees at the periphery. These drills are made in a wide range of sizes and with both taper shanks and straight shanks.

LANGELIER DUPLEX MULTIPLE DRILLING MACHINE

The illustrations which accompany the following description show a double-acting horizontal multiple drilling machine recently brought out by the Langelier Mfg. Co., Providence, R. I. This machine was designed for drilling such parts as motorcycle, bicycle and side car hubs, or for any cylindrical parts requiring one or several holes at opposite ends. The outstanding feature of the machine is simplicity, both as regards operation and general design. The multiple heads, which are interchangeable, are carried in sliding housings, both of which are actuated simultaneously by a single hand-feed lever, compounded to obtain the required leverage.

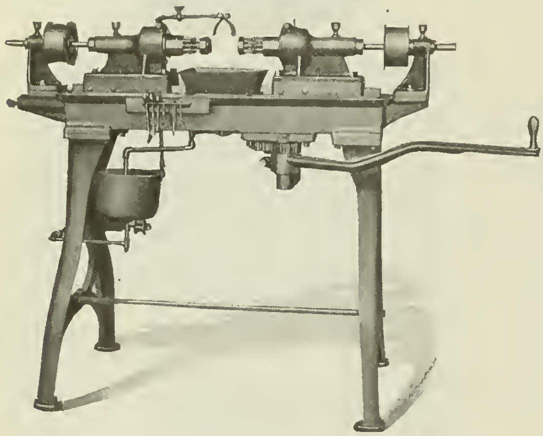


Fig. 1. Langelier Double-acting Horizontal Multiple Drilling Machine

Drive is transmitted through floating pulleys mounted in brackets at each end of the bed. A double-splined spindle slides in the pulley, transmitting the drive to the multiple heads and permitting free motion of the housings. This construction eliminates all belt pull on the spindles, so that they carry no other load than that required for driving the heads.

The jigging is simple and remarkably rapid. The jigs, one to each multiple head, are self-contained with the heads, being located by a central keyed spring plunger. The jig on the right-hand head contains an indexing device. Slipping the work loosely into either jig, the heads are brought together by a movement of the feed lever. This clamps the work between the jigs, while continuing the travel of the heads feeds the drills into and through the work, the spring plungers receding into the heads. As the holes are on very close centers, only every alternate hole is drilled at one operation. After withdrawing the drills, the work is indexed by a twist of the wrist, a spring plunger engaging one of the holes already drilled; then a second operation completes the circle. A new piece may be inserted the instant the drills are withdrawn, as the open construction permits the finished piece to drop into the chip pan, where it may be removed while the next piece is being drilled. The machine drills two sizes of hubs, so that two sets of interchangeable heads are provided. The unit construction of the multiple head practically eliminates any setting up, as the heads may be interchanged in a few minutes. By test, the first three samples drilled were finished inside of one minute, there being a total of thirty-six holes per

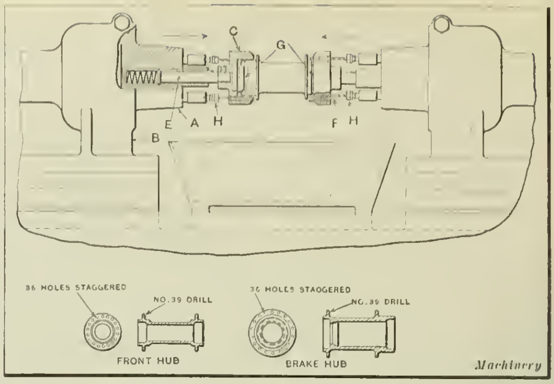


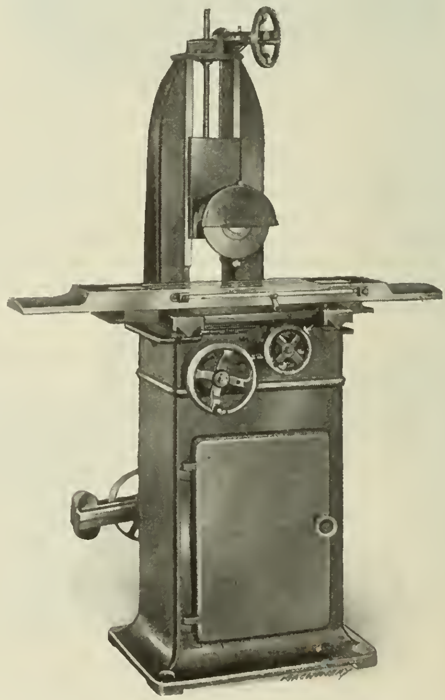
Fig. 2. Sectional View of Jigs for drilling Rear or Brake Hub

hub, using a No. 39 drill. This is at the rate of 6480 holes per hour.

Micrometer adjustment is provided for the drills by means of adjustable collets, while a single adjustable stop, shown at the left-hand end of the machine, suffices for both heads. Fig. 2 shows a section through the jigs for the rear or brake hub. *A* is the multiple head, contained in the sliding housing *B*. The jigs are shown at *C*, the plunger receding into the head as shown at *E*. The index pin is shown at *F* in the right-hand jig. The work is located and held by the three-point centers *G*, the springs having sufficient tension for a firm grip, while the several drills entirely neutralize any tendency to creep. The adjustable collets are shown at *H*. Automatic oil feed is provided, driven from an overhead countershaft which is furnished with the machine. While peculiarly suited to the class of work described, the machine may readily be adapted to a wide range of work of practically any shape within the capacity of the heads, as jigs may be attached to the bed in place of the chip pan shown.

"REID" SURFACE GRINDER

The increasing demand for surface grinding machines has led the Boston Scale & Machine Co., 381-389 Congress St., Boston, Mass., to place on the market the machine shown in the accompanying illustration. This is known as the "No. 2 Reid



"Reid" Surface Grinder built by Boston Scale & Machine Co.

surface grinder," and is intended for production grinding as well as for the general run of tool-room grinding handled by machines of similar capacity. It will grind work up to 18 inches in length, 6 inches in width, and 12 inches in height.

The wheel-spindle is of steel, hardened, ground and lapped, and runs in phosphor-bronze bearings, which are provided with means for taking up wear. It is raised and lowered by means of a handwheel that may be seen at the top of the machine, and this wheel is graduated to read to 0.0005 inch. The wheel-spindle is designed to take wheels up to 7 inches in diameter, ½-inch face and ¾-inch hole.

The work-table is 46 inches long, 8 inches wide, and has a working surface 18 inches long by 6 inches wide, which is provided with three T-slots. The power longitudinal feed to the table is 18 inches and the power cross-feed is 6 inches. The table travel is automatic in either direction and reversal is brought about by means of dogs at the front side of the table that trip the reversing lever. When desired, the reversing lever may be thrown out and the table moved beyond the reversing point without interfering with the dog adjustment.

The transverse movement of the table is automatic and the feed may be set to operate at the end of each stroke or at the end of each complete forward and return stroke. The feed can be easily changed from one direction to the other. The amount of feed may be varied from 0.007 to 0.084 inch, and it is not a friction feed, but is positive in its action. A feature of the machine is the method of quickly starting or stopping the machine at will by a push-rod that operates from the center of the longitudinal hand-feed. Pulling this rod out starts the machine, and pressing it in stops it instantly.

The countershaft furnished with the machine has tight and loose pulleys 8 inches in diameter, and a 3-inch belt is recommended. The countershaft should operate at 360 revolutions per minute. The floor space of the machine is 65 by 30 inches, and the net weight, 1300 pounds. The shipping dimensions are 40 by 35 by 72 inches, occupying 58 cubic feet of space, and the shipping weight is 1600 pounds.

RICKERT-SHAFER RADIAL TAPPING MACHINE

A machine known as a ½-inch Model R or radial tapper is a recent product of the Rickert-Shafer Co., 612 W. 12th St., Erie, Pa. The machine has a capacity for tapping any hole within a radius of 48 inches, and the arms can be folded to provide for tapping holes as close as 8 inches from the column. The arms swing on ball thrust bearings, making the machine easily handled; and it is said to be so sensitive that the point of the tap will readily align the spindle with the hole to be tapped. The spindle is driven by a friction drive consisting of an aluminum disk which has essentially the same coefficient of friction as cast iron, although its centrifugal force is only about one-third as great. This friction disk is placed between two paper frictions and may be brought into contact with either the driving or reversing friction by pressure applied to the operating lever. Adjustment is so regulated that the spindle is in motion before the tap is brought into contact with the work, although it is revolving only while the machine is in operation. All spindle thrusts are taken by a series of S. K. F. ball thrust bearings.

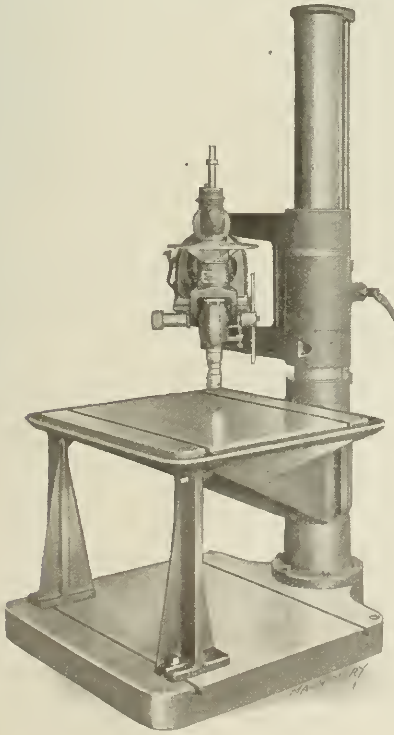


Fig. 1. Rickert-Shafer Radial Tapping Machine with Double Arm folded

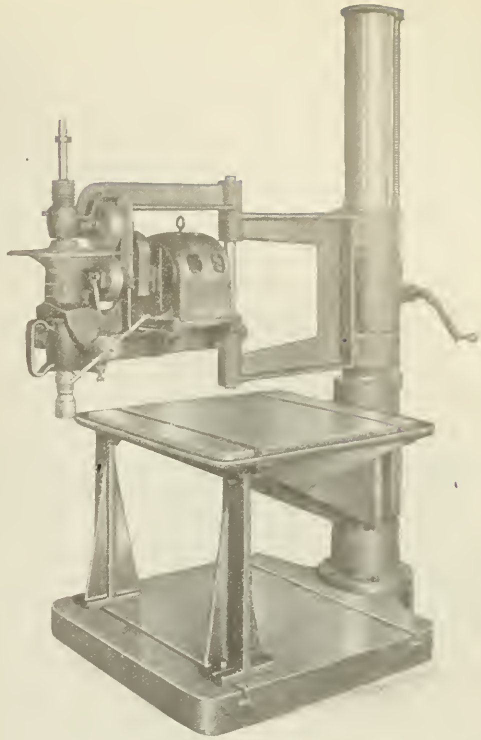


Fig. 2. Rickert-Shafer Radial Tapping Machine with Double Arm extended

These machines are equipped with a direct-connected motor, the motor being set back of the spindle to drive the frictions through bronze intermediate gears. By placing the motor in the spindle head instead of driving through gears and shafts or belts from a position back of the machine, all tendency for the arms to double up under the heavy pull is entirely eliminated, and there are no belts or other parts to require attention. These machines may be furnished with either a plain table or a swivel table. The plain table is used for work in which all holes are tapped square with the bottom of the work, while the swivel table is employed for handling angular work, such as the holes in eight- and twelve-cylinder crank-cases. The machines are equipped with either a positive drive tapping chuck or a quick-change chuck for use in case more than one size of hole is to be tapped in the same piece. All work up to 22 inches high can be tapped on the table, while work up to 46 inches high can be tapped on the base by swinging the table out of the way. The table has a working surface 30 by 30 inches square, while the base has a working surface 36 by 36 inches in size. These machines have a capacity for tapping holes in steel from ¼ to ½ inch, and when tapping in cast iron they are capable of taking care of holes from ¼ to ⅝ inch in diameter. The weight of the machine is approximately 2000 pounds.

PEERLESS CUTTING-OFF SAW

The Peerless Machine Co., 1611 Racine St., Racine, Wis., has recently developed a line of high-speed heavy-duty cutting-off saws. The principles embodied in these tools enable them to meet the demand for cutting the largest sized materials, and yet they are so sensitive that the smallest sizes can be cut as readily. The illustrations give an idea of the rigidity of these tools. The principal feature is the manner of controlling the saw guide, which it will be noted is overbalanced by four coil springs. These springs are mounted in such a position that no strain is left on the bearings, thereby making it very sensitive in its movement. The springs tend to bring the saw frame upward.

The feeding mechanism consists of a ratchet bar and a set of dogs. The dogs are mounted in one end of an oscillating arm, and the other end has a roller that engages with a cam on the crankshaft, the roller being forced against the cam by a spring. Changing the tension of the spring increases the feed pressure which is entirely controlled by the lever shown on the left-hand side of the machine. When the lever is at the bottom, the feed is entirely relieved, and when the machine is in operation the saw frame will not feed down. The moment a little tension is put onto the feed spring the frame feeds down. When the saw frame has completed its cutting stroke, the cam forces the roller down, which relieves the tension on the feed spring, and as the saw frame is overbalanced, allows it to rise and clear the work until the cutting stroke commences again. At this point the cam runs off the roller, allowing the spring to force up on the oscillating arm, and the other end to pull down on the ratchet bar. The two ratchet dogs alternately engage on each thirty-second movement of the ratchet bar. This insures uniform feed pressure on the blade throughout the entire cut; otherwise the feed spring tension would be greater either at the beginning of the cut or at the end.

It will also be understood that in this type of feeding mechanism there is no friction, nothing to wear or slip, whether the spring is under full tension or no tension. Whatever point the feed lever is set at the feed remains uniform, just the same as if a weight were hung onto the frame for feeding. In case the machine is accidentally or intentionally

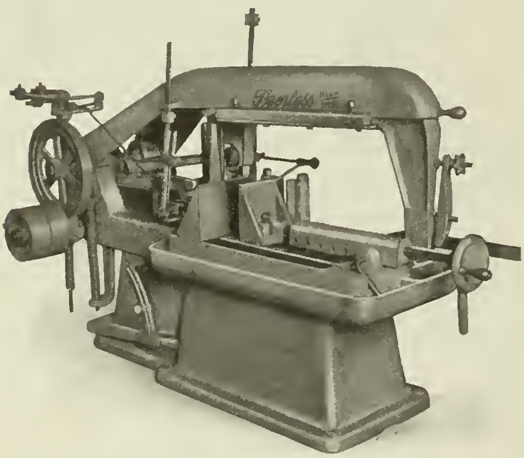


Fig. 1. Peerless High-speed Heavy-duty Cutting-off Saw

started while the saw blade is above the work it will feed right onto the work, using up the full movement of the cam until the blade comes in contact with the work; then the feed is decreased to whatever the blade will cut. If the blade should break, it again feeds right down the full movement of the cam until it comes in contact with the automatic stop; then the feeding mechanism is automatically released and the belt shifts onto the loose pulley. As the saw frame is overbalanced, it will then automatically rise to the height at which the gage is set. This relieves the operator of raising a heavily weighted cumbersome saw frame. All that is necessary for him to do is to loosen the vise, move the stock ahead and pull the belt-shifting lever forward. It will also be understood, owing to the frame being overbalanced so the movement is always upward, instead of down, that there is never any possible chance of the saw dragging on the idle stroke, regardless of the stopping or starting position of the crank. With this construction the saw frame can never drop in case the blade breaks, which may not only cause accidents to the machine but to the operator as well.

The feeding mechanism is connected with the belt-shifting lever and does not engage the feed until the belt has been

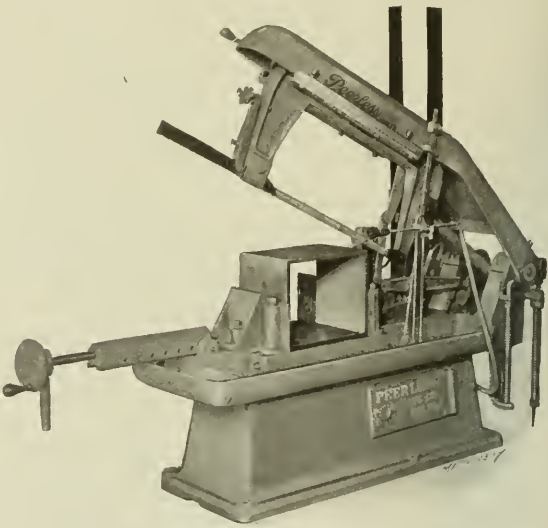


Fig. 2. Opposite Side of Peerless Saw shown in Fig. 1

shifted three-fourths onto the tight pulley. This allows the machine to get up full speed and the cutting compound to flow onto the work before the blade comes in contact, which is an important feature in this type of machinery. If a blade is allowed to make two or three strokes dry over the work before the compound flows, it affects the temper of the teeth and then the blade is condemned. This gives the operator complete control of the machine by the use of one hand, as he does not have to hold onto the saw frame with one hand while starting with the other. The feeding mechanism is so sensitive that the blade can be brought onto the work so it merely touches, making it well suited for cutting delicate work or when commencing cutting on square stock. This is accomplished by the feed lever shown on the left-hand side of the machine. The saw frame is all in one casting, as well as the saw guide, making it impossible to get out of alignment. Provision is also made for taking up wear in the saw frame slide.

This machine is driven by a set of reducing gears, four to one, which allows for a good sized driving pulley on the main shaft. A large gear is keyed onto the crankshaft and the pinion and driving pulley are cast in one. The crankshaft is made of steel, being of the center crank type, having two extra long bearings, making a substantial drive. All bearings are large, allowing the machine to be worked to its full capacity without the least vibration in any of its mechanism. The rear vise jaw swivels, allowing for miter work to be cut. The front vise jaw is of a quick-acting type, provided with a handwheel for quick adjustment on square and a ratchet handle for powerful grip. The saw blade holders are of special design, allowing different length blades to be used according to the size of stock cut. The height gage, which is located on the right-hand side of the machine, can be set so the saw frame automatically rises to whatever height the stock is being cut. A depth gage is also provided for allowing the machine to stop automatically at any depth of cut. A notched segment on the left-hand side of the machine for controlling the feed is provided with a stop gage so the same feed pressure can be applied; on some classes of work it may be necessary to relieve this feed lever in order to start the cut,

and the lever can then always be brought back to the same position.

In the cabinet base is located a brass gear pump for circulating the cutting compound onto the blade. The nozzle for distributing the compound is locked in position by thumbscrews, allowing for adjustment either way; therefore, there is no danger of its jarring loose, allowing the nozzle to move and the blade to run dry and be ruined. The saw table has two T-slots, one on each side of the blade, allowing for irregular work to be bolted onto the table. The T-slot next to the saw blade is provided with two movable angle-plates, preventing work from rolling after being cut off. A tray for collecting compound and returning it to the cabinet base is extra deep, making lots of room for saw chips and no danger of compound flowing over onto the floor. These machines are also designed for direct motor drive and with six-speed gearboxes. The illustrations represent a machine with a capacity for 13- by 16-inch stock, and it weighs approximately 1800 pounds.

S. A. & S. RECALESCENCE POINT FINDER

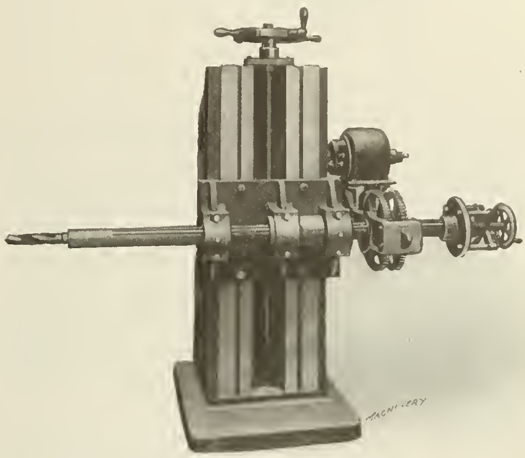
A tool is heated and quenched in oil or water to make it harder. Raising the temperature of the steel causes changes in the chemical arrangement of the elements composing the steel after the temperature has been raised to a sufficient degree. These changes are responsible for the results obtained by the well-known processes of hardening and tempering. If a piece of steel that has once been heated to a sufficient temperature to produce hardening is allowed to cool very slowly, these changes of chemical composition take place in the reverse direction, so that the steel comes back to its original condition; but if the heated tool is cooled quickly, *i. e.*, quenched immediately after removing it from the furnace, the changes in chemical composition are permanent and result in the hardening of the steel.

In addition to the line of internal and external grinders and the small tools made by the Slocum, Avram & Slocum Laboratories, Inc., 531-539 W. 21st St., New York City, this firm is also manufacturing a recalescence point finder for use in hardening tools. This is one of the first tools that has been put on the market which commercializes in an adaptable form the well-known fact that all tool steels lose their power of attracting a magnet during the interval between the decalescence and recalescence points. The Slocum, Avram & Slocum recalescence point finder consists of a specially constructed magnet, which is of compact form and carefully balanced on the brass arm, to allow the attraction of magnetic force to be shown up to the time the decalescence point is reached. At this point the steel which is being heated entirely loses its power of magnetic attraction and then reaches—at a temperature of from 85 degrees to 100 degrees F. beyond this decalescence point—that correct critical point at which the steel should be quenched.

For shop use this is a very practical way of determining the so-called "critical point" or proper temperature at which steels should be quenched in conducting the hardening operation. To make it as convenient as possible to use in the shop, the Slocum, Avram & Slocum recalescence point finder is packed in a serviceable case and provided with interchangeable extensions for the arm, making it possible for the operator to quickly apply the tool either in a gas furnace of the smallest or largest type, or to use it over an open coal-heated forge. The practicability of adapting this tool for general work in shops that are not equipped with pyrometers should commend it to attention. It is claimed to be a substitute for the pyrometer, but is valuable for use in small shops where there is not enough work to warrant the installation of an expensive pyrometer equipment.

PEDRICK COLUMN BORING MACHINE

The Pedrick Tool & Machine Co., 3639 Lawrence St., Philadelphia, Pa., is now building a column-type boring machine, which is illustrated and described herewith. This machine consists of a boring-bar mounted in a saddle which is moved vertically on the column, and it is also planned to furnish a machine of this form to be used on a floor-plate. Another variation would be to construct the machine with an outer support for the bar and with the machine proper mounted on a long bed at right angles to the bar, to provide for drilling or boring parallel holes in a piece of work. The portability of the machine serves many useful purposes when working on large pieces. Another feature is simplicity of the design, which enables the machine to be built at a moderate cost,



Column Type of Boring Machine built by Pedrick Tool & Machine Co.

although it has a fairly wide range. A powerful train of compound gears drives the boring-bar, power being furnished by an electric motor. By using different sizes of gears, various speed changes may be obtained.

In order to describe the operation of this machine, it is first necessary to describe the boring-bar, because it is the operation of this bar that differentiates the machine from other types of boring equipment on the market. The standard Pedrick portable boring-bar carries a square-thread feed-screw in a groove in the bar. This screw is supported in bronze bearings of special design which provide for taking the thrust. In re-boring cylinders and performing similar operations, the bar is held in bearings at both ends of the cylinder and a cutter-head engaging the feed-screw by a half-nut travels along the bar while performing the boring operation.

In the new column-type boring machine which forms the subject of this description, the same action is possible, the bar being supported at the outer end by a column of conventional design with an adjustable bearing to provide for aligning the bar. The advantages of boring in this manner are clearly apparent, as the bar does not have to be twice the length of the work and the work can be brought close to the main bearing so that the bar is rigidly supported. In this way larger work can be handled, a machine with a 3½-inch bar being capable of boring holes 24 inches in diameter. This method has been termed boring with a "fixed" bar.

Heretofore it has not been possible to use this type of boring-bar for any operation through which the bar could not be passed. Conditions have often called for a bar to bore long holes, but owing to the construction, the smallest diameter of the bar is limited, because the feed-screw would be too weak to give much service. A method has just been developed for making this type of bar travel like the spindle of a drill press or boring machine, thereby avoiding the limitation just referred to. This is accomplished without the use of additional mechanism, and the bar may be converted from a fixed bar to a traveling bar almost instantly. When the machine is used with the bar traveling, it possesses the same characteristics as the standard boring machines.

In the end of the bar there is a Morse taper hole for the insertion of different tools and appliances, and either drills or auxiliary bars may be used. By this means the machine will bore or drill holes smaller than the diameter of the main

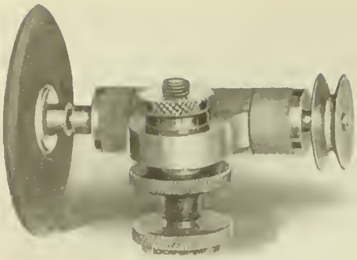


Fig. 1. External Grinding Attachment

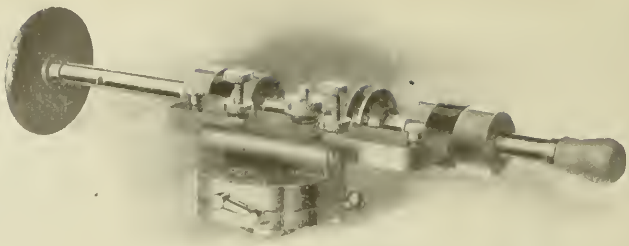


Fig. 2. Internal Grinding Attachment

bar. Imagine a piece of work having five bearings three or four inches in diameter, located at intervals of five feet. In machining this work, a suitable auxiliary bar is passed through the bearings and fitted to the end of the main bar, allowing the bearings to be bored consecutively. The work may be done accurately without requiring the use of a large boring mill, and attention is called to the fact that the machine may be taken to the work instead of requiring the work to be brought to the machine. The principal dimensions are: minimum distance from center of bar to floor-plate, 14½ inches; maximum distance from center of bar to floor-plate, 56½ inches; size of baseplate, 48 by 29 inches; size of saddle, 25 by 18 inches; vertical travel of saddle on column, 42 inches; and net weight of machine, 4200 pounds.

S. A. & S. GRINDING ATTACHMENTS AND TOOL-ROOM SPECIALTIES

The Slocum, Avram & Slocum Laboratories, Inc., of 531-539 W. 21st St., New York City, have developed a line of external and internal high-speed precision grinding attachments for bench lathe use, which are also applicable to the lighter types of engine lathes. The external grinder is shown in Fig. 1, from which it may be seen that, exclusive of the post, there are but six actual working parts. This attachment is held in the toolpost of the lathe with a special form of elevating screw that permits the grinding wheel to be adjusted with relation to the center of the work without loosening the post itself. This method of mounting also provides for swiveling the entire attachment without affecting the vertical adjustment. This type of base mounting is so designed that it supports the grinding spindle mounting, so that chatter is impossible.

The construction of the spindle, which permits of a speed of 8500 R. P. M. without heating, is interesting. The spindle and its bearings are both of tool steel, hardened and ground. thus furnishing the best possible bearing surfaces. The spindle diameter is 5/16 inch, and the double taper bearings are 3/4 inch in length. The bearing at one end is integral with the spindle, and the other bearing is a bushing that may be adjusted to take up wear. To provide adequate lubrication, the body of the fixture is bored out to form a generous pocket from which oil runs to the bearings as needed. The bearings at both ends are protected with brass dust-caps that exclude all dirt and grinding dust.

This grinding attachment will carry wheels up to 4 inches in diameter and is adapted for the precision grinding of centers, plug gages, spindles and other tools requiring similar precision. The wheels for this attachment are mounted on taper arbors that may be readily inserted in the spindle without disturbing the mounting. By using a number of these taper wheel-arbors, wheels may be instantly changed without removal from mountings.

Internal Grinding Attachment

The internal grinding attachment is illustrated in Fig. 2. This attachment is designed for high-speed precision internal grinding, driving the wheels at sufficient speed to obtain their most efficient cutting qualities, and particular care has been taken to guard against chatter. A feature of this attachment is the graduated swivel base that is especially valuable in grinding compound tapers, as it may be used in conjunction with the compound rest of the lathe. The compound rest may be set to one taper, while the graduated base of the attachment may be changed quickly to agree with the second taper.

A second feature is the provision that enables the operator to draw the grinding wheel instantly away from the work at any stage of the grinding operation, thus allowing him to quickly and accurately measure the work in hand without interference from the wheel. This is accomplished by a hinge connecting the head that carries the grinding-wheel spindle mounting with the base of the fixture. Adequate provision is made for return to the identical position where the operation left off by using hardened elevating adjusting screws. A clamping screw locks the hinge and holds the fixture securely in the grinding position.

The construction of the spindle is of interest, and is similar to that of the external grinder, except that the bearings are very widely spaced. This spindle is 7/16 inch in diameter, made of tool steel, hardened and ground. The spindle does not turn in its bearings, but slides in bearing sleeves, which, in turn, rotate in the bearings. Tool-steel balls at the base of the set-screws in these sleeves allow the spindle to slide but not to rotate. This sliding action forms the only source of wear upon the spindle. As in the case of the external grinding attachment, the spindle is provided with a taper socket to receive wheel-arbors. The spindle is fed longitudinally by hand, and because of its special mounting is very sensitive in its action.

The spindle bearings are made of tool steel, and like the tool-steel spindle, are hardened and ground. These sleeve-like bearings are ¾ inch long and provided with a double taper that allows perfectly free rotation, yet without end play. Adequate protection of the bearings against dirt and dust is afforded by brass bearing caps. The oil reservoir in the internal grinding attachment is even more adequate than in the external attachment, for a deep reservoir runs back into the body, and oil is supplied through dust-proof oil cups.

Toolmaker's Square with Indicator

The indicating toolmaker's square shown in Fig. 3 is a device for determining instantly how many degrees a piece of work is out of square. Formerly it was necessary for the toolmaker to hold a solid square on the work before a light and judge the variation from 90 degrees by his eye. With this new indicating square this is not necessary, as it determines at once how many degrees the work is out. The engaging pin is for making it into a perfect square and holding it to a fixed angle of 90 degrees.

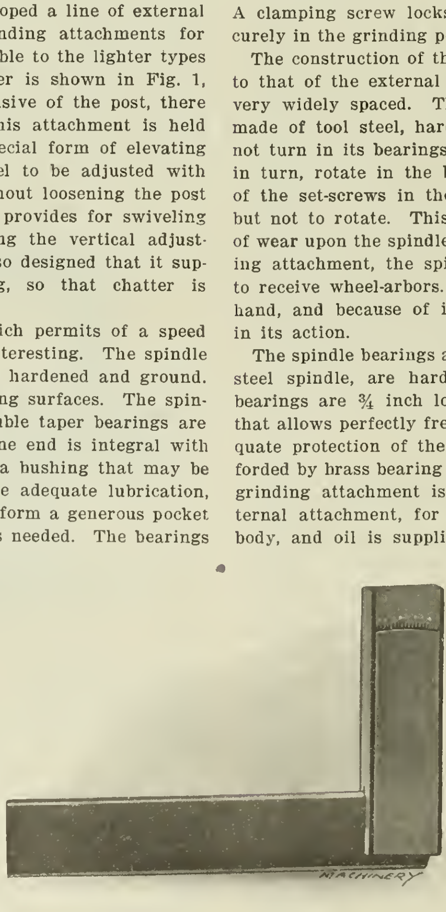


Fig. 3. Indicating Toolmaker Square

Fig. 4. Adjustable Limit Snap Gage

In addition, there is a thumbscrew that permits the blade to be locked at any desired angle up to 10 degrees plus or minus, thus making the square to all intents and purposes an angle gage. The blade is hardened and ground and has two knife-edges, so that the outside or inside edge of the square may be used at will. In general appearance, the square resembles a solid square, as all the mechanism is within the stock, but the interior is readily accessible by withdrawing a slide from either side.

Adjustable Limit Snap Gage

The adjustable limit snap gage shown in Fig. 4 has an interchangeable but solid anvil base made of tool steel, hardened, ground and lapped. This lower flat anvil is so balanced in its proportions that it provides a supporting surface from which the gaging operation may be started, thus

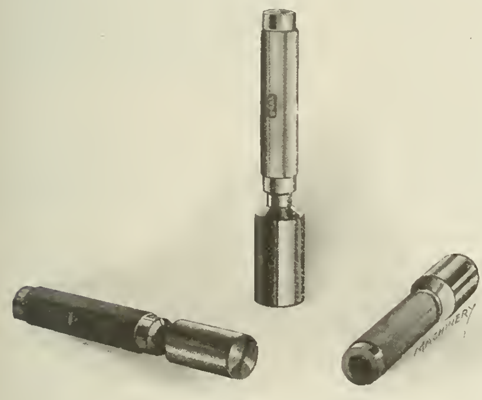


Fig. 5. Interchangeable Plug Gages

bringing the brunt of the gaging contact on this generous anvil block and not on the gaging points above. The two gaging plugs may be set to "Go" and "Not Go" sizes quickly, and when once set may be readily sealed by the gage inspector. The body of the gage is made of a fine close-grained gray iron casting. Before being machined the gage castings are thoroughly seasoned, and while heavy enough to withstand shop use, they are as light as an efficient gage of this type should be. A fiber finger grip on each side of the gage prevents expansion due to heating in the hand. The size of the gage is stamped in inches below the fiber grip on each side. The tool-steel plugs and anvil are made as individual units, ground and lapped before assembling, and are interchangeable.

Interchangeable Plug Gages

Fig. 5 shows one gage from a line of interchangeable plug gages made by the company. These plugs have a two-piece screw-head which operates the plug forward or back as desired. The plug is lapped and closely fitted to the screw head by a spring lock-washer, uniting the plug to the screw as a single unit. The handle is of cold-rolled steel left soft, while the plug itself is of hardened, ground and lapped tool steel. The handle is hollow, and the gages proper have taper shanks that fit into the taper socket of the handle. This gage is most flexible in its adaptability, as one handle can be used for several gages. The saving in steel is considerable and the lightened handle makes the gage sensitive to handle. Provision is made for pinning the gage to the handle when deemed advisable. The gage is adaptable for use on plug thread gaging, and when desired can be furnished in the double-end type in which the "Go" and "Not Go" ends may be used in the same handle.

Sine Bar Fixture

Fig. 6 shows the type of sine bar that the S. A. S. Laboratories are building. This sine bar is universal in its use, the distinguishing feature being the method employed for facilitating the setting of the bar in the desired position. The bar has one end fixed, and can be readily set at any angle by swinging the bar up or down, the lower button, which is constant, acting as the fulcrum, while the upper button slides in the radial slot. After the bar is set, the work can be easily clamped in position by the holes shown. This sine bar is made in different sizes, covering all toolmaking requirements.

Thread Measuring Machine

In Fig. 7 is the new thread measuring machine for checking such work as plug gages, etc., by the three-wire system. The work is held on a central arbor that runs in bushed holes in the fixture. At right angles to the work is a deep slot in the fixture that terminates in a T-slot. In this slot slides a special micrometer caliper; the measuring points of this caliper are on a plane with the center line of the arbor, and as the caliper is keyed in the T-slot, it always retains its alignment. The micrometer is set by means of Johansson gages, the gage to be measured being placed in position and the right wires slipped between the gage and the measuring points. This method eliminates the trouble usually encountered in holding the wires in place by means of elastic bands, and insures perfect measurement. When testing concentricity, the work is easily rotated on the arbor without disturbing the alignment.

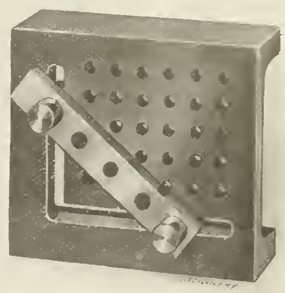


Fig. 6. Improved Type of Sine Bar

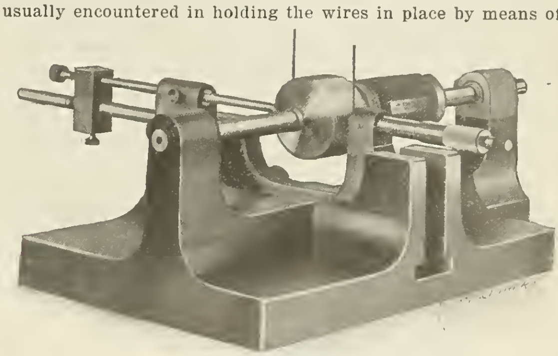


Fig. 7. Precision Thread Measuring Machine

SIMPLEX INDEPENDENT CHUCK

Some users of independent chucks have experienced trouble through loss of gripping power after the chucks have been in use for some time, because there are no means of taking up lost motion between the jaws and their guides. With the view of overcoming possible trouble from this source, the Simplex Tool Co., Woonsocket, R. I., has designed an independent chuck, which is illustrated and described herewith. The body is

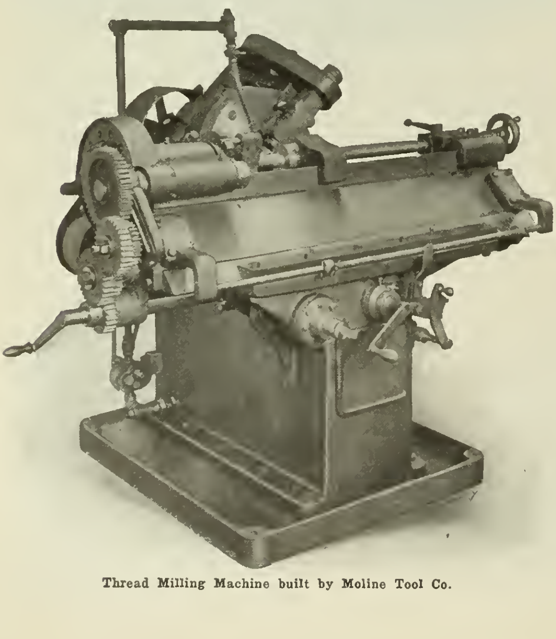
Simplex Four-jaw Independent Chuck

made of high-grade cast iron and the jaw ways are deeply planed across the face. These jaws are separably reversible and are so constructed that any backlash which develops is automatically adjusted. All screws are made from forgings and turned all over; they are hardened and tempered to give the desired strength and durability. The screw bushings are of high-carbon steel and provided with durable bearings and collars for taking up the end thrust of the screws.

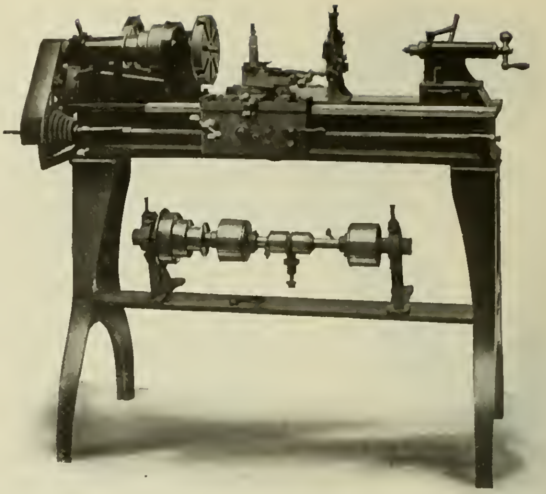
MOLINE THREAD MILLING MACHINE

To meet the requirements of shops that are called upon to cut heavy worms and spirals, the Moline Tool Co., Moline, Ill., has developed what is known as a heavy-duty thread milling machine, which is illustrated and described herewith. In handling work of the kind for which this machine is intended, it is essential to have the machine as rigid as possible, and in working out the design great care was taken to combine the features of heavy construction and simple design. The Moline Tool Co. has had wide experience in handling the class of work done on this machine, and this decided the company in favor of a machine with a traveling table and the cutter held stationary with the exception of providing sufficient traverse to feed the cutter in and out of the work. The majority of operations of this kind are of such a kind that a driving gear can be used on the cutter-arbor which is much larger than the diameter of the cutter, and this is a desirable condition both as regards durability of the cutter and smoothness of the cut. Bearing this in mind, it was decided to use a large driving gear on the cutter-arbor, although this gear can be removed and a small gear substituted when necessary.

The cutter-arbor is hardened and ground and runs in bronze bushings. It is driven through a powerful spur and spiral gear train. The lead-screw is splined its entire length and is made heavy to avoid danger of torsional deflection. The change-gears used on this machine are six pitch. The indexing device consists of a plunger which drops into an indexing plate set into the back of the main spindle driving gear. Work can be held on centers or in a collet chuck, or a three-jaw chuck can be screwed to the spindle nose. A steadyrest block is furnished to which bushings can be fitted for supporting worms on their large diameter or on the shaft, as may be desired. The capacity of the machine is for swinging 8 inches and taking work up to 30 inches in length between centers; the spindle is bored 3 9/16 inches to allow a 3 1/2-inch shaft to pass through it. The regular equipment furnished includes a pump and piping with a tank in the base, a two-speed countershaft, an index plate with any desired number of holes, a bushing for the steadyrest block, and a set of change-gears. The weight of the machine is approximately 5000 pounds.



Thread Milling Machine built by Moline Tool Co.



Sterling 12-inch Back-geared Lathe

STERLING LATHE

The Sterling Machine Tool Co., Paulding Place, Cincinnati, Ohio, is now building the 12-inch back-geared lathe that forms the subject of the following description. This lathe is built with beds of different lengths to provide for taking 24, 36, and 48 inches between centers. Reference to the illustration will show that the machine is of light but compact design, and it is said to be capable of turning work accurate to 0.0015 inch in 18 inches. The lathe has independent longitudinal and power cross-feeds, semi-quick-change gears, a compound rest, and is made to be driven by either foot power, a belt, or individual motor. The regular equipment furnished with the machine includes a compound rest, steadyrest, faceplate, friction countershaft, gear guards, and the necessary wrenches for making all adjustments. Extra attachments that are available for use on the machine include a milling attachment, gear-cutting attachment, turret attachment, and taper attachment.

The principal dimensions of the machine are as follows: swing over bed, 12¼ inches; swing over carriage, 8 inches; diameter of hole through spindle, 1 inch; diameter of spindle nose, 1⅝ inch; size of front and rear spindle bearings, 1 7/16 by 2¼ inches; size of cone pulley, 3, 4½, and 6 inches in diameter by 1½ inch face width; ratio of back-gears, 7 to 1; diameter of tailstock spindle, 1 3/16 inch; diameter of lead-screw, 13/16 inch; threads per inch on lead-screw, 5; travel of tail spindle, 4½ inches; length of carriage on bed, 12 inches; travel of compound rest, 2¼ inches; size of lathe tools, ½ by 1 inch; range for thread cutting, 3 to 120 threads per inch; and diameter of faceplate, 8 inches.

BAUSH STATION TYPE CRANKSHAFT DRILLING MACHINE

For drilling and reaming six holes in the flange of crankshafts, the Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass., has recently designed and built a special form of its station type machine, which is illustrated and described herewith. While the details have been modified to meet the requirements of this work, the general features are similar to preceding types of machines built for other purposes; in the present instance six holes can be drilled and reamed in the flange of a crankshaft in fifty seconds. Fig. 1 shows station No. 1, where the operator loads and unloads the crankshafts. Attention is called to the "start" and "stop" push-button control, which is conveniently located at the operator's right hand. This is an Electric Control & Mfg. Co.'s apparatus, and it governs a five-horsepower Westinghouse motor mounted on top of the machine. Below the electric switch there is a hand-lever for controlling the feeding of the drill heads to the work.

All the bearings in the machine are automatically lubricated,

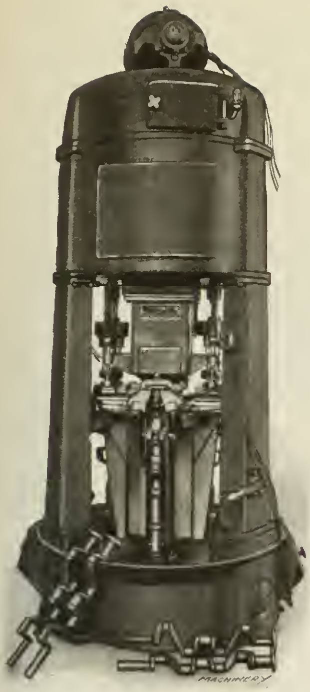


Fig. 1. Baush Station Type Machine for drilling and reaming Six Holes in Crankshaft Flange

and sight-feed oilers are located where the operator has a clear view of them. Stations Nos. 2 and 3 are shown in Fig. 2, and this close view shows clearly how each crankshaft is supported vertically on centers and held in fixtures which are free to float universally in order to line up correctly with the heads each time the table is indexed. At station No. 2 two pin holes are drilled in the crankshaft flange, and these holes are reamed at station No. 3. Flexible tubes carry cutting oil to the tools, and attention is called to a pump located near the base of one column; this pump is furnished with a relief valve shut-off. There is a fourth station at which the four bolt holes in the flange are drilled. On this machine the 15/32-inch drills are driven at 202.6 revolutions per minute and are fed at 0.0053 inch per revolution. For reaming, 0.441-inch reamers are driven at 74.6 revolutions per minute, and the rate of feed is 0.0138 inch per revolution. The machine is 4 feet in diameter by 10 feet high and weighs approximately 5050 pounds.

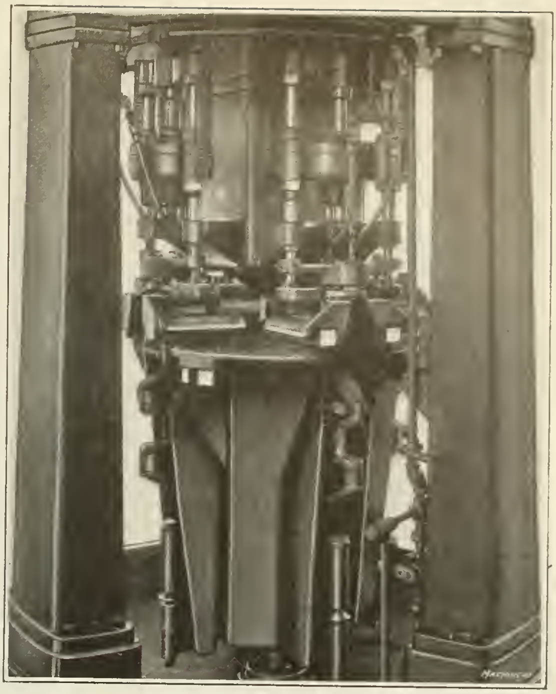


Fig. 2. Close View of Stations Nos. 2 and 3 on Machine shown in Fig. 1

LEISY-PATTON SHAPER

The Leisy-Patton Co., Cleveland, Ohio, is now building a shaper which forms the subject of the following description. Taper gibs have been provided throughout to afford means of adjustment. The table support is readily adjusted to suit any elevation, and the cross-rail cavity for the table feed-screw is on an angle which serves to prevent accumulation of chips and dirt. Both the body and base of the machine are ribbed internally to eliminate spring and afford the necessary rigidity. The semi-steel bull gear is run by a bronze pinion, which combination affords the double advantage of strength and durability.

The principal dimensions of this machine are as follows: maximum length of stroke, 20½ inches; horizontal travel of table, 26¼ inches; distance from table to bottom of ram for position of lowest adjustment, 14½ inches; size of vise jaws, 12 inches long by 2½ inches high; maximum opening of vise jaws, 10 inches; width of ram, 10 inches; length of ram, 38½ inches; length of ram bearing on column, 31¼ inches; minimum speed of ram, 8 strokes per minute; maximum speed of ram, 98 strokes per minute; maximum feed, 3/16 inch per stroke; size of table, 18⅜ by 14 inches; length of rocker arm, 31⅝ inches; width of belt, 4 inches; speed of countershaft, 215 revolutions per minute; diameters of four-step cone pulley, from 7¾ to 13 inches, 3 inches face width; number of available speed changes, 8; and floor space occupied by machine, 4 feet, 2 inches by 4 feet, 5 inches.

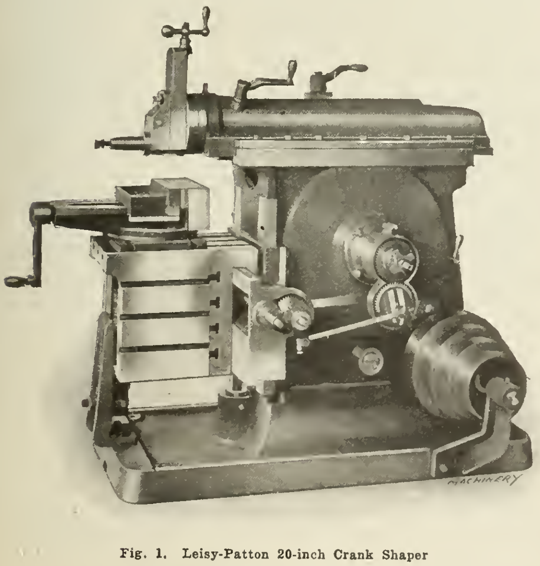


Fig. 1. Leisy-Patton 20-inch Crank Shaper

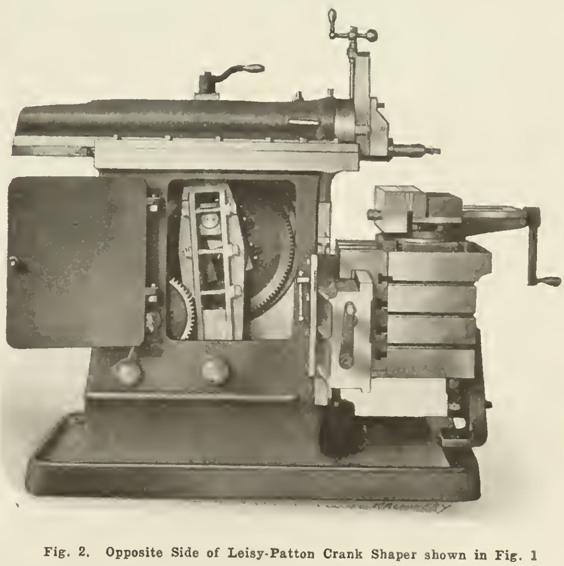


Fig. 2. Opposite Side of Leisy-Patton Crank Shaper shown in Fig. 1

J. G. BLOUNT DRAW-IN FRICTION HEADSTOCK

J. G. Blount Co., Everett, Mass., is now building a friction headstock lathe with a draw-in mechanism, which is illustrated and described herewith. This machine is well adapted for the rapid production of small machine parts. The spindle is provided with a draw-in attachment and is driven by means

J. G. Blount Friction Headstock Lathe with Draw-in Mechanism

of a friction, operated by a foot-treadle. A spring under the sleeve draws the collet back into the spindle and causes it to grip the work, while a forked lever spans the sleeve and is connected to the foot-treadle in such a way that application of pressure opens the collet and instantly stops the spindle. The work can then be removed or put into the collet, and both of the operator's hands are free to handle the work or tools. Self-oiling bronze bushings support the spindle, and the spindle nose is fitted with a hardened bushing to avoid wear while closing the collet; also, the spindle nose is threaded to provide for using a chuck or faceplate. This headstock is also arranged for mounting on a bench, and collets can be used which have a capacity for handling work up to 5/8 inch in diameter.

NEW MACHINERY AND TOOLS NOTES

Polishing and Buffing Lathe: Noble & Westbrook Mfg. Co., Hartford, Conn. It is claimed that as the unbalanced grinding or buffing wheels used on this lathe will automatically find and revolve in their center of gravity, these machines make unnecessary all preliminary balancing of the wheels when setting up.

Bench Drilling Machine: Henry & Wright Mfg. Co., Hartford, Conn. The work may be drilled either on the base or on the swinging table. The maximum distance from the table to the chuck is 3 1/16 inches, and from the base to the spindle, 8 inches. The minimum distance from the base to the spindle is 5 inches. The machine weighs 135 pounds.

Single-purpose 17-inch Lathe: Wickes Bros., Saginaw, Mich. While this machine is intended for fast heavy work, it is not equipped with back-gears or screw-cutting mechanism. It has three feeds, which are operated by the quick-change lever and the spindle has ball thrust bearings for taking up the end thrust. An automatic stop may be provided.

Wire and Metal Former: M. D. Kilmer & Co., Cleveland, Ohio. This former will handle wire from No. 26 to No. 3 gage, with only slight changes in adjustment. With the ten adjustments furnished, it is possible to make a large number of finished forms. Figures on the plate indicate the length of wire to be fed and the angle to which it should be bent.

Grinder for Gear-cutters: Fenn Mfg. Co., 516 Asylum St., Hartford, Conn. The work and the indexing mechanism are mounted on a table that swings on bearings protected from dirt by oil-soaked felt washers. As this table may be raised or lowered on the vertical post, the cutter may be located in the desired position. The motor is attached to a hinged plate beneath the bed and the belt is inside the head.

Hellman Universal Triangle: Charles E. Baker, Indianapolis, Ind. This instrument is a 6-inch, 45-degree, nickel-plated steel triangle, with the hypotenuse in two parts, the larger of which moves on a hinge. The loose end of the hinged section has a groove that fits over a tongue milled to the proper radius on a triangle and may be set to form any angle from 0 to 45 degrees with one side and from 45 to 90 degrees with the other.

Air Compressor: Yokom Sales Co., Port Huron, Mich. The piston of this compressor is driven by a ball-bearing eccentric, the bottom of the piston being held in contact with the outer ring of the bearing by springs. The small compressor, which has a 3-inch bore, has a capacity of 1.8 cubic foot of air per minute, and a power consumption of 1/4 horsepower, while the larger machine delivers 4 cubic feet of air and requires 3/4 horsepower.

Pipe-threading Machine: William T. Johnson Co., Cincinnati, Ohio. This machine is fastened to the section of pipe to be threaded by an expanding sleeve. A standard pipe-thread taper cut on one end of this sleeve serves as a feed-screw. The arm that engages this thread also carries the cutting tool, which is a piece of 3/8-inch square high-speed steel. The operation is repeated a number of times, the tool being advanced a little each time, just as when cutting a thread on a lathe.

Titeflex Metallic Tubing: Titeflex Metal Hose Corporation, 141 Broadway, New York City. Because of the U-shaped sections of this tubing, packing is unnecessary, as there is no sliding of the parts of the joints. It is claimed that the joint becomes tighter with an increase of pressure; that the tubing will carry practically any pressure; and that it is unaffected by heat or cold. For tubing that is to be subjected to rough usage or abnormal exterior wear, a covering of interlocking steel ribbon is provided.

Blueprint Ironer: American Laundry Machinery Co., Cincinnati, Ohio. All types of blueprints, black-line, and Van Dyke prints are ironed and dried by this machine. A fabric apron carries the prints underneath and around a 20-inch cylinder, which may be heated by steam, gas, or electricity. The machine requires 55 cubic feet of gas per hour, 11 kilowatts of electricity, or from 1 1/2 to 2 boiler horsepower of steam at from 6 to 10 pounds pressure. Allowing for delays, it has a capacity of 45 square feet per minute.

Automatic Grinding and Polishing Machine: Kane & Roach, Niagara and Shonnard Sts., Syracuse, N. Y. This machine is designed to grind and polish 1/4- to 5/8-inch tubes and drill rods. In order that there will be no scratches on the finished product, the material is fed in through hardwood tubes. It is then run between hardened tool-steel rolls set at such an angle that the material revolves as it is fed between the polishing belts. The feeding rolls revolve the material between these belts in a direction opposite to the travel of the belts.

Remote Control Switch: Cutler-Hammer Mfg. Co., Milwaukee, Wis. The solenoids that operate this switch, one opening and one closing it, are energized by circuits connected to push-button control switches, which may be placed wherever desired. The contacts are kept closed by a mechanical latch, thus reducing the current consumption. The switches are made with a capacity of 100 amperes for use on either alternating or direct current; they are also made in single-, double-, and triple-pole types. One of their applications is the control of lighting circuits from a distant point or central location.

Motor Headstock for Wood-working Lathes: Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. In this lathe the faceplates, or centers, are mounted directly on the motor shaft, and various speeds are obtained by means of the controller mounted at the front of the lathe. Motor speeds of approximately 570, 1140, and 3460 revolutions per minute are provided with alternating current, and from 600 to 3000 revolutions per minute with direct current. In the latter case, a commutating-pole shunt-wound motor is used. With the alternating current, a dynamic braking effect is obtained by manipulating the controller for the next lower speed.

Adjustable Lifting Truck: F. J. Bloodgood Co., Binghamton, N. Y. This truck, which can lift and carry loads from 1000 to 6000 pounds, has a U-shaped frame, the width of which is easily varied, so that the truck can handle loads of any widths. In use, the frame is placed around the object to be carried and the front is raised by means of the screw jack attached to the base of the U at the front of the truck. When the front of the object is raised sufficiently, a bar is passed through the rear wheels, which are placed slightly back of the center of the load; then the jack is lowered, placing the greater part of the weight upon the roller bearing wheels. The frame is not relied upon for support to any extent.

* * *

According to invoices certified at the American consulate general at Rio de Janeiro, Brazil, the exports of manganese ore to the United States increased from 244,946 metric tons, valued at $2,880,107, for 1915, to 496,498 tons, valued at $7,928,869, for 1916.

TORSIONAL TEST OF "NATIONAL" PIPE

The accompanying illustration shows what at first glance might be taken for a twisted sheet of rubber, but instead it is a piece of eight-inch "National" line pipe after having been subjected to a torsional stress of 713,000 inch-pounds and twisted 360 degrees. Eight-inch line pipe weighs about 29

Torsional Test of "National" Line Pipe

pounds per foot, and the wall is approximately one-third inch thick. The test specimen shows the homogeneity, ductility and high tensile strength of the steel.

* * *

ACTIVITIES OF THE S. A. E.

A Washington office has been opened by the Society of Automobile Engineers (hereafter to be known as the Society of Automotive Engineers) in the Munsey Bldg. in connection with the Council of National Defense. This action was taken to bring about closer cooperation of the society with the various government departments. The society has cooperated with the quartermaster's department in drawing specifications of the 1½- and 3-ton military trucks. A great deal of other work remains to be done.

Because of war conditions, the summer meeting scheduled to be held the last week in June at Ottawa Beach, Lake Mich., has been called off. An extensive canvass of many connected with the activities of the society showed a general feeling that few of the members could afford to spend four days at the summer meeting. Instead of four days at Ottawa Beach, it was voted to spend one day on the summer meeting at Washington, D. C.

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LUBRICATION OF CUTTING TOOLS—CORRECTION

It has been brought to our attention that there might possibly be some misunderstanding with reference to the statement in the third paragraph, left-hand column, on page 707 of the April number, in the article "Lubrication of Cutting Tools—4," regarding the investigation on fire hazard of cutting oils. The investigation referred to, which was conducted by Edward A. Barrier, chemical engineer, was undertaken by the Inspection Department of the Associated Factory Mutual Fire Insurance Cos., on their own initiative, as a result of their appreciation of the fact that large quantities of cutting oil as at present used in many machine shops might present a serious fire hazard.

* * *

"CHAMPION" ENGINE LATHE

The "Champion" engine lathe is made by the Champion Tool Works Co., Cincinnati, Ohio. An article in the April number describing the "Lancaster" 13-inch lathe made by the Champion Blower & Forge Co. of Lancaster, Pa., was erroneously headed "Champion Engine Lathe," from which some may have inferred that the lathe made by the company is to be known as "Champion." The article, however, states that the lathe is to be known as the "Lancaster."

NATIONAL METAL TRADES ASSOCIATION'S CONVENTION

The nineteenth annual convention of the National Metal Trades Association was held in New York City, April 23 to 26, inclusive. The convention program proper began Wednesday morning. William H. Van Dervoort, president, delivered a masterly address in which he reviewed the business conditions and pointed to some of the problems that would confront American manufacturers during the war and particularly following the close of the war. F. C. Caldwell, treasurer, in making his report, referred to the difficulties that had been experienced during the past year with labor and labor unions and the drains on the treasury incident to combating strikes and labor hold-ups. The treasury, nevertheless, is in very satisfactory condition, thanks to the generosity of the membership. John D. Hibbard, commissioner, reported on the activities of the association, going into considerable detail as to the work done; and Homer D. Sayre, secretary, also reported on the activities with which the secretary was particularly concerned. Reports of standing committees were made by F. A. Geier, on industrial education; W. A. Viall, on apprenticeship; John W. O'Leary, on membership; and by F. E. McKee, on the prevention of industrial accidents. Unfortunately, Howard E. Coffin, who was scheduled to speak on the activities of the Council of National Defense, was unable to be present because of the emergency with which the country is now confronted. Other papers in the afternoon schedule were:

"The Bankers Cooperation with Industry," by F. C. Schwedtman.

"National Industrial Conference Board," by William H. Barr.

"The American Institute of Weights and Measures—What it Stands for," by Luther D. Burlingame.

The regular convention banquet was held Wednesday evening at the Hotel Astor.

On Thursday morning Wallace Downey delivered an address on the merchant marine, following which were timely addresses by A. L. Humphrey of the Westinghouse Air Brake Co., George F. Steedman of the Curtis & Co. Mfg. Co., and James T. McCleary of the American Iron and Steel Institute.

* * *

WORLD'S GOLD OUTPUT

A century ago, the bulk of the world's gold output, which was $7,300,000 annually, was derived from workings in the Ural Mountains; but as other sources of supply were discovered the production rapidly increased until, in 1916, it amounted to $465,845,700. Forty-seven per cent of this, or $218,973,000, was produced in South Africa, 41 per cent being obtained in the Rand. The total gold output of the British Empire was $292,904,900; $11,193,000 was obtained in India. Until the discovery of the Yukon fields, nearly all the output of Canada was a by-product in connection with copper smelting, and averaged only about $973,000 worth of gold per annum; last year's Canadian output was $19,709,300. While the total output of the American fields, since the first Californian finds in 1847-48, has been approximately $3,397,000,000, the output of the United States last year was $92,643,000. This was about $4,000,000 more than the output in 1913 but about $6,000,000 less than that of 1915.

* * *

UNITED STATES ARMOR PLATE PLANT

The United States armor plate and projectile plate plants for which Congress appropriated $12,700,000 will be built at Charleston, W. Va. The armor plant appropriation was $11,000,000, and the projectile plant appropriation $1,700,000. The location was chosen as being ideal because of being near large coal deposits and deposits of basic and Bessemer iron ore. Limestone is also quarried in the vicinity. The chief reason, however, for locating the plant near Charleston is the security afforded by being in the Appalachian range many miles from the seacoast, where it is not likely to be seized in an invasion by an enemy.

ELECTRICALLY HEATED PRESSES FOR MOLDING MATERIAL

In industrial service electric heating has many advantages over steam heating which represent an actual saving in money, and in almost every instance the former effects an increase in efficiency that offsets any difference in cost. A step toward the more general application of electric heating in industrial processes has recently been made by the Westinghouse Electric & Mfg. Co. of East Pittsburg, Pa., in the adoption of electric heating for twenty-three presses used in the manufacture of molded composition material. These presses were formerly heated by steam, but a trial electrically heated press proved so satisfactory that the entire set of presses in the company's molded insulation department is now being modified for equipping with electric heaters.

The illustrations show the construction of the machines and the relation of the heaters to the presses. The heat is furnished through two plates, 1 foot square by 3½ inches thick, shielded on their exposed surfaces with magnesia to reduce the radiation losses. The upper plate is stationary and has a hole in it in which a thermometer is inserted to indicate the temperature, as shown in Fig. 1. The lower plate is movable vertically. Each plate is made up of two parts, in each of which there are two grooves. The heating units lie in these grooves, as can be seen in Fig. 2. Thus there are four heating units to each plate, or eight per press. Each unit is 12 inches long by 2¼ inches wide, 3/16 inch thick, and is rated at 300 watts. The heating units are of the Westinghouse steel-clad bayonet type, consisting of a flat ribbon resistor assembled in a mica sheath and enclosed in a heavy steel casing. This construction reduces the possibility of injury to a minimum, and also provides rapid transfer of heat from the resistance element, thus insuring long life under severe conditions of service.

The presses are arranged in sets of four. Current is supplied to each set through a multi-tap transformer and a dial plate. By turning the controller handle on the dial to different positions, varying voltages can be impressed across the heaters. The dial has fifteen contacts and furnishes fifteen voltages, varying from a maximum of 220 volts—the line voltage—to a minimum of 150 volts, with relative inputs for each set of heaters of from 2400 watts maximum to 1200 watts minimum. This arrangement provides for an input of high value for quick heating when the press is cold and it is desired to heat it rapidly; one of low value when the press is not to be used but is to be kept hot for later use; and several intermediate inputs when it is desired to keep the press hot while in steady use on work having different heat requirements.

In the morning the heating plates of the presses, after having been idle during the night, are cold. Before putting a mold into the press, the operator first has to bring the temperature up as quickly as possible. This is accomplished by turning the controller handle to the maximum heat position, the two plates being pressed together to decrease the radiation losses as much as possible. When the proper operating temperature has been reached, the controller handle is turned back to the position experience has shown will maintain the proper temperature for heating the molds. The lower plate is then lowered and the mold to be heated is placed on it, when the lower plate is raised again, with a certain pressure. The press is then left in this position for the length of time required to heat the mold, when the lower plate is again lowered, the hot mold removed, and another cold one put in its place.

During the noon hour, or during periods of rest when the press is not being used but it is desired to keep the plates hot for future use, the controller handle is turned to the position which will supply the radiation losses of the machine, the plates being left together to decrease such losses.

The temperature and the length of time required for one operation depends on the material being heated and the size

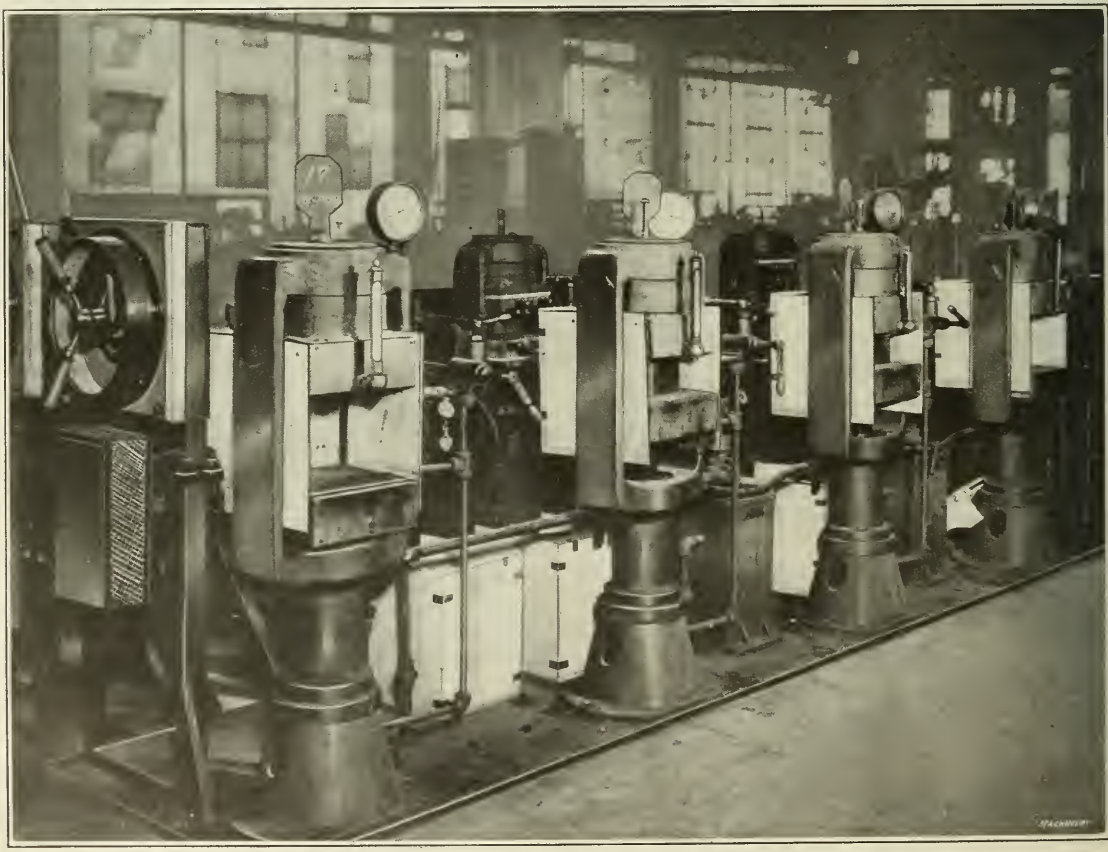

Fig. 1. Electrically Heated Presses and Transformer for varying Voltage

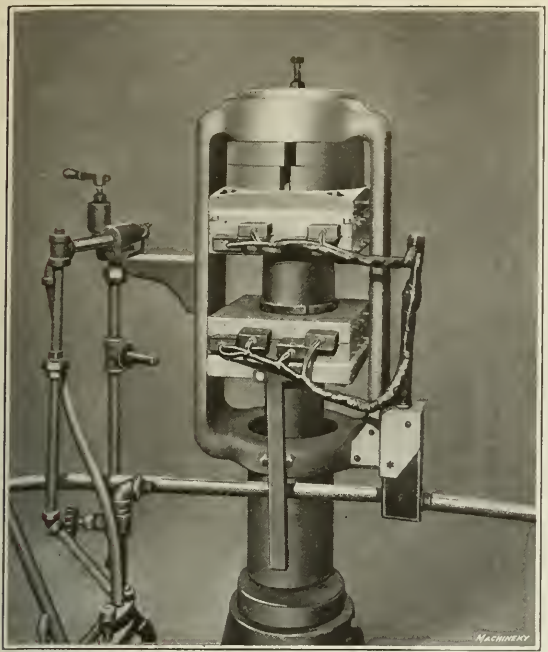

Fig. 2. Close View of Press with Magnesia Covering removed to show Wiring and Heating Units

of the mold. A series of tests made on one of the presses shows that from 1 to 1¼ hour is required to heat the plates of a press, starting with the plates cold, and that 1800 watts are required to keep the press hot while in steady use for work requiring a temperature of 180 degrees C. Should the nature of the material be such that a different temperature is required, or if it is desired to increase or decrease the amount of heat, it is only necessary to turn the controller handle to a position that will give the proper amount of heat necessary.

* * *

THE METRIC SYSTEM IN GREAT BRITAIN

The tremendous change that has taken place in Great Britain during the past three years manifests itself in numerous ways. In the field of engineering, perhaps no indication is more significant than the fact that *Engineering*, in a leading editorial, in the issue of March 30, entitled "The Metric System," takes a friendly view toward the adoption of the metric system in Great Britain and, while retaining its usual well balanced judgment on engineering questions, expresses opinions that can be understood in no other way than as an advocacy of the metric system. This, indeed, would have been unbelievable and unheard of three years ago.

"There are only two systems possible in this country (Great Britain)," says *Engineering*, "our own and the system which is already obligatory with 437,000,000 people and optional with 727,000,000 in other countries. . . . The adoption of the metric system in this country has been largely treated as an academic question in the past. In spite of our system—or want of system—we have been successful, and our exports have risen with satisfactory uniformity. We have made money, we have amassed capital, and we have spent lavishly. But we are now entering upon another phase under quite new conditions. After the proclamation of peace, we shall be faced with greatly increased wages and enormous taxation, and the national income, which was once ample, will no longer suffice. Prices will be high, and although the working classes will be able to spend, the middle classes with fixed incomes will be obliged to curtail their outlay. Under such conditions we must extend our trade abroad by every possible means, and to do so we must copy our rivals—that is, we must take trouble to meet the desires of our customers. The first step toward that end is to count the cost and to compare it with the possible gain, and, if the calculation shows a profit, to go forward. It must be remembered that the cost is not a continuing one. Once the outlay and confusion attending the change have been encountered, they are at an end, while the profit will go on from year to year."

It is further mentioned that since 1840 thirty-four countries have abandoned their original standards and adopted the metric system. Not one country has adopted the British measures, and no country has abandoned the metric system and gone back to its old units. *Engineering*, however, by no means underestimates the difficulties of a change. It recognizes that "in no country was the change so difficult as it will be here, for in none was manufacture so highly organized. We shall have to pay for our footing when we enter the community of metric countries, and the point that waits for settlement is what it will cost us. . . . Our own impression is that the cost will be found to be very much less than many anticipate."

The above statement from *Engineering* is reproduced because of the peculiar interest to American engineers at the present time, when the subject is again being considered in this country, and when two organizations have been founded, one known as the American Institute of Weights and Measures, the object of which is to oppose the metric system, and the other, the American Metric Association, the object of which is to further the adoption of the metric system in the United States. The activities of these two organizations will tend to make the subject more thoroughly understood by engineers in the United States, and in the course of discussions that will take place, much valuable information, both for and against the metric system, will, no doubt, be placed on record. Should Great Britain adopt the metric system, it is evident that the question of its adoption in the United States will become more acute than ever, and the more authoritative and unbiased opinions on the subject that can be placed before American manufacturers and engineers, the more easily will a decision be reached when the time comes that a decision must be reached.

* * *

SPECIAL GEAR-HOBBING MACHINE

When the Phoenix Mfg. Co., Eau Claire, Wis., started to prepare for the manufacture of Conradson engine lathes, difficulty was experienced in making the necessary arrangements for cutting the gears. The shop was not equipped with machines for cutting the gears used in the lathe headstock, carriage, etc., and both builders of gear-cutting machinery and shops engaged in the performance of contract work in gear-cutting were so busy that it was impossible for the Phoenix Mfg. Co. either to buy gear-cutting machinery to cut gears in its own shop or to contract for having the gears cut and obtain reasonably prompt deliveries. When these conditions became apparent, C. M. Conradson decided that the only step open to the company was to build a special machine for doing this work, and the result of his efforts in this direction is the gear-hobbing machine which forms the subject of this article.

In order to facilitate the work of building this machine as far as possible, the design was worked out in such a way that use could be made of one of the bed castings for a Conradson lathe. Those who are familiar with the construction of these lathes will notice that use has also been made of the standard tailstock and parts of the standard carriage. This machine is adapted for hobbing spur and spiral gears and worm-wheels, and to adapt it for handling all these classes of work, mechanism had to be provided to meet the following conditions: In hobbing spur and spiral gears, provision must be made for rotating both the gear blank and the hob, and also for feeding the hob across the face of the gear. For hobbing worm-wheels, similar provision must be made for rotating the work and hob; but instead of feeding the hob across the face of the blank, it must be fed into the work to cut the teeth to the required depth. The means provided for obtaining these results will be explained in detail as the different sections of the mechanism are described. It will be of interest to note that all the work involved in designing and building this machine was completed in six weeks; and using the prices for gear-cutting quoted by jobbing shops as a basis of calculation, the machine paid for itself within the first thirteen days that it was in operation.

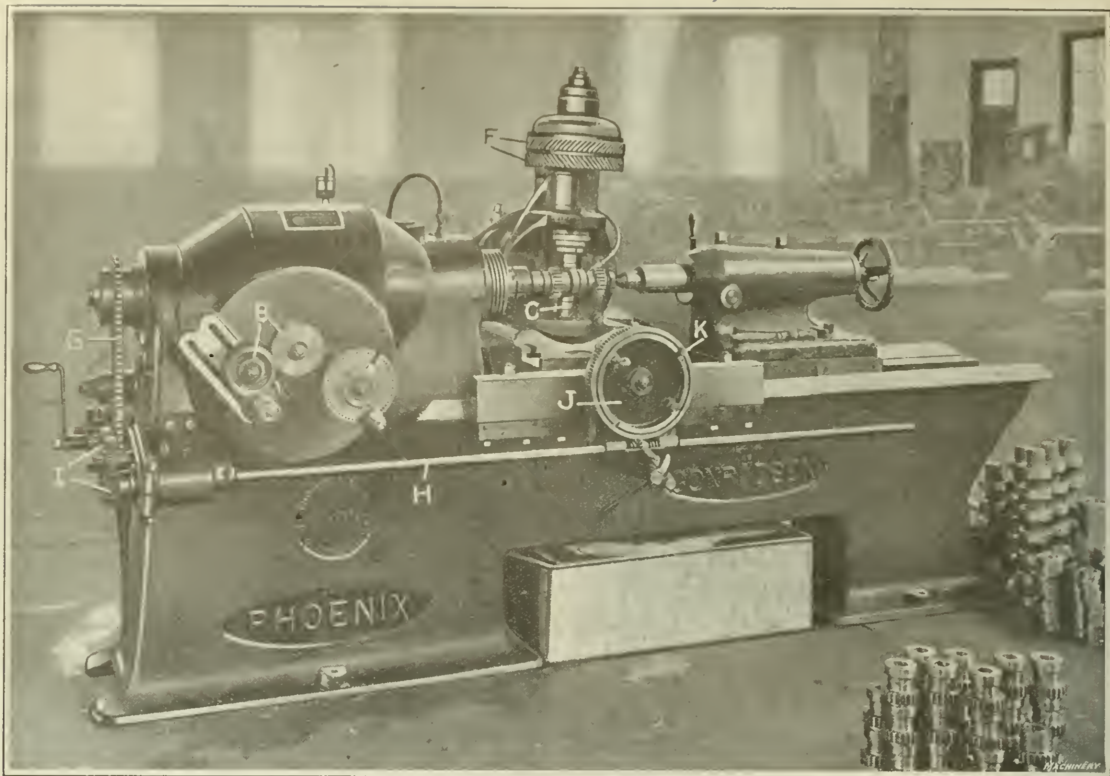

Fig. 1. Special Gear-hobber set up for hobbing Small Spur Gears

In the end view shown in Fig. 2, it will be seen that driving pulley *A* is mounted at the end of a cross-shaft. From this, power is transmitted to change-gears *B*, shown at the front of the headstock in Figs. 1 and 3; and suitable gears can be employed for rotating the gear blank at the desired rate for cutting gears of different sizes. These change-gear ratios have been worked out in such a way that the figuring out of change-gears for cutting the different gears has been simplified as far as possible, making it entirely improbable that the operator will make mistakes. Of course, it is apparent that power is transmitted from gears *B* to the main spindle in the headstock that drives the mandrel on which the gear blank is carried.

The head that carries the hobbing spindle *C* is mounted on the back of the lathe carriage, and in this way it was an easy matter to arrange for longitudinal traverse of this head to provide for feeding the hob across the face of the gear blank. This feed motion is obtained by means of gears *D*, shown at the end of the machine in Figs. 2 and 3, suitable change-gears being provided to enable the rate of feed to be adjusted according to the requirements. It will be noted in these illustrations, however, that the feed motion provided by gears *D* is disengaged; this is because the machine is shown engaged in hobbing a worm-wheel, so that this feed motion is not required. From the change-gears *D*, power is transmitted through a feed-screw to the carriage, provision being made in this way for traversing the carriage along the ways to feed the hob across the face of the gear blank.

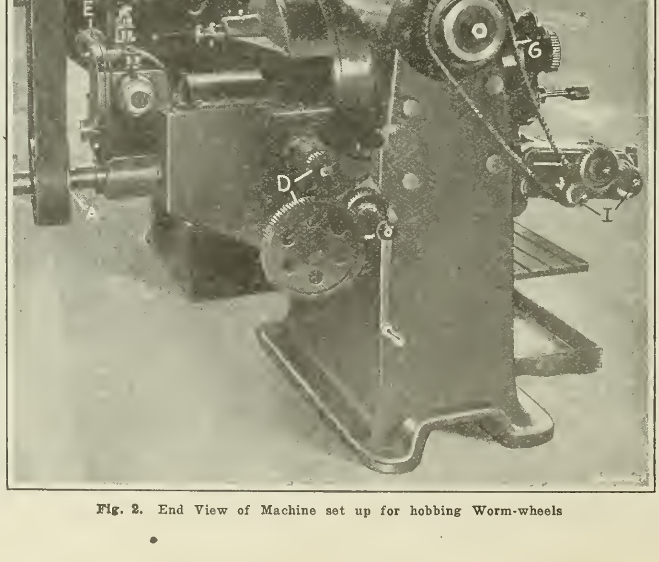

Fig. 2. End View of Machine set up for hobbing Worm-wheels

The drive to the hob is taken through a pair of spiral gears from the main driving shaft that carries pulley *A*, and transmitted through shaft *E*; a second pair of spiral gears and a pair of bevel gears transmit power to the herringbone-gear drive *F* at the top of the head that carries the hobbing spindle. The arrangement of this herringbone-gear drive will best be understood by reference to Fig. 1, in which the cover has been removed in order to show it more clearly. In hobbing spur gears, the hob rotates in uni-

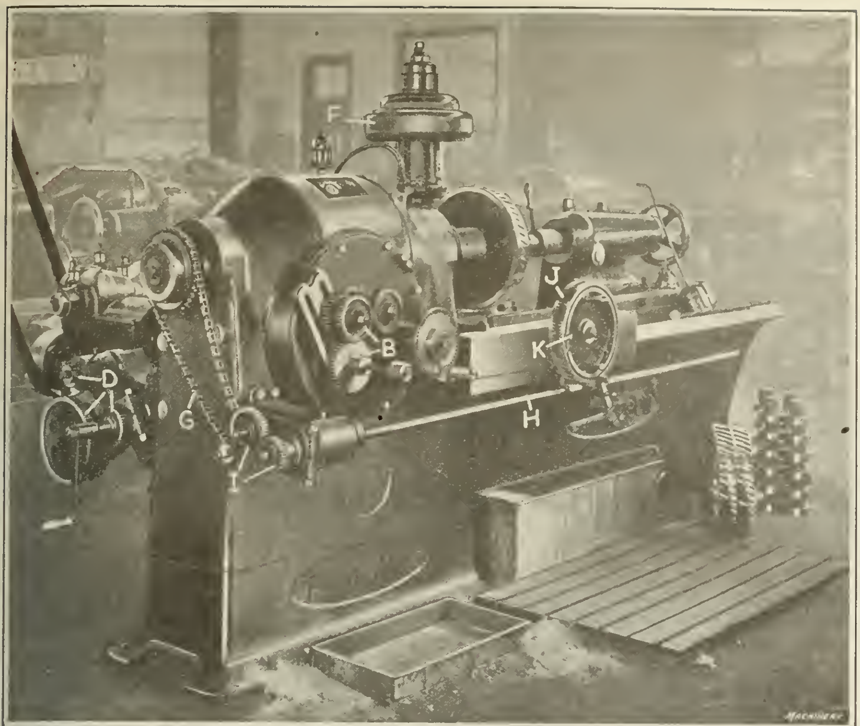

Fig. 3. Machine shown in Fig. 1 set up for hobbing Worm-wheels

son with the gear blank while the hob is fed across the face of the gear. This is not the case in hobbing spiral gears, because it is necessary to cut the teeth to the required spiral angle, and this result is obtained by having a differential motion between the speed of rotation of the hob and the speed at which the gear blank is rotated. To obtain this, change-gears *B* are selected in such a way that this drive and the gearing used for transmitting motion from driving pulley *A* to the hobbing spindle, will give the required ratio between the speeds of the hob and the gear blank. In this way, a suitable differential movement is obtained so that the gear blank will gain on the hob, which results in cutting the teeth to the required spiral angle instead of straight. There is a swivel in the head which carries the hobbing spindle, to provide for setting the hob at the desired angle when hobbing spiral gears. A similar angular setting is sometimes made in hobbing spur gears to compensate for the lead of the hob.

For hobbing worm-wheels, it is necessary to feed the hob into the work, instead of traversing it across the face of the gear blank. On the machine under discussion, this is accomplished by means of the lathe cross-slide which supports the gear-hobbing head. From the headstock spindle a chain drive *G* transmits power to a rod *H* that runs along the front of the machine. At the end of this rod are placed change-gears *I* which provide for regulating the rate of cross-feed; and mounted at the end of the cross-feed screw there is a worm-wheel *J* which meshes with a worm on the horizontal feed-rod *H*. This worm-wheel is furnished with a loose center that carries an adjustable stop *K*; and by setting the loose center and stop in the desired positions, provision is made for tripping the cross-feed when the teeth in the worm-wheel have been hobbed to the required depth. The loose center of the worm-wheel has a micrometer dial graduated on its circumference, and stop *K* is set at the zero mark on this scale. The scale is then run around and set in the desired position opposite an index mark on the rim of wheel *J* so that the cross-feed will be tripped at the desired point. The operation of this mechanism is sufficiently accurate to enable the feed to be disengaged for hobbing gear teeth with a limit of accuracy of 0.008 inch. An idea of the rate of production obtained from this machine will be gathered from the accompanying table, which shows results with spur and spiral gears and worm-wheels of different materials. E. K. H.

RATES OF PRODUCTION OBTAINED ON SPECIAL GEAR-HOBBER

Type of Gear	Material	No. of Teeth	Pitch	Face Width	Lead or Spiral Angle	Production, Gears per Hour
Spur	Cast iron	56	8	1		8
Spur	Carbon steel	25	6/8	1		4
Spiral	Aluminum bronze	27	3	2½	45°	2¾[1]
Spiral	Cast iron	27	4½	1¾	45°	1
Worm	Semi-steel	40	0.4	1½	0.8"	7½
Worm	Semi-steel	44	0.3	1⅜	0.6"	10
Worm	Aluminum bronze	51	1" c. p.	2½	5"	1
Worm	Cast iron	51	¾	1¾	3¾"	2¼

Machinery

[1] One gear completed in 2¾ hours.

* * *

The Panama Canal will have an important rival, it is claimed, in the Uyuni-Tupiza Railway, which will connect La Paz, Bolivia and Buenos Aires. When completed, this route will make it possible to travel from one coast to the other in two or three days less than is now required by the Trans-Andine route, and when in the winter the latter route is closed and the mails must be sent through the Straits of Magellan, ten days will be saved. This railway is also said to be a quicker and more direct transportation route from Europe to the west coast of South America than the Panama Canal, and it is expected that it will be used to a great extent by European exporters.

* * *

FRANK A. SCOTT, CHAIRMAN MUNITIONS BOARD

Frank A. Scott, recently elected chairman of the General Munitions Board of the Council for National Defense, is exceptionally well qualified for that position on account of his wide experience in organization and his familiarity with mechanical work in the executive capacities which he has filled during his business experience. Mr. Scott was born in Cleveland in 1873 and has been a resident of that city all his life. He has always been interested in civic problems and for twenty years has been closely associated with many of Cleveland's activities. As secretary of the Cleveland Chamber of Commerce for ten years, he was associated with numerous public enterprises, and later was connected with one of Cleveland's foremost banking institutions. It was while in the banking business that Mr. Scott was appointed receiver of the Municipal Traction Co., where he made a wide reputation for executive ability. In 1909 he was called to become secretary of the Warner & Swasey Co., of which he is now vice-president and general manager. Mr. Scott has traveled extensively in England, France, Germany and Russia, and his familiarity with conditions in those countries forms a part of his fund of practical information which al-

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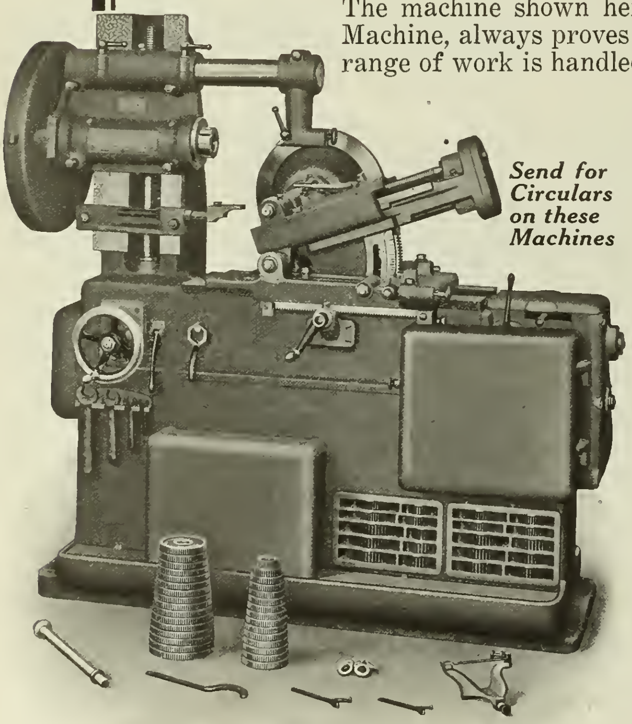
Specify

Brown & Sharpe Gear Cutting Machines

BS TRADE MARK

because they produce accurate gears, at a rate that meets the present abnormal demand for fast production. Constant speed drive with high belt contact gives powerful driving action. Ample rigidity permits rapid, heavy cuts to be taken. Independently driven indexing mechanism assures rapid indexing under all conditions. Full control from front of machine allows quick setting up and rapid production.

The machine shown here, our No. 13 Automatic Gear Cutting Machine, always proves a good investment in shops where a wide range of work is handled. On this machine



Send for Circulars on these Machines

You Can Cut Spur and Bevel Gears, Sprockets and Clutches

and maintain accuracy and fast production on all. Let us tell you more about our entire line of gear cutting machines, all of which are

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Frank A. Scott, Chairman of Munitions Board

together constitutes an equipment of exceptional value for the important position to which he has been called.

The General Munitions Board will be charged with supplying the army and navy with munitions and equipment, and will pass on the country's military and industrial requirements. The work of the Board corresponds to that undertaken by the British Ministry of Munitions, and it comprises twenty men, fifteen of them army or navy officers, as well as a number of civilians. Besides Mr. Scott, its civilian members are Bernard M. Baruch, Howard E. Coffin, Julius Rosenwald and Dr. Franklin Martin.

PERSONALS

Richard Klaw, Jr., has been appointed advertising manager of the Pawling & Harnischfeger Co., Milwaukee, Wis.

W. Burr Bennett has been made chief engineer and general manager of the Wayne Engineering Co., Honesdale, Pa.

S. H. Reck, general manager of the Greaves-Klusman Co., Cincinnati, Ohio, builder of engine lathes, has resigned.

Charles V. Bacon, consulting and analytical chemist, has moved his offices and laboratory to 3 Park Row, New York City.

C. H. Roberts, formerly factory accountant of the Hess-Bright Mfg. Co., Philadelphia, Pa., has been appointed comptroller.

H. P. Eilers, formerly with Manning, Maxwell & Moore, Inc., has opened an office in the Singer Bldg., New York City, where he will handle machine tools for domestic and export trade.

R. M. Bateson, formerly New York City representative of the W. F. Davis Machine Tool Co., Rochester, N. Y., has made arrangements to represent Ogden R. Adams, machinery merchant of Rochester.

Norman Bell, formerly sales engineer in the automobile division of the Lunkenheimer Co., Cincinnati, Ohio, has joined the Norma Co. of America, New York City, as sales engineer of "Norma" ball bearings.

John H. Marlotte, for many years prominently identified with the machine tool business in the Detroit district, has become connected with the J. R. Stone Tool & Supply Co. of Detroit; he will manage the machine tool department.

W. J. Hill, formerly superintendent of the Embury Mfg. Co., Warsaw, N. Y., and lately with the T. H. Symington Co., Rochester, N. Y., has taken a position as representative of Ogden R. Adams, dealer in machinery and equipment, Rochester.

Zenas W. Carter, Boston, Mass., has been appointed commissioner to supervise publicity, promotion and investigation for the Associated Metal Lath Manufacturers, whose offices have been moved from Chicago to Cleveland, Ohio, Room 901, Swetland Bldg.

Eugene R. Seiter, machine tool designer for five years with the Cleveland Automatic Machine Co., and later with the Warner & Swasey Co., both of Cleveland, Ohio, has resigned from the latter company and joined the Foster Machine Co., Elkhart, Ind., as sales engineer.

H. A. Howard, for many years connected with the C. & C. Electric Co., Garwood, N. J., and until recently associated with the Deihl Mfg. Co., has been appointed manager of the New England office of the C. & C. Electric & Mfg. Co. Mr. Howard has had a wide experience in the electrical line over a quarter of a century.

W. F. Schaphorst, mechanical engineer and advertising expert, and a frequent contributor to the technical press, has established an engineering advertising service office in the Woolworth Bldg., New York City. Mr. Schaphorst will specialize in advertising service for manufacturers of high-grade engineering products.

Maxwell C. Maxwell, formerly superintendent of power and plant of the machine tool department of the Yale & Towne Mfg. Co., Stamford, Conn., has been appointed general superintendent. A. O. Blackman has been appointed superintendent of power and plant, and J. B. Freysinger has been made superintendent of the tool and machine department.

Prof. C. R. Richards, professor of mechanical engineering and head of the department since 1911, has been appointed dean of the College of Engineering and director of the Engineering Experiment Station of the University of Illinois, to succeed Dr. W. F. M. Goss, who resigned to become president of the Railway Car Manufacturers' Association of New York.

George Schow has made arrangements to take charge of the interests of the Export Service & Industrial Corporation, having offices in the First National Bank Bldg., Chicago, Ill. Mr. Schow has been elected a director of the corporation, and will look after its activities in Norway, Sweden, Denmark, Holland, Russia and Siberia. He will continue to cooperate as before with the Northern Engineering & Trading Co. of Christiania, Norway.

Dr. Robert Grimshaw of New York City, an engineer of broad experience in this country and in Europe, will sail for South America early in June as a special agent representing the Bureau of Foreign and Domestic Commerce, to study the markets in Brazil for metal-working and wood-working machinery and for prime movers. Firms desiring to get in touch with Dr. Grimshaw may address him at Room 409, Custom House, New York City.

Fred. A. Geier, president of the Cincinnati Milling Machine Co., Cincinnati, Ohio, and a former trustee of the University of Cincinnati, has made a gift of $25,000 to the university, which will be known as the Frederick A. Geier Students' Loan Fund. The annual interest is to be used to provide loans to students of the cooperative engineering course who need financial assistance. The Cincinnati Milling Machine Co. reserves the right for the first twenty-five years to recommend students eligible for assistance, and the faculty of the college shall have the right to determine the eligibility of students in this department of the university who work two weeks in the factories and study two weeks at the university.

OBITUARIES

James B. Brady, a well-known salesman of machinery and railway supplies, director of Manning, Maxwell & Moore, vice-president of the Standard Steel Car Co., president of the Independent Pneumatic Tool Co., and an officer of other manufacturing concerns, died at Atlantic City, April 13, of heart trouble, aged sixty-two years. He was familiarly known as "Diamond Jim" because of his fondness for jewels, but although a well-known man about town, he was an able salesman and keen business man.

Hiram J. Grover, sales manager of the small tools department of the Brown & Sharpe Mfg. Co., Providence, R. I., died March 29, aged forty-two years. Mr. Grover was born in St. Louis, Mo., and after attending Washington University, he was employed by the Sumter Telephone Co. for a few years. During this time he married Miss Susan Ziegler of Sumter, S. C., who died a year ago. He entered the employ of the Brown & Sharpe Mfg. Co. in January, 1904, and in May, 1905, was made sales manager of the small tools department in which position he continued until the time of his death. Mr. Grover was a man who combined with natural ability and quickness of thought a personality that won for him a large number of friends in and outside his business circles. He leaves a son.

COMING EVENTS

May 8—Annual meeting of the Society for Electrical Development, Inc., at the United Engineering Societies Bldg., New York City. J. M. Wakeman, general manager, United Engineering Societies Bldg., New York City.

May 14-15—Meeting of the American Gear Manufacturers' Association at Pittsburg, Pa. F. D. Hamlin, secretary, Earle Gear & Machine Co., Philadelphia, Pa.

May 14-16—Annual meeting of the National Association of Manufacturers at the Waldorf-Astoria Hotel, New York City. George S. Boudinot, secretary, 30 Church St., New York City.

May 21-22—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 21-24—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

May 31—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

June 11-14—Spring meeting of the Electric Power Club at Hot Springs, Va.; Homestead Hotel, headquarters. C. H. Roth, secretary, 1410 W. Adams St., Chicago, Ill.

June 13-15—Annual convention American Railway Master Mechanics' Association at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 13-20—Annual meeting of the Railway Supply Manufacturers' Association at Atlantic City, N. J., in connection with A. R. M. M. and M. C. B. Associations' conventions. J. D. Conway, secretary and treasurer, 2136 Oliver Bldg., Pittsburg, Pa.

June 18-20—Master Car Builders' Association's convention at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

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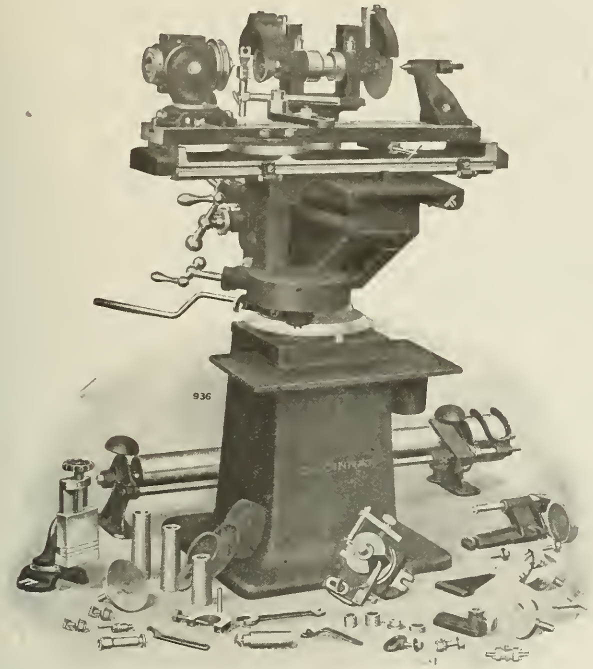
Then Investigate Your Own Cutter-Sharpening Facilities



"It has long been recognized that proper clearance and rake are of vital importance to cutting tools. Unfortunately, milling cutters which are more sensitive and more easily affected by different clearances have received little attention. It may, therefore, be assumed that the great majority of cutters are improperly sharpened. The user can correct these errors in stock tools by proper sharpening. There are cases on record where a cutter, intelligently sharpened for a particular cut, has increased the output of a milling machine 60%."

Our wide experience in milling has proved the necessity of having exactly the correct clearance on cutters. But cutter grinders were too incomplete to insure reproduction of the right clearance on repeated grindings. We set ourselves the task of solving this difficulty. The 40 per cent, 50 per cent or 60 per cent increased output that proper clearance means was certainly worthy of our best efforts. In the No. 1½ UNIVERSAL CUTTER AND TOOL GRINDER we offer you the result—a simple, correct clearance angle feature.

The machine carries a graduated dial on its headstock spindle from which the clearance angle for all cutters may be read direct.

As a result of obtaining this correct clearance angle the feed may be greatly increased, the cutter cuts as it was designed to; the tendency to chatter is removed—and you get greater efficiency from your millers.

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CINCINNATI MILLING MACHINE COMPANY

CINCINNATI OHIO, U. S. A.

June 23-30—Industrial exposition and export conference at Springfield, Mass. John C. Simpson, general manager.

June 25—Summer meeting of the Society of Automobile Engineers at Washington, D. C. Coker F. Clarkson, secretary, 29 W. 39th St., New York City.

August 30-September 1—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Museum of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

SOCIETIES, SCHOOLS AND COLLEGES

University of Wisconsin, Madison, Wis. Preliminary announcement of the summer session, which extends from June 25 to August 3, inclusive.

Columbia University, Morningside Heights, New York City. Bulletin containing announcement of the summer session day and evening courses. The summer session begins July 9 and continues through August 17.

American Institute of Weights and Measures, 20 Vesey St., New York City, has issued bulletins 1 and 2 on the metric system. The first is known as "The Six Metric Myths," and the second, "Endorsements That Count." Copies are sent free to any address. Other bulletins will follow in season.

Municipal School of Technology, Manchester, England. Journal containing a record of the investigations undertaken by members of the school during the year 1914. The articles contained are as follows: Energy Distribution for Natural Radiation; Slow Reversals of Stress and the Endurance of Steel; Experiments with Lathe Finishing Tools; Prevention or Abatement of Smoke; Training of Sanitary Engineers; Action of Strong Nitric Acid on Cotton Cellulose; Dilution Limits of Inflammability of Gaseous Mixtures; Ignition of Gaseous Mixtures by Electric Discharge; History of Dyeing; Catalytic Acceleration of Vulcanizing Process; Industrial Gas Burning; Action of Sulphuretted Hydrogen upon Hydrosulphites; Determination of Carbon Monoxide in Air; Strength and Wearing Qualities of Cloth; Null Method of Testing Vibration Galvanometers; and Commutation of C.C. Generators and Rotary Converters.

NEW BOOKS AND PAMPHLETS

Court Decisions on Workmen's Compensation Law, July 1, 1914, to August 1, 1916. Special bulletin 81 of the Department of Labor, New York, issued under the direction of the Industrial Commission.

Fatal Accidents Due to Falls in Building Work, Their Frequency, Causes and Prevention. Special bulletin 80 of the Department of Labor, New York, issued under the direction of the Industrial Commission.

The Personal Relation in Industry. By John D. Rockefeller, Jr. Published by John D. Rockefeller, Jr., 26 Broadway, New York City. Reprint of an address delivered at Cornell University, January 11, 1917, dealing with the relations between employers and employes.

How to Run an Automobile. By Victor W. Page. 178 pages, 5 by 7½ inches; 72 illustrations. Published by the Norman W. Henley Publishing Co., New York City. Price, $1.

This book is a non-technical compilation of the operating instructions furnished by motor car manufacturers for car users. It contains, in addition, many practical hints based on the observation and experience of the writer. The work is of interest not only to motor car users, but also to students of mechanism, as it shows a variety of details of modern motor car design.

Oxy-acetylene Welding and Cutting. By P. F. Willis. 180 pages, 4 by 6 inches; 52 illustrations. Published by the author, St. Louis, Mo. Price, 50 cents.

This little book was written in the light of ten years' experience of the author as the proprietor of a welding shop using the oxy-acetylene process, and should be useful to operators of oxy-acetylene apparatus generally. It treats of acetylene, oxygen, the welding and cutting torch, the apparatus and its installation, preparing for welding, welding of different materials, welding of sheet metal and pipe, and welding of miscellaneous pieces. The first portion of the book is presented in the catechism style, after which the matter appears in the usual descriptive style.

The Theory of Machines. By Robert W. Angus. 340 pages, 6 by 9 inches; 193 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $3.

This work is in two parts, part one being the principles of mechanism and part two the elementary mechanics of machinery. It is the second edition of a work published several years ago, but rewritten and revised throughout, making it practically a new book. Questions at the end of each chapter have been added, and the phorograph of Professor Rosebrugh has been introduced. The contents of the work by chapter heads follow: The Nature of the Machine; Motion in Machines; Velocity Diagrams; The Motion Diagram; Toothed Gearing; Bevel and Spiral Gearing; Trains of Gearing; Cams; Forces Acting in Machines; Crank Effort and Turning Moment Diagrams; The Efficiency of Machines; Governors; Speed Fluctuations in Machinery; The Proper Weight of Flywheels; Accelerations in Machinery and Their Effects; Balancing of Machinery. The chapter on balancing is new.

Compressed Air for the Metal Worker. By Charles A. Hirschberg. 321 pages, 5½ by 8 inches; 294 illustrations. Published by the Clark Book Co., Inc., New York City. Price, $3.

The aim of the author in writing this book was to explain in a practical way how compressed air is used to advantage in the metal-working field, having been impressed with the dearth of information in published form relating to industrial uses of compressed air. The book is intended for shop owners, superintendents, foremen and machinists, and is offered to mechanical engineering students as a supplement to theoretical text-books. It treats of the compressed air power plant; air compressor details; air compressor accessories; installation and care of air compressors, accessories and pipe lines; portable pneumatic tools; care and operation of pneumatic tools; compressed air uses in the power plants; compressed air uses in foundries; sandblasting; compressed air uses in the machine shop; compressed air uses in the forge shop; compressed air uses in boiler shops and structural steel plants; the uses of compressed air for hoisting, handling, conveying; cleaning with compressed air; the application of paint, lacquer, enamel, metal coating, etc., by compressed air; pumping with compressed air.

Preliminary Mathematics. By Professor F. E. Austin. 173 pages, 4¾ by 7½ inches. Published by the author, Hanover, N. H. Price, $1.20.

This book is uniform in style with the author's previous publications reviewed in MACHINERY, but is intended especially for those who lack the fundamental training in mathematics necessary for understanding engineering literature in general. The work, we believe, is well within the comprehension of any man able to read and perform ordinary arithmetical calculations. A study of the book from cover to cover should result in giving the average person such a grasp of the fundamentals of mathematics as to enable him to read intelligently the ordinary works on mechanics, electricity, etc. The arrangement of the matter is as follows: quantity, measurement, number, symbols of number and notation, use of letters in mathematics, algebraic symbols, symbols of operation, decimals, multiplication of positive and negative numbers, negative exponents, algebraic expressions, ratio and proportion, solution of equations, constants and variables, logarithms and their general properties, linear equations, quadratic equations, arithmetical progression, geometrical progression. The principles are illustrated with many examples given for practice.

Steam Turbines. By William J. Goudie. 519 pages, 5½ by 8½ inches; 230 illustrations. Published by Longmans, Green & Co., New York City. Price, $4 net.

The work was written to suit the requirements of engineering students, but the methods of calculation outlined should be found useful by engineers in general who have to deal with the design or operation of steam turbines. Numerous examples have been introduced throughout the text. The data in most cases were selected in conformity with practical requirements. The subject matter follows: Classification of Steam Turbines; Impulse Turbines; Reaction Turbines; Combination Turbines; Properties of Steam; Entropy Diagrams; Nozzles; Blading; Rotors; Mechanical Losses and Their Prevention; Condition Curve—Reheat Factor—Internal Efficiency and Efficiency Ratio; Steam Consumption; Provisional Determination of General Proportions of Compound Turbines—Impulse Turbines; Provisional Determination of General Proportions of Compound Turbines—Axial Flow Reaction (Parsons) and Combination Turbines; Provisional Determination of General Proportions of Compound Turbines—Radial Flow Reaction Turbine (Ljungstrom Type); Governing; Steam Tables; Mathematical Tables. The development of steam turbine practice during the past ten years has been so rapid that it has been difficult for engineering literature to keep abreast, but the author has given in this work an able and up-to-date treatise of a comparatively new branch.

Practical Marine Engineering. By C. W. Dyson. 982 pages, 6 by 9 inches; 550 illustrations. Published by "Marine Engineering," New York City. Price, $6 net.

The first edition of this work, published in 1901, was written by Prof. W. F. Durand, at that time head of the department of naval architecture and marine engineering, Cornell University. The book has since appeared in three editions; the fourth edition has been thoroughly revised and entirely rewritten by Capt. C. W. Dyson of the Bureau of Steam Engineering, U. S. Navy Department. The work contains fifteen chapters with the following heads: Principal Materials of Engineering Construction; Fuels; Boilers; Oil Fuel Burning; Marine Engines; Description of the Principal Parts of Marine Engines; Auxiliaries; Valves and Valve Gears; Refrigeration; Electricity on Shipboard; Propulsion and Powering; Operation, Management and Repair; Steam Engine Indicators, Indicator Cards and Torsion Meters; Special Topics and Problems; Computations for Engineers. Many miscellaneous problems and questions with page references to the part of the book where the answers to each question may be found, make the work invaluable to candidates for marine engineers' licenses. In fact, the book has been arranged throughout with the view of making it of greatest value to this class. It is, however, a work that any marine engineer should find acceptable for his library.

The Founder's Manual. By David W. Payne. 676 pages, 4½ by 8 inches; 215 illustrations. Published by D. Van Nostrand Co., New York City. Price, $4.

This is a handbook especially intended for the foundryman, containing, in addition, a great deal of material of a general character. The information has been drawn from many sources, especially the proceedings of the American Foundrymen's Association, "The Foundry," "Castings" and "Iron Age"; a number of MACHINERY's data sheets have also been reproduced. In the selection of the material, the author states that proper consideration has been given to beginners and others whose knowledge of foundry practice is limited. The first 240 pages of the book are made up of general information, such as is found in handbooks generally, on elementary mathematics; weights and measures; natural sines and tangents; tables of wire, sheet metal, pipe and machine details; mechanics; alloys; belting; and other miscellaneous information. Then follows a section covering somewhat over 400 pages devoted specifically to the iron and steel foundry, treating of pig iron, cast iron, mixing iron, test-bars, chemical analysis, standard specifications, malleable iron, steel castings, foundry fuels, cupolas, sand, cores, molding machines, and foundry cost accounts. The book is well printed and nicely bound in flexible leather, but its make-up gives evidence of lack of editorial experience, many pages being only half filled with material, and the arrangement generally leaving much to be desired. This, however, does not materially detract from the value of the book for reference purposes.

Gisholt Turret Lathe Guide—Care and Tooling. 254 pages, 6 by 9 inches; profusely illustrated. Published by the Gisholt Machine Co., 1205 E. Washington Ave., Madison, Wis., for distribution among Gisholt lathe owners and operators.

This book, though a publication issued in the interests of machine tool building concerns, is a valuable treatise on a specialized form of machine tool and specialized machining practice, which should interest mechanics generally. Tooling, which is an almost inexhaustible subject, is treated at length. The section contains many illustrations of standard and special tools for rough- and finish-turning, facing, boring and reaming, giving proper allowances between rough and finish cuts, so as to maintain uniformity of sizes and quality of finish. The uses and advantages of the Gisholt turret lathe are briefly given in the introductory matter, following which are instructions on the care and operation of machines; standard tool equipment; setting of tools; chucking; boring and fitting jaws; chuck jaws, with many illustrations of special forms; centering and supporting spiders; steadyrests; toolpost and toolpost tools; tool grinding, with chart of standard shapes and illustrations of many special shapes; uses of taper attachment; turret tools, including drills and boring-bars, with numerous illustrations; reamers, showing construction and special forms; and facing heads, with examples of common and special forms. Thread cutting and feed changes on the Gisholt machines are described, and details for changing gears are given. The machining of heavy pieces receives attention, and then follow lay-out instructions and time study sheets, of which several examples are given. List of parts with illustrations for ordering conclude the book.

NEW CATALOGUES AND CIRCULARS

General Electric Co., Schenectady, N. Y. Bulletin 40400 A, descriptive of belt-driven alternators, Form PB.

Brown Hoisting Machinery Co., Cleveland, Ohio. Catalogue P, illustrating the line of "Brownhoist" overhead hand traveling cranes.

Arthur Colton Co., Detroit, Mich. Catalogue of "Colton-Detroit" hammered high-speed twist drills with over-size tangs and wide flutes.

Foster Machine Co., Elkhart, Ind. Catalogue of the Foster No. 1B universal turret lathe with tools and attachments. This machine can be used either for bar or chucking work.

Gisholt Machine Co., 1205 E. Washington Ave., Madison, Wis. Pamphlet reproducing advertisements of the Gisholt machines that have appeared in the "American Machinist."

Fulton Machine Tool Co., 1438 Bryson Place, Chicago, Ill. Bulletin of the Fulton heavy-duty manufacturing lathe, 18¼-inch swing, 7-foot bed, with plain headstock and friction headstock.

Permanent Products Co., 1020 Engineers Bldg., Cleveland, Ohio. Circular and catalogue of "Permanent" nut locks, showing construction of various types of nut locks, including "Permanent."

National Tube Co., Pittsburg, Pa. Bulletin 27, entitled "Uses of National Pipe," showing the wide variety of uses of National pipe and giving tables of information concerning its physical properties.

Moccasin Bushing Co., Chattanooga, Tenn. Catalogue of "Moccasin" self-oiling bronze bushings for loose pulleys, sheaves and general purpose bearings that are required to run a long time without attention.

Nutter & Barnes Co., Hinsdale, N. H. Catalogue of cutting-off machines and saw sharpeners, containing a detailed description of these machines and illustrating the 4-, 6-, 8- and 10-inch cutting-off machines.

McCrosky Reamer Co., Meadville, Pa. Catalogue 5, illustrating and giving specifications for McCrosky adjustable reamers, "Wizard" quick-change chucks and collets, F.P.M. turret tool-holder, and "Searchlight" universal lamp brackets.

Standard Machinery Co., Auburn, R. I. Sixty-two-page catalogue covering this company's line of plain and automatic drop-hammers. The catalogue also shows the new patented safety device for use in connection with these drop-hammers.

Rivott Lathe & Grinder Co., Brighton District, Boston, Mass. Catalogue of the Rivett line of lathes and grinding machines, comprising precision bench lathes, back-geared precision lathes, precision turret lathes, lathe attachments, internal grinders, Rivett thread tools, chucks, etc.

National Tube Co., Pittsburg, Pa. Reprint of a paper entitled "A Method for Practical Elimination of Corrosion in Hot Water Supply Pipe," presented by F. N. Speller, metallurgical engineer with the National Tube Co., before the American Society of Heating and Ventilating Engineers.

Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletin 501, entitled "Spraco Products," illustrating and describing the various lines made by the company, which include air washing and cooling equipment, paint spraying equipment, sprinklers, flow meters and nozzles.

Fitchburg Machine Works, Fitchburg, Mass. Catalogue of the "Radical" automatic, in loose-leaf form, with details of construction, countershaft and floor plans, lists of parts, etc. The catalogue has been compiled with a view to making the construction and operation clearly understood by the average user.

National Lamp Works of General Electric Co., Nela Park, Cleveland, Ohio. Bulletin 30, on "Protective Lighting for Industrial Plants," which is published as a result of a large number of requests for information as to the best use of lighting as a precautionary measure against damage to industrial plants.

Langelier Mfg. Co., Providence, R. I. Catalogue of high-speed belt-driven ball-bearing drilling machines having a capacity from 0 to 11/32 inch. These machines are made with single spindles or in gangs with two or more heads mounted on one pedestal. They can be supplied with motor drive if desired.

New Departure Mfg. Co., Bristol, Conn., has begun the publication of a weekly house organ called "New Departure News," for circulation exclusively among its employes. It is devoted to social matters, sports, timely health hints, personal matters and other news of interest to the employes of a large organization.

New Departure Mfg. Co., Bristol, Conn. Sheets Nos. 91 FE to 94 FE, inclusive, for loose-leaf binder, illustrating the use of ball bearings in bevel drive gearing for vertical shaft of deep well pump, polishing or buffing jack equipped with ball bearings, ball bearing wheels for cableway car, and ball bearings for double winding drum.

National Tube Co., Frick Bldg., Pittsburg, Pa., has issued a wall hanger calendar entitled "National Preparedness," on which appears a poem by Berton Braley having for its theme the part played by pipe in modern civilization. The poem is illuminated with colored views showing some of the many uses to which pipe is applied.

Peter A. Frasse & Co., 417-421 Canal St., New York City. April, 1917, stock list, giving sizes in stock ready for immediate shipment of Frasse electric tool steel, polished drill rods, electric and open-hearth alloy steels, chrome-nickel steels, cold-finished screw steels, cold-drawn flats, coppered Bessemer rods, cold-rolled strip steel, and odd lots of high-speed steel.

Advance Tool Co., Canal and Jackson Sts., Cincinnati, Ohio. Catalogue of small tools, comprising solid counterbores, Woodruff keyseat cutters, side milling cutters, slotting end-mills, end-mills, milling cutters, adjustable hollow mills, plain hollow mills, collet chucks, limit gages, lathe mandrels, roller plug mandrels, hand milling machines, chucking reamers, shell reamers, etc.

Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass. Loose-leaf catalogue illustrating and describing Baush universal joint, Bocorselski universal joint, portable multi-drill heads, Baush patent spindle arm for multiple-spindle drilling machines, high-speed multiple-spindle drilling machines of the hand lever type, and high-speed multiple-spindle drilling machines of the screw type.

Sloan & Chace Mfg. Co., Ltd., Newark, N. J. Catalogue of precision machinery and special tools, showing views of the Sloan & Chace bench lathe equipped with compound slide-rest, milling attachment and screw cutting attachment. The catalogue contains a detailed description of the various attachments and parts of the lathe, and illustrates also bench milling machines, automatic pinion cutters, automatic gear-cutters and drilling and tapping machines.

Kearney & Trecker Co., Milwaukee, Wis. Catalogue 20, illustrating Milwaukee milling machines of the horizontal and vertical types. The various features of the machine are described in detail, such as the column, knee, table and saddle, system of automatic flooded lubrication, constant speed drive, speed and feed mechanism, etc. Specifications are given for the various sizes of Milwaukee milling machines, as well as for the milling cutters that are used with them.

New York Revolving Portable Elevator Co., Jersey City, N. J. Bulletin 50, describing and illustrating the revolvator, a portable elevator or tiering machine with a revolving base, which swings around on its own center like a turntable. The use of this revolvator enables floor space to be used to advantage in piling; it makes it possible to stack heavy and bulky cases, bales, etc., clear up to the ceiling in store-rooms and warehouses, leaving no waste space and making wide aisles unnecessary.

American Tool Works Co., Cincinnati, Ohio. Circular 392, illustrating the American six-foot triple-purpose radial drilling machine, which represents a departure from the standard radial drilling machines in the design of the head, which is quadruple-geared and affords four distinct speeds; these, in turn, are divided into two separate ranges, one for heavy tapping and boring, the other for high-speed drilling and light tapping. The boring and tapping range, in conjunction with the eight gear-box speeds, comprises sixteen speeds ranging from 15 to 81 R. P. M.

Schuchardt & Schutte, 90 West St., New York City. Catalogue of S & S gage standards, which comprise sets of standard blocks or units for measurement and for comparing the accuracy of other standards. These sets are made in different combinations; for instance, the No. 9 set is adaptable for combinations of 0.0001 inch, and the No. 8 for combinations in steps of 0.001 inch. The catalogue gives the number of blocks and the units of measurement for the various sets, and shows holders and measuring jaws for S & S gage standards. It also describes briefly the S & S precision measuring screw-testing microscope.

Kasenit Co., 11 Water St., New York City. Booklet treating of up-to-date methods of casehardening, and giving particulars of "Kasenit" casehardening compounds. The aim of the book is to give useful general information which will enable casehardeners to find out details best suited to their own steel and class of work. The book gives information on carbonizing, carbonizing powder, the re-use of spent "Kasenit," heat-treatment, the hardening shop, casehardening furnaces, heat controlling appliances, quenching, distortion or warping, boxes and how to pack them, tongs and other appliances, cleaning work, open-hearth hardening, and tests of hardness and toughness. "Kasenit" is made in three standard grades, Nos. 1 and 2 being intended for surface and open-hearth hardening and No. 4 for casehardening in closed boxes.

TRADE NOTES

Gibb Instrument Co. has moved from Pittsburg, Pa., to 5716 Euclid Ave., Cleveland, Ohio.

B. L. Mallory Machine Co., 131st St., Cleveland, Ohio, has changed its name to Geometric Stamping Co.

Ternstedt Mfg. Co., Detroit, Mich., maker of automobile accessories, window regulators, etc., announces the opening of its new factory in Detroit.

Walcott Lathe Co., Jackson, Mich., has increased its capital stock from $100,000 to $700,000, and is now in an entirely new factory, equipped with new machinery, and is building approximately 175 to 200 lathes per month.

Worcester Stamped Metal Co., successor to W & S Mfg. Co., Worcester, Mass., has completed an addition to its plant which increases its manufacturing capacity about 100 per cent. The company specializes in stamped metal parts.

Modern Machine Tool Co., Jackson, Mich., manufacturer of the "Modern" cutting-off machine, will erect an addition to its plant that will triple the present floor space. This increase has been made necessary by the rapidly growing demand for its product.

J. N. Lapointe Co., New London, Conn., dedicated its new plant on Pequot Ave., April 14. A public parade of employes and citizens marched through the city, following which there was the raising of the flag and the fourth annual banquet at the Crocker House.

Reynolds Pattern & Machine Co., Moline, Ill., will move its plant to Massillon, Ohio, about August 1, where it will be known as the Reynolds Machine Mfg. Co. The notice in the April number stated that the change of location had already been made, which is incorrect.

Pangborn Corporation, Hagerstown, Md., has purchased and taken over the sandblast business conducted by Elmer E. Perkins and George A. Cooley, Monadnock Block, Chicago. Mr. Cooley has joined the Pangborn Corporation and Mr. Perkins will continue his business in condensing driers and dry kilns.

Maino Machine Tool Co., Jackson, Mich., manufacturer of shapers, has broken ground for a new shop, 60 by 100 feet. The building will be of steel and brick construction, with saw-tooth roof. It is expected that the added facilities will enable the company to meet adequately the heavy demand for its shapers.

Stahl Gear & Machine Co., 1930 E. 40th St., Cleveland, Ohio, has been started by George Stahl, formerly of the Horsburgh & Scott Co., to manufacture gears. The new concern will cut spur gears up to 60 inches diameter, 2 diametral pitch; bevel gears up to 24 inches diameter, 1½ diametral pitch; spiral gears and other gearing products.

Vanadium-Alloys Steel Co., First Ave. and Ross St., Pittsburg, Pa., announces that arrangements have been made whereby the following firms will represent the company in the sale of high-speed steel, also alloy and carbon tool steels: E. T. Ward's Sons, Boston, Mass.; George Nash Co., New York City; Field & Co., Inc., Philadelphia, Pa.; and George Nash Co., Chicago, Ill.

Eccles & Smith Co., 69-71 First St., San Francisco, Cal., announces that Chris. Eccles was recently elected president and manager and Charles F. Bulotti secretary. The company has stores in San Francisco and Los Angeles, Cal., and Portland, Ore., in which is carried a stock of railway supplies, machine tools, small tools, pneumatic and electric tools, air compressors and iron and steel products.

Poole Engineering & Machine Co., Woodberry, Baltimore, Md., has acquired the exclusive manufacturing and selling rights of the "Turbo-gear," formerly manufactured by the Turbo-Gear Co., Inc., of Baltimore. The Turbo-gear is a highly developed speed reduction device for use with high-speed electric motors, steam turbines, other prime movers, etc. A descriptive catalogue is ready for distribution.

Welding Patents Investigating Committee, Room 700, Renkert Bldg., Canton, Ohio, has issued a list of 221 contributors to the investigation now being made by the Welding Patents Investigating Committee into the spot-welding patents. A meeting of manufacturers using spot-welding machines representing a capital of $100,000,000 convened at Canton in February for the purpose of securing a thorough investigation of these patents.

Union Chain & Mfg. Co., Seville, Ohio, manufacturer of steel chain belting, rivetless driving chains, sprocket wheels, buckets, elevating and conveying machinery, etc., has increased its capitalization from $40,000 to $60,000. The company's New York office has been removed to 30 Church St., and remains in charge of J. R. Shays, Jr. Oliver J. Abell, formerly Western editor of the "Iron Age," is in charge of the Chicago office at 565 Washington Blvd.

Acme-Greaves Machine Tool Co., Cincinnati, Ohio, was incorporated under the laws of the state of Ohio, April 4. The new company is a merger of the Acme Machine Tool Co. and the Greaves-Klusman Tool Co., both of Cincinnati. The Acme Machine Tool Co. manufactures turret lathes and the Greaves-Klusman Tool Co. builds a line of engine lathes. The incorporators are C. H. M. Atkins, B. B. Quillen, George Langen, A. J. Jones and William A. Greaves. The new company is incorporated with $1,000,000 capital.

Canedy-Otto Mfg. Co., Chicago Heights, Ill., manufacturer of post radial drilling machines, upright drilling machines, etc., has just completed a large addition to its plant, which will nearly double the capacity. The company has also installed another 25-ton cupola in its foundry, and it will soon place upon the market a line of 14-, 16- and 18-inch medium-priced engine lathes, and a base and column radial drilling machine with 2½- and 3½-foot arms, which will eliminate a number of the expensive features of the higher-priced drilling machines.

H. T. Dempster, 7 E. 42d St., New York City, calls the attention of American manufacturers to the possibilities of developing direct trade connections in Italy. Mr. Dempster resided twenty-five years in Italy, and has acquired a comprehensive knowledge of the economic conditions existing therein. He has developed a plan making it possible for American producers to merchandise their products directly through their own representatives, who, under trade expert supervision, should be able to secure full advantages through local distributors.

Russo-American Merchants & Manufacturers Exchange, Inc., 120 Broadway, New York City, has been established to improve conditions as regards American supply and the Russian demand for American-made products. Russia is regarded as a practically inexhaustible market for American industrial products, and many are raising the question as to the best means of bringing together the consumer and American manufacturer. The Exchange will publish a comprehensive directory of American industries, of which about 40,000 copies will be distributed throughout Russia.

Eastern Brass & Ingot Corporation, Waterbury, Conn., is an organization that has recently moved to Waterbury from Chicago and established a plant for the reclamation of brass filings and turnings. The process employed was developed by O. C. Duryea, and consists of pressing the brass turnings, which have been carefully cleaned of all foreign material, including iron and steel chips, into briquettes, using a press capable of exerting a pressure of about 500 tons per square inch. The resulting briquettes are melted with very little loss from oxidation. The new plant has a capacity of several hundred tons a day.

Alvord Reamer & Tool Co., Millersburg, Pa., has purchased all the property of the Alvord Reamer Co. and the Millersburg Fifth Wheel Co., both of Millersburg, and will continue the long established business heretofore conducted by these companies. The officers of the Alvord Reamer & Tool Co. are F. T. McGuire, president; G. R. Kurrie, vice-president; J. Boyd Coates, secretary; and John Clymer Boltz, treasurer. The company has modern equipment for the manufacture of reamers, milling cutters and special metal-cutting tools of every kind. The capacity of the tool plant and forging department has lately been materially increased in order to meet the demands for the products. Sales offices are maintained in Philadelphia, New York City, Chicago, Minneapolis, San Francisco and Baltimore.

Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio, has completed plans for rebuilding the portion of the plant recently destroyed by fire. The plans include the erection of two additional buildings, which will give better manufacturing facilities for the company's rapidly expanding business. The plans provide for the erection of four complete new buildings, consisting of a machine shop, a three-story stock-room, a new power plant and a structural and forge shop. The machine shop and stock-room are replacements on a much larger scale of the portion burned. The machine shop will be 200 feet long and 100 feet wide, of fire-proof construction, steel, concrete and brick being used throughout, including steel window frames and sashes. The floor space is 100 per cent more than that of the building replaced. An electric traveling crane of 20 tons capacity will serve the center bay, and two smaller electric cranes of 3 tons capacity each will be installed in the side bays. The stock-room building will be 50 by 60 feet, the power plant, 42 by 60 feet, and the steel fabricating shop, 50 by 60 feet. It is planned to have the new buildings in full operation July 1.

Methods are described in the following article for cutting and testing precision screws for astronomical and other scientific instruments. These screws are sold under a guarantee that the error in lead does not exceed 0.001 millimeter, i. e., approximately 0.00004 inch, from a theoretically accurate helix of the same lead. This degree of accuracy is greater than that required in any ordinary shop work, but the principles described should prove of value in shops called upon to cut highly accurate lead-screws, etc. The article includes instructions for using two forms of interferometers, one of which provides means for measuring to one-millionth inch.

In ordinary machine shop practice the standard of workmanship is considered satisfactory if the error in machining does not exceed 0.001 inch. On tool-room work, where greater care is taken than in the average manufacturing operations, a considerably higher limit of accuracy may be attained, but highly skilled toolmakers of wide experience will feel satisfied with a piece of work if they are sure that the limit of error is not over 0.0001 inch. In any class of shop work, it is a waste of time, and entails a deliberate loss of production, to strive for a higher degree of accuracy than is absolutely necessary, and the limits referred to for the manufacturing plant and the tool-room have been found to mark the boundary line between products that will give good service and those with which unsatisfactory results are likely to be experienced through difficulty in assembling, failure to operate properly, and similar troubles.

In making parts of scientific instruments, the case is very different, because here errors which would be quite insignificant in any commercial work may be multiplied as a result of conditions under which the instruments are used, so that data obtained with inaccurate apparatus would be highly misleading instead of a means of furnishing valuable information. A case in point is seen in astronomical and physical instruments—say micrometers and comparators. Micrometers are used in connection with astronomical telescopes for determining the distance between the stars, or with spectroscopes for locating the position of spectrum lines, etc., the measurements being made directly with the micrometers, while with comparators or measuring machines the measurements are made on photographs of the stars or spectra. When using a comparator, the cross-hair of a microscope on the comparator is first centered on one star, after which the position of the microscope is noted. It is then moved by means of a screw until the cross-hair is centered on another star; and the distance between these two stars on the photograph is determined by the number of turns made by the screw. The actual distance between the two stars is then calculated from these data and other information at the disposal of the astronomer. Very little thought will make it apparent that in order to secure data that constitutes a reliable basis of calculation, the comparator screw must be of the highest accuracy, because a slight error in setting the instrument is multiplied many times, due to the great distance of the stars from the telescope and the multiplication of an error of arc with increase of distance from the center.

Realizing the importance of this point, instrument makers and scientists have given a great deal of thought to the development of methods for eliminating every possible error in screws, and this has been made the subject of exceptionally careful study by William Gaertner & Co., 5345 Lake Park Ave., Chicago, Ill., to whom we are indebted for information concerning the interesting methods of precision screw cutting described in this article. Errors in screws may be either "periodic" or "progressive." When a screw has a periodic error, it has what is commonly known as a "drunken" thread; the inaccuracy appears in every revolution of the screw, and usually proceeds in regular intervals from zero to a maximum error and back again to zero. In case the screw has progressive errors, it has the well-known errors of pitch, *i. e.*, the

[1]Associate Editor of MACHINERY.

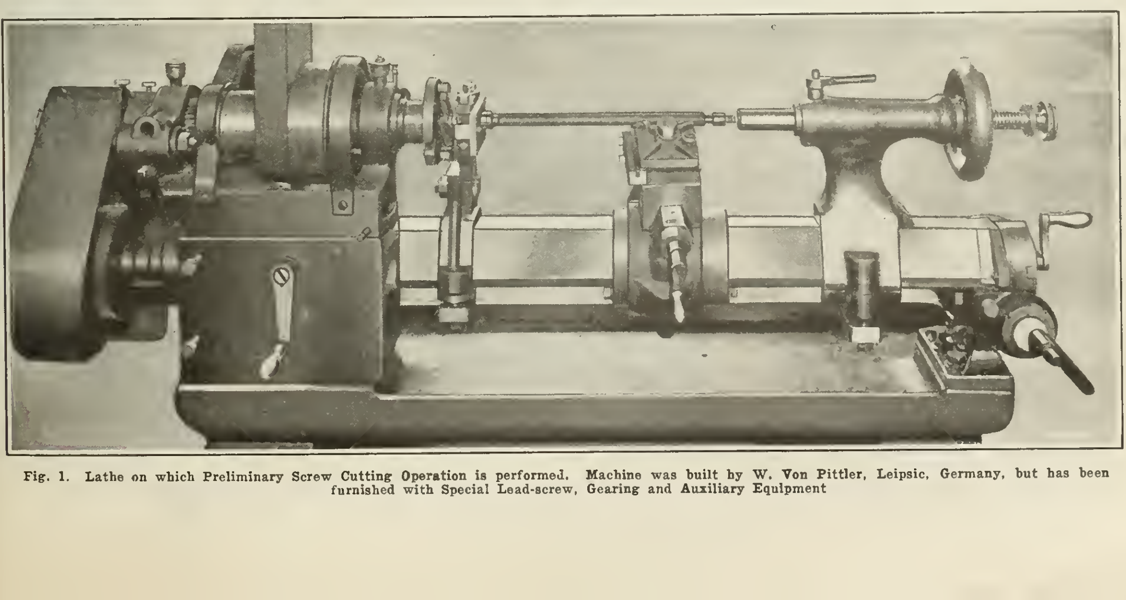


Fig. 1. Lathe on which Preliminary Screw Cutting Operation is performed. Machine was built by W. Von Pittler, Leipsic, Germany, but has been furnished with Special Lead-screw, Gearing and Auxiliary Equipment

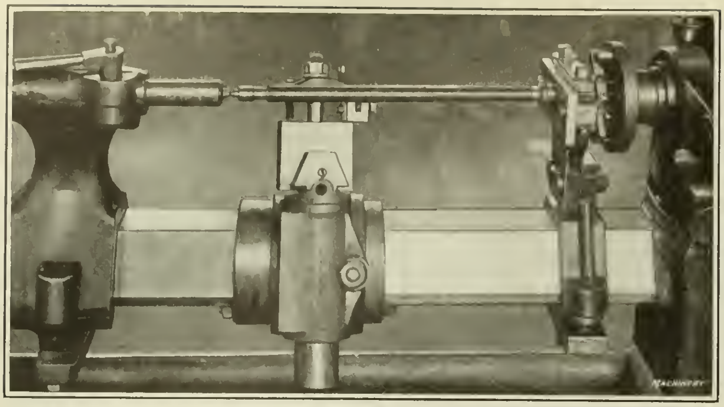


Fig. 2. Close View of Tool, Work and Work-holding Device taken from Back of Machine

pitch of the thread is not uniform throughout the entire length of the screw, so that when turned in a nut such a screw advances different amounts for different revolutions. From this it will be evident that a progressive error is entirely irregular.

In screw cutting, the operation of a lathe is chiefly governed by the familiar lead-screw and change-gears, and accuracy of the product of a screw cutting lathe is largely dependent upon the precision of its lead-screw and gears and the straightness of the lathe bed. So far so good, but the man who starts making a study of methods of precision screw cutting will eventually ask himself the question, "Where did the first lead-screw come from and what is responsible for its accuracy?" There are various methods of originating screws, and for the purpose of this article it will be satisfactory to describe one employed by the late C. Reichel, a celebrated instrument maker of Berlin, Germany. This method consisted of taking wire of uniform diameter and, say, exactly one millimeter in size, which was closely wound and soldered onto a mandrel and mounted on the lathe spindle. The lathe used for this work was what is known as a "sliding mandrel lathe," and this type of machine is still in use in instrument shops for chasing short threads. Mr. Reichel then made a multiple thread cutting tool of the chaser type, which had the teeth very accurately spaced, and proceeded with this to cut down the wire to form a screw thread.

The cutting tool was held stationary in the slide-rest, and a block of hard wood, also held stationary on a separate support, formed the nut or guide for the screw mandrel, the cutting tool and nut being 180 degrees apart. When the lathe was slowly run forward, with the cutting tool in contact with the wire thread, it was observed that the tool did not touch uniformly, but showed a "wobbling" tendency in the thread, and usually touched one high spot in each revolution. The multiple tool was the means of correcting both periodic and progressive errors that could not have been eliminated if the work had been done with a single-pointed tool. After correcting errors in this screw, it was used as a "master" from which other screws were cut. In all precision screw cutting, provision of accurate concentric bearings on the screw is of just as much importance as the cutting of an accurate thread, and the nut must be fitted to the screw with the greatest care.

It will be of interest to refer at this time to the way in which periodic or progressive errors are developed while cutting a thread. In both cases, a variety of causes may be responsible for the trouble, but as a general thing the periodic error is due to eccentricity of the lathe spindle or to lack of uniformity in the gearing on the lathe, which is a result of inaccuracy on the gear-cutting machines. The errors in the gears become effective at those intervals where the teeth in which there are errors come into mesh, and at such times an error is introduced in the screw cut on the lathe through lack of uniformity of movement of the lead-screw on the lathe. Production of screws with a so-called progressive error or errors of pitch is harder to explain than the screw with the periodic error, because the discrepancy follows no fixed rule. This error may be due to inaccuracy in the gears, to lost motion in machine members, lack of straightness of the lathe bed, or to numerous other causes.

Gaertner Practice in Screw Cutting

In making precision screws, observance of the following points is a matter of great importance if accurate results are to be obtained: (1) The steel must be fine grained and homogeneous. (2) After roughing out the thread, the screw must be carefully examined to see that no defects in the steel have been exposed during the process of screw cutting. (3) The rough-cut screws must be put aside to "season" for several months so that they will take the full "set" developed through removal of the surface skin from the metal, after which the finishing cuts may be taken with the assurance that there will be no further distortion. In the Gaertner shop, the preliminary work of screw cutting is done on a lathe of German manufacture made by W. Von Pittler of Leipsic. However, the design of this machine has been considerably modified and many details have been improved or entirely renewed to adapt the machine for the precision work for which it is now used. The provision of an accurate lead-screw and gearing are typical examples of the changes that were made. In cutting screws for astronomical or similar instruments, precautions must be taken to avoid the introduction of errors of such slight magnitude that they could be entirely disregarded on many classes of commercial work.

Reference to Figs. 1 and 2, which show a front view of the lathe on which the preliminary screw cutting operations are conducted and a close view of the tool and work taken from the opposite side of the machine, respectively, will show that, instead of setting up the work in the usual way, the screw is mounted on stationary centers, *i. e.*, dead centers, and the cutting is done on the same bearings on which the screw is afterward used in the apparatus for which it is intended. Clamped to one end of the screw is a dog which engages the lathe spindle and provides for rotating the screw. It will be apparent that the chief reason for this method of procedure is that it insures cutting the thread on the screw in accurate

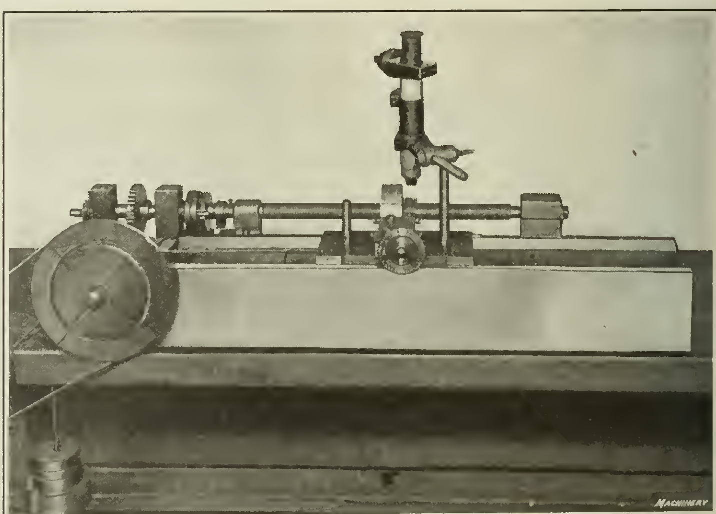


Fig. 3. Screw Recutting Machine designed to operate on Principle shown diagrammatically in Fig. 4. Particular Attention is called to Bearings for supporting Screw to be recut, and Special Coupling between Work and Machine Spindle

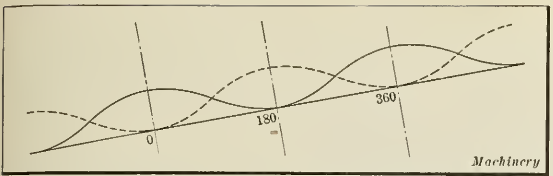


Fig. 4. Diagram showing Possibility of designing Screw Recutting Machine that automatically regulates Depth of Cut according to Error in Lead of Thread

alignment with the bearings that have already been turned at the ends of the screw blank; in addition, slight inaccuracies that might be introduced in the screw as a result of belt pull and slight errors in the lathe spindle bearing are overcome. With the work set up in this way, the method of cutting the screw is practically standard, except that after roughing out the thread, the screw is set aside to season, as mentioned.

Recutting Machine for Removing Periodic Errors from Thread

Various means have been tried for eliminating the periodic error from screw threads, but the method of recutting used by William Gaertner & Co. is among the most satisfactory. Credit for the development of this method is given to the late C. Reichel of Berlin, Germany; and the theory of this operation is best shown by reference to the chart presented in Fig. 4. Both curves show the way in which a periodic error in a thread runs from zero to a maximum and back again to zero during a period required for one revolution of the screw. After grasping the full significance of this fact, it was realized that by recutting the screw with a tool carried on a slide, the position of which could be governed according to the amount of correction required at different points on the thread, it would be possible to make the thread absolutely accurate. This result is obtained by the use of a nut, consisting of a single V-shaped point, which enters the thread. It will be seen that the nut is carried on a yoke that extends over from the slide, and different settings may be made, so that the nut is placed 180, 90 or 45 degrees from the tool. Fig. 4 shows diagrammatically the conditions that exist when the nut is set 180 degrees from the recutting tool. Here it will be noticed that when the nut engages the screw thread at a point of maximum error, the tool lying opposite the nut engages the thread at a point where there is no error. Conversely, when the tool is at the point of maximum error, the nut is at a point where the error is zero. In this way the nut moves the tool-slide along the bed and advances the tool to the work at a rate that is governed by the amount of error to be removed from the screw thread at the point where the tool is working. A counterweight, connected to the tool-slide by a cord, relieves the screw thread and nut of much of the strain incident to moving the tool-slide along the bed of the machine.

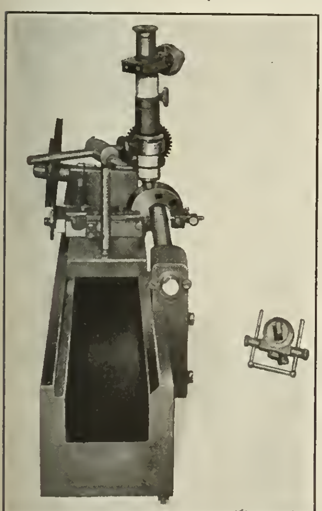


Fig. 5. End View of Machine shown in Fig. 3, showing Yoke that supports Nut and Tool

A recutting machine operating on this principle is shown in Figs. 3 and 5; the best idea of its method of operation will be gathered from the end view, where it will be seen that the nut is located at the back of the screw, and the cutting tool at the front of the screw to correspond with the conditions shown diagrammatically in Fig. 4. When the nut is at a point of maximum error, the tool is opposite a point of zero error, and is clear of the work, so that no cut is being taken. After the screw has made one half turn, so that the nut comes to a point of zero error, the tool-slide has advanced so that the tool is taking a cut of maximum depth. Of course, for intermediate positions, the depth of cut ranges between zero and the maximum. The amount of metal removed during this recutting operation is extremely small. Viewing the operation of the tool with the naked eye, one would say that the tool was not in action, but when observed through a microscope provided on the machine for that purpose, one can easily see how the tool starts to take a very light cut, which gradually increases and leaves a fine dust of metal on the lip of the tool.

One traverse of the cutting tool over the screw, with the nut set at 180 degrees to the tool, results in reducing the error in the thread to one-half its previous magnitude. After taking this cut, the nut is transferred to the 90-degree position and a second cut is taken, which results in again dividing the error in half. Then the nut is set so that it is at 45 degrees from the tool, and a third cut is taken, which once more divides the existing error in half. In this way the final error in the thread is only 12½ per cent of that which originally existed, and as the original screw cutting operation performed on the Von Pittler lathe was done with every possible care, it will be apparent that the accuracy of the finished screws is extremely high. As a matter of fact, screws are sold under a guarantee that the error in lead will at no point exceed 0.001 millimeter, *i. e.*, 0.00004 inch from the path of a theoretically accurate helix, although far greater accuracy has been secured. The attainment of such a degree of precision will certainly be appreciated by every skilled mechanic.

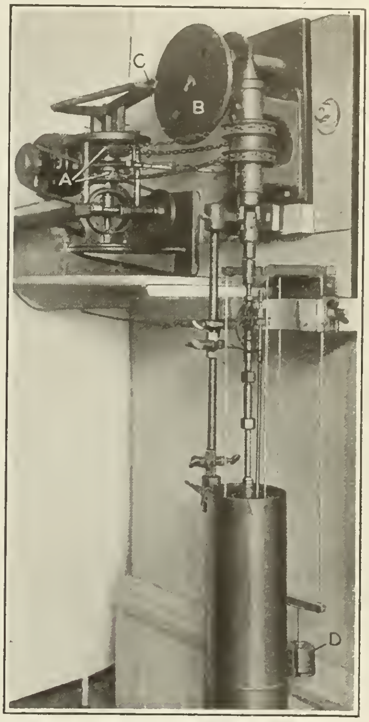


Fig. 6. Automatic Lapping Machine for imparting High Finish to Screw Thread after it has been recut

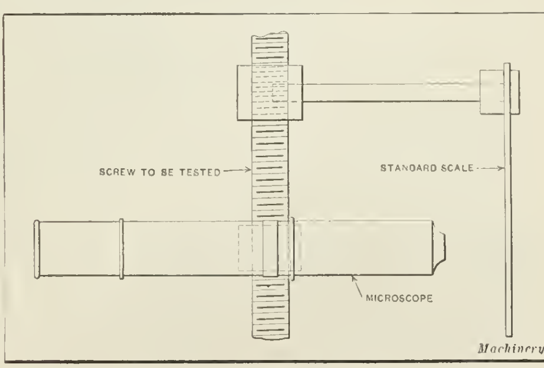


Fig. 7. Method of testing Accuracy of Precision Screw with Microscope and Standard Scale

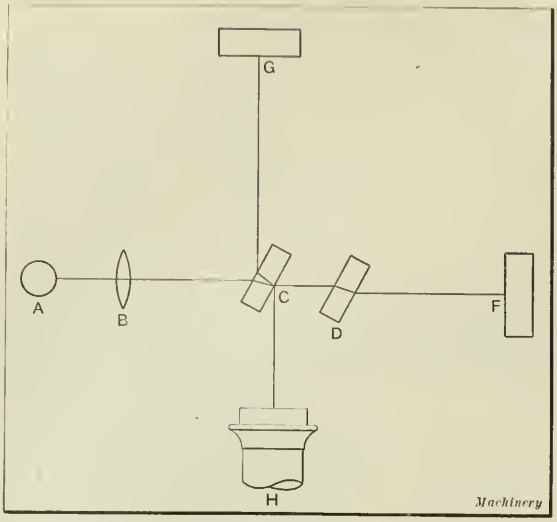


Fig. 8. Simple Form of Interferometer Suitable for Use in testing Precision Screws snd for making Other Forms of Accurate Measurements

To obtain such a degree of accuracy calls for a machine operating on the principle described, that is, making the periodic error at one side of the screw adjust the position of the tool to eliminate the error at the opposite side. But this would be inadequate if great care were not taken in constructing the machine and setting up the work to obviate lost motion and other troubles of a kindred nature. In building the machine, great care was taken to obtain the best possible fit for all bearings and slides, and have the guides absolutely straight. In setting up the work, corresponding care is taken, the ultimate object being to bring the axis of the screw exactly parallel to the guides, and to eliminate every possibility of lost motion. Instead of being satisfied with mounting the screw on centers, it will be seen that bearings are provided which are carefully fitted so that the accurately finished bearings at each end of the screw will be carried in them without chatter or vibration. On the spindle there is a faceplate to provide for driving, but if the screw were driven through a dog, there is little doubt that strains would be developed that would result in errors, so that the accuracy of the thread would be impaired during the process of recutting instead of improved. As a substitute for the dog, it will be seen that a special form of coupling is provided between the lathe spindle and work. This coupling compensates for any lack of alignment, and relieves the work of all strains that might be put upon it through the use of the usual form of driving dog.

Lapping Screw to Polish Thread and Reduce Error

Before adopting the practice of recutting screws on the machine shown in Figs. 3 and 5 to eliminate the error, the screws were lapped in a machine of the type shown in Fig. 6. It will be seen that the machine is furnished with a universal joint that drives a chuck in which is carried the screw to be lapped. This machine is driven by an electric motor that transmits power by means of a belt and worm drive to a vertical shaft on which are mounted two sprocket wheels *A*. Located between these sprockets is a clutch, which may be engaged with either sprocket to provide for driving through the open or crossed chain to get forward or reverse rotation of the main spindle of the machine. The control of this clutch is effected by means of a small worm at the upper end of the main spindle, which drives disk *B* by means of a worm-wheel and spur gears.

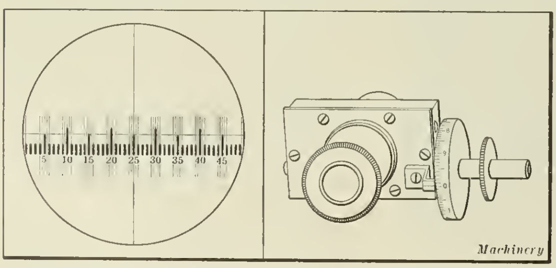


Fig. 9. Appearance of Interference Fringes and Scale in Eye-piece of Telescope; and Micrometer Head for recentering Scale Graduations on Fringes

Holes are drilled around the periphery of this disk, into which two stop-pins may be fitted; these pins are set to give reversal at the desired point. This result is obtained by having the pins strike lever *C*, which throws over the clutch between sprockets *A* and reverses the drive. When this is done, disk *B* runs back in the opposite direction until the other pin in the disk strikes lever *C* from the opposite side, when the clutch is thrown in the opposite direction and the machine once more reverses. The reservoir in which the screw rotates is filled with a mixture of oil and the finest grade of emery. Closely fitted to the screw there is a long nut, which is supported by counterweight *D*. The nut runs up and down the screw with each reversal in direction of rotation; and by having its weight removed from the screw, there is no tendency to introduce unequal wear on the screw thread. A stirring device keeps the mixture of oil and abrasive thoroughly agitated. This consists of a number of small propeller blades mounted on a vertical shaft, which is driven by the same motor that drives the machine. In this way the lapping nut is constantly

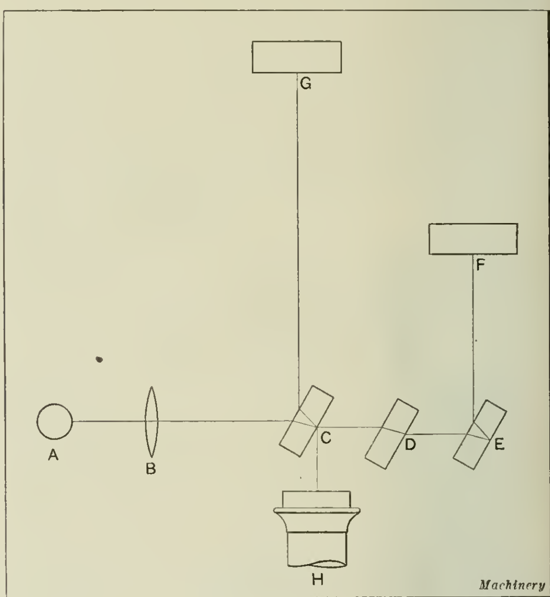


Fig. 10. Diagram showing Principle of Operation of Interferometer shown in Figs. 11 and 12

supplied with fresh abrasive, and the fine particles of steel and worn particles of abrasive are washed out of the nut. Anyone who is familiar with the process of lapping a screw knows what damage would be done by allowing small steel chips to remain mixed with the abrasive material, and to avoid trouble from this source several strong magnets are suspended in the tank to collect these chips as fast as they are produced.

Mention has already been made of the fact that William Gaertner & Co. are prepared to furnish screws under a guarantee that the error in lead does not exceed 0.001 millimeter. Of course, to give a guarantee with a screw means that it will have to come up to the specifications, and so each screw has to be properly tested before it is sent out from the shop. Now to investigate the accuracy of a screw throughout its full length is a tedious and laborious proceeding, and is usually left to the scientist who is going to use the instrument of which the screw forms a part. For instance, to test a screw for one of the small comparators of 3¼ inches or 80 millimeters range, employing the microscope method of testing, requires about a month of the observer's time.

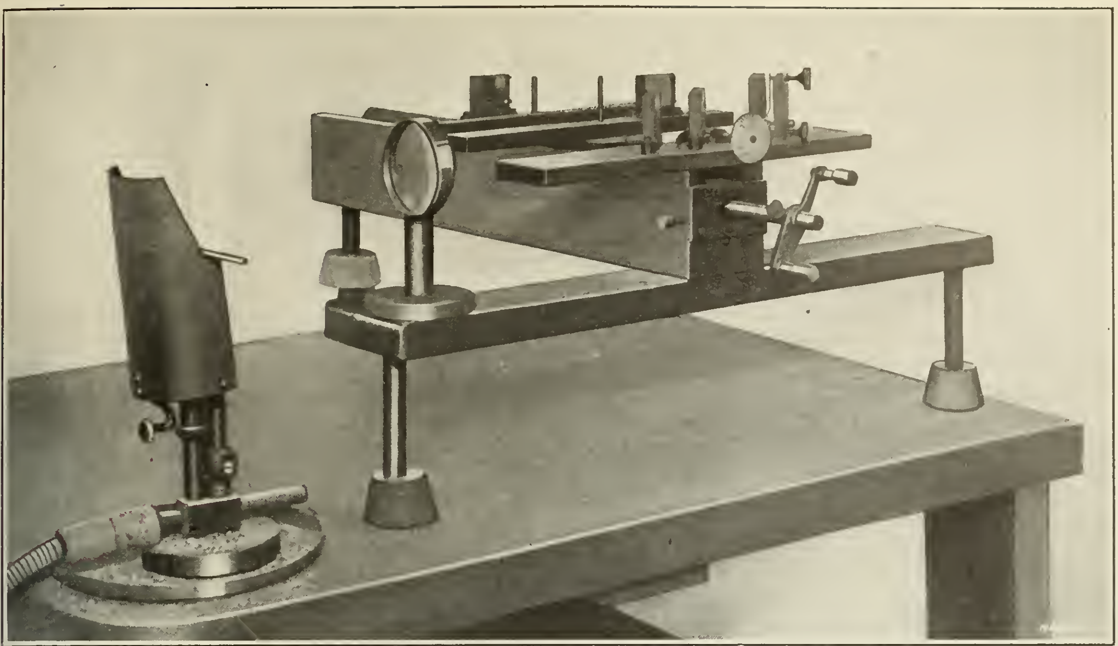


Fig. 11. Special Application of Interferometer Principle for rapidly testing Accuracy of Precision Screws. This Test shows whether Error is Periodic or Progressive, and whether Maximum Allowable Error is exceeded, but Results are Qualitative rather than Quantitative

In testing a screw in the laboratory, the work is usually done on the completed instrument; and a microscope of suitable magnifying power, having a fine wire (spider thread) in the eye-piece, and an accurately divided scale are employed. The microscope may be carried on the slide which is moved by the screw or it may be held stationary on the frame of the apparatus and the scale placed on the slide. If the microscope is movable, the scale is placed on a stage below and carefully adjusted to be parallel with the axis of the screw. Suppose the pitch of the screw is 1 millimeter, the scale will be divided up into spaces of 0.1 millimeter. The microscope is focused on the scale and adjusted so that the spider thread in the eye-piece will bisect a scale mark. If the screw head has a graduated dial with 100 divisions and the microscope is moved to the next line on the scale, the reading on the dial should be ten divisions.

In moving the microscope from line to line on the scale, and observing the readings on the graduated dial, the screw is directly compared with the scale. Any discrepancy from the required readings on the dial for each corresponding movement of the screw indicates an error. But what about the error in the scale, and what about the errors that may be made in setting with the microscope? These are two uncertain factors to be figured with. The scale may be tested at the Bureau of Standards, so that the value of every scale division is known, and the error of setting may be eliminated by taking the mean of a number of readings; but anyone will see that testing a screw by this method is, at best, a slow and tedious proceeding and requires great patience and a trained observer, so that it would not be suitable for use in a shop.

Another and quicker method that has been used is to mount the microscope and scale on two separate carriages, which are moved by the screw, as shown diagrammatically in Fig. 7. The microscope cross-hair is adjusted to a scale mark, and if the screw is then turned, both the microscope and scale should advance the same amount if the screw is free of errors, and the scale mark should remain in the same position in the field of the microscope. Any shifting of the scale mark indi-

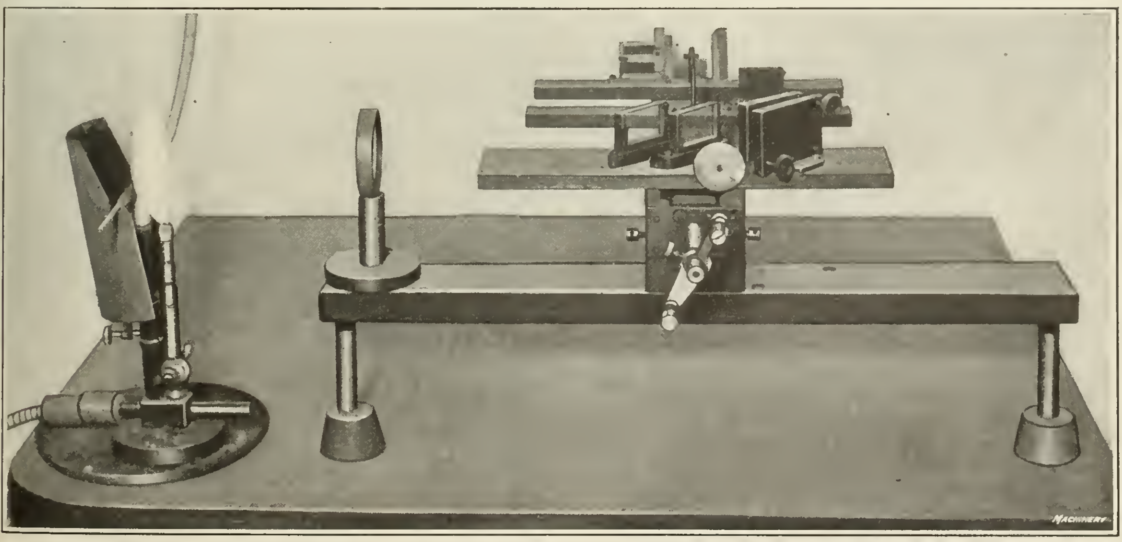


Fig. 12. Front View of Interferometer shown in Fig. 11. This shows Ways on Bed and Bearings which support Screw to be tested

cates an error in the screw, but it will only show the difference in pitch of the screw at the two places on which the nuts engage.

The most accurate and reliable method of testing the errors of a screw, or of measuring any small unit of length, is based on the application of interference of light waves, and this method is used in the Gaertner shops. It will be impossible in this article to enter into a detailed discussion of the theory of optical interference, which may be found in any standard book on optics. The instrument used for testing by this method is known as an "interferometer," and it is the means of obtaining the most accurate results in length measurements; this method has become identified with the name of Prof. A. A. Michelson, who has brought it to its present general form and has made the most extensive application of it in research work.

Fig. 8 shows the arrangement of optical parts of a simple form of interferometer. Light from a source A rendered approximately parallel by lens B is divided at surface C of the first glass plate into two beams, one passing on to mirror F, and the other being reflected to mirror G. After reflection from the mirrors, these beams of light are reunited at C and observed at H by a low-power telescope. The image from mirror F is seen in the direction of CG, and attention is called to the fact that mirror G makes an angle slightly different from 90 degrees with F, thus fulfilling the conditions of interference. Plate D (compensator plate) is of exactly the same thickness as plate C, thus producing similar optical distances in both paths CG and CF. In the usual form of interferometer, mirror F is held stationary and mirror G is moved by means of a screw. If both the mirrors and plates are properly adjusted, there will be seen at H what are known as interference fringes, which have the appearance of bands of high lights and shadows.

By adjustment of the mirrors the space between two adjoining bands may be made any desirable distance, say two to five millimeters. If sodium light is used which has a wave length of 0.000589 millimeter, the space between two bands represents one wave length, *i. e.*, 0.000589 millimeter, or 0.000023 inch. If now the cross-hair of the telescope is adjusted to the center of one band and mirror G is moved ½ wave length, or 0.000294 millimeter, the optical path CGC will be changed a full wave length and the next adjoining band will appear under the cross-hair. If the bands are adjusted, say, 5 millimeters apart, a travel of 5 millimeters in the telescope will be equal to a motion of the mirror of 0.000294 millimeter, or 0.0000116 inch, from which it will be seen what a high degree of accuracy is obtainable and that a one-millionth part of an inch can not only be estimated but actually measured.

Fig. 9 shows in diagrammatic form the appearance of the interference fringes in the eye-piece of the telescope when the interferometer is adjusted to space these fringes at intervals of 5 millimeters. By suitable adjustment, the fringes may be centered on scale graduations, but in order to provide for accurately measuring any given displacements, the telescope is provided with a micrometer, by means of which the scale can be moved in the eye-piece of the telescope. In this way the scale graduations can be brought back to the central position, and the necessary movement to so center the graduations is indicated by the micrometer dial. Error in centering the scale graduations on the interference fringes is eliminated by taking the mean of a series of readings. In testing screws, the interferometer is used similarly to the microscope and scale, Fig. 7, but instead of measuring the unit of length on the scale, light waves are used and the number of interference bands are counted in the telescope while turning the screw a fixed amount.

Every progressive instrument maker must have a method of testing which is capable of giving absolutely reliable information, but which is more rapid than the one just described. In the Gaertner shops such a method is provided by an application of the interferometer principle, as shown in Figs. 11 and 12; but probably a better understanding of the method of using this apparatus will be gathered from the diagrammatic view in Fig. 10, which shows the principle clearly. It will be seen that the equipment consists of a bed, in which are carried bearings for the screw to be tested. At the forward end of this bed there is a stand, on which are mounted two glass plates and one mirror, which receive light from the "sodium" gas flame A; the rays of light are concentrated by means of a lens B set up in the stand placed between the light and the first glass plate C. Sliding along the bed of the machine are two bars, on each of which are supported mirrors F and G. These mirrors must be carefully adjusted so that they are exactly parallel with each other. Each mirror stand carries a nut that consists of a single point which is a close fit in the thread of the screw to be tested; and such adjustment of the apparatus is made that interference bands appear in the field of the telescope.

Under these conditions, observation from the eye-piece of a telescope at H reveals the interference bands, which have the appearance of vertical bands of high light and shadow. As the handle at the front of the machine is turned, rotation of the screw causes the two bars supporting mirrors F and G to be traversed along the bed of the machine, and in the case of a periodic error in the screw, this results in causing the central fringe to first move slightly away from a cross-hair in the field of the telescope and then return to this cross-hair. In the case of a progressive error, the central fringe also moves away from the cross-hair in the telescope, but with an error of this kind the fringe may continue to move away instead of returning to the starting point. From the distance through which the interference fringes move in the field of the telescope, the observer is able to estimate the amount of error that exists in the screw thread, and if this error does not exceed that which is allowable, the screw is pronounced ready for use. If, on the other hand, a considerable error is discovered, it is necessary to correct this error or make a new screw. The advantage of this method of testing is that while it is not "quantitative," that is, does not show the actual amount of error that exists at each point on the screw thread, as in the method previously described, it does afford a rapid method of determining whether the maximum error in the screw exceeds that which is allowable. This is all that the instrument maker is interested in, and so the interferometer method is the means of saving him the expense of having men spend a large amount of time in testing the accuracy of each screw by the tedious micrometer-microscope method to which reference has been made.

* * *

THE METRIC SYSTEM IN GREAT BRITAIN

The question of the adoption of the metric system is apparently very much at the front in Great Britain, judging from the comment in all the British engineering journals. *Engineering*, as already mentioned in MACHINERY, leans toward the metric system. The *Mechanical World*, in an editorial entitled "The Metric System," while not over-enthusiastic about the expense that a change in weights and measures will bring with it, nevertheless states that "the prospects are in favor of the metricists." Among other bodies, the Institution of Electrical Engineers in Great Britain has asked the Board of Trade to make the compulsory adoption of the metric system part of the new trade policy of the British empire. The opposition to the system, which was very active some ten or twelve years ago, when the subject was last seriously considered, does not seem so active now. In engineering circles there is apparently no great enthusiasm over the prospect of a change, but rather an evidence of grim determination to accept the inevitable without making too much fuss. At any rate, it seems to be the plan to make the transition as gradual as possible, and this is, indeed, very necessary if the industries are not to be seriously upset. The bill that is proposed does not make compulsory the use of the metric system in the manufacturing industries, but simply requires that trading must be done in the new system. Should the British government adopt the proposition to introduce the metric system along these lines, it will be evident that the leaders of the industries in Great Britain are fully convinced that the step will not be detrimental to the nation, and that there will be a profit in the new system in the long run, although the expense at first will be heavy.

THE CUTTING TOOL AND THE CURLING CHIP

ANALYSIS OF CUTTING ACTION IN RELATION TO LUBRICATION

BY FRANK RICHARDS[1]

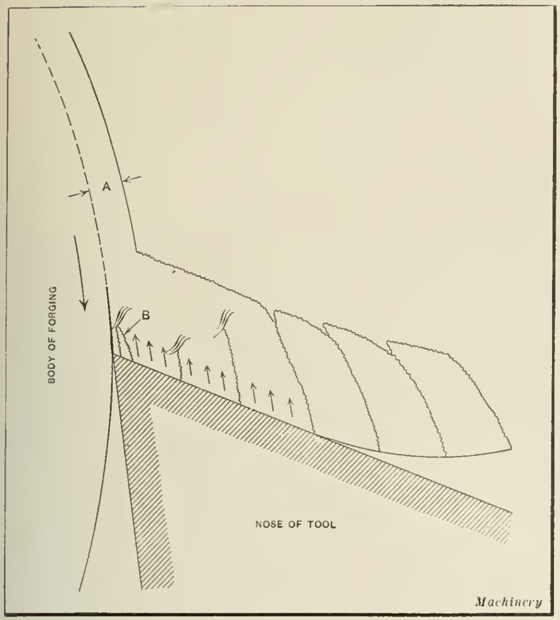


Fig. 1. Accepted Cutting Action of Tool

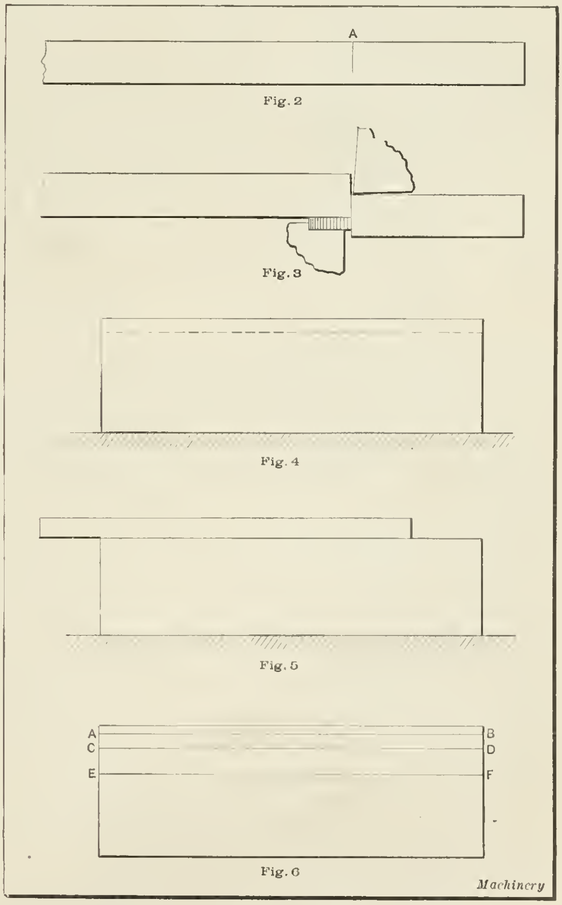
THE articles in MACHINERY on "The Lubrication of Cutting Tools" are of considerable interest. The topic is one of the greatest importance and the material presented has evidently been carefully collected and compiled. While the articles must have been read with interest and profit by many, to me they have been, perhaps, more valuable for the suggestions obtained from them than for the actual information presented.

I have looked in vain, up to the present time, for a satisfactory account of the actual function of a so-called "cutting tool" in the operation of separating chips from the surface of a large body of metal, say steel, as in an engine lathe, especially in connection with modern high-speed practice, and the articles referred to perhaps leave more questions to be answered than there were before.

In any discussion intended to lead to the establishment of conclusions acceptable for practical guidance, nothing is of more importance than that the preliminary assumptions be correct. A false start may not only lead to grievous error, but may lead us farther from the truth we set out to seek. So I will say frankly that at the beginning of the article on "The Lubrication of Cutting Tools" there is one statement that cannot possibly be correct. We are told that the severing of the chips from the body of the metal by the thrust of the cutting tool is essentially a shearing action. Now, how can this be so? Fig. 1, which is reproduced from the article referred to, in the January number of MACHINERY, cannot be said to show any shearing action. The essential characteristic of a shearing operation is the sliding of two surfaces in contact with each other at the time of severance, these surfaces being instantly created at the time that the shearing takes place and by the act of shearing. Say that a bar of metal, Fig. 2, is to be cut at *A* by shearing. The bar is laid upon the lip of a cutting shear, Fig. 3, and as the shearing blade descends the piece is cut off, being slid downward in the manner shown. This, without doubt, will be accepted as a simple and true representation of the shearing operation, and there is nothing analogous to it in the severing of the chip by a cutting tool on the lathe or planer.

Suppose that a heavy chip, as indicated by the dotted line in Fig. 4, is to be taken off a block of metal that is securely fastened upon a planer bed. If the action were that of shearing, the entire slab would have to be shoved off all at once, as in Fig. 5. Certainly nothing suggestive of such an operation occurs in the severing of the chip. We are assuming here, as it does not in any way affect the fact, that the block of metal is stationary and that the tool moves, as in a shaper. It might be suggested that while the shearing does actually take place, as theorized, the shearing and the accompanying sliding of the metal upon itself takes place only for a short distance at a time, immediately in front of the point of the advancing tool. The portion of the chip that is slid along in the act of shearing is more or less crushed or distorted ahead of the actual cut by the pressure of the advancing shearing tool, and then doubles up and scrambles out of the way by the shortest route. But even this assumption does not seem tenable, as there is no swelling of the outer surface of the chip much in advance of the cut, which would be characteristic of the operation if the shearing assumption were correct.

Referring again to the block of metal, the line *AB*, Fig. 6, may represent the line of cleavage for a thin chip or shaving to be taken off the surface, and the line *CD* will represent a much heavier chip. We may assume that the metal of the block is entirely homogeneous, which it practically is in all cases as far as the cutting of it or the making of chips is concerned; consequently, the particles have the same strength of cohesion along the line *CD* as along the line *AB*, and it should take no more force to sever a chip of the metal along the line *CD* than along the line *AB*. Yet we know that the



Figs. 2 to 6. Diagrams illustrating Shearing Action

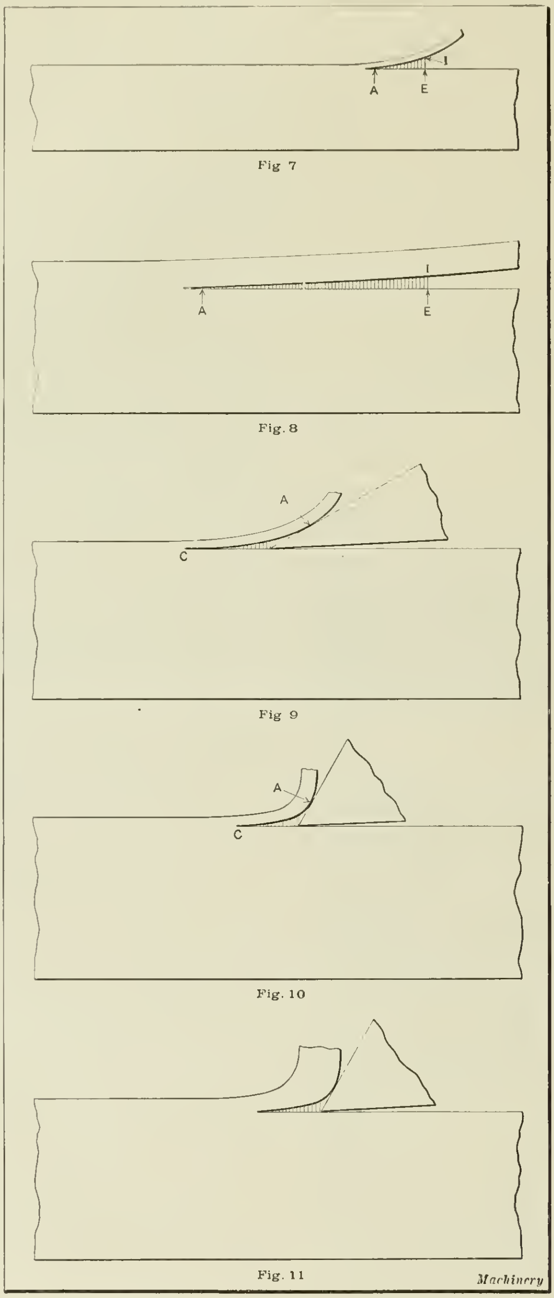
[1]Address: 229 W. 135th St., New York City.

force required is much greater for the thicker chip and that if the chip were still deeper, as at EF, it would be impossible to make the cut with any ordinary cutting tool or with the power of any ordinary machine.

Figs. 7 and 8 will show how and why this is so. These sketches are exaggerated to give an idea of what takes place at the innermost point when the actual separating of the metal occurs. The chip is not simply lifted off, nor can it be said to be sheared off, as there is relatively no sliding movement. It must be actually torn off, and a certain space EI, Figs. 7 and 8, say 0.0001 inch, may be traversed in tearing before the chip has entirely let go its hold upon the body of metal. The strain of tearing, which is continuous as long as the machine is in motion, may be all the way from A to E in each case before the chip has entirely pulled away.

Some idea of the ultimate tearing action and the effect of the metal-cutting tool may be had in any machine shop by noticing the surface produced by a fine, broad-nosed tool with a thin water cut on, say, a large steel shaft in the lathe. Although, to the eye, the surface has a beautiful finish, it will feel very different from a surface that has been polished by emery or other abrasive. If the palm of the hand is moved over a polished surface, it feels perfectly smooth, but if the hand is moved over the water-cut surface, a certain roughness is perceptible — a suggestion of minutely projecting prickly points. These are the summits of the microscopically ragged peaks left in the process of tearing the metal away. In addition, if the palm of the hand is moved lightly around the water-finished shaft, first in the direction in which the cutting tool has gone and then in the reverse direction, the surface will feel as if it is serrated or saw-toothed. But the most curious thing is that the roughness will be found to be in the opposite direction to what we might expect. It would seem that if there were any difference, the surface would feel smoother when going over it in the direction in which the tool has passed and that the invisible saw-teeth would face that way. But the fact is that they face in the other direction. With the water-cut surface on the piece in the lathe and with the lathe stopped, a person standing in front of the lathe will find that the work feels smoother when he draws his hand toward him than when he moves his hand toward the back of the lathe.

In Figs. 7 and 8, the distance EI from the chip to the body of the metal at the point where the chip may be said to have entirely let go its hold is assumed to be the same in each case. Say that the tearing away begins at A and is completed at E; then for the entire distance from A to E in each case great force is required to do the tearing. As the chip in Fig. 7 is thin, it curls away more quickly, or with a shorter radius, than the thicker chip in Fig. 8. Consequently, the distance AE in Fig. 8, through which the force is continuously applied to do the tearing, is more than double the distance from A to E in Fig. 7, and more than double the force will be required at any instant to tear away a continuous chip.



Figs. 7 to 11. Diagrams illustrating Action of Metal while being cut

In the present discussion, it is the heavier chips in which we are most interested. The heavy chip requires greater force because of the slowness with which the thick chip curls away before the advancing tool. The inevitable suggestion follows that to reduce the power requirement we should shorten the tearing away period by curling the chip with a quicker or sharper curvature. Of course, if the chip were very hot, it would bend more sharply, so that the heat of the chip is to be regarded not as incidental but as a most essential condition of high-speed practice. The hot chip necessarily requires for its production high-speed steel, the essential characteristic of which is its ability to retain a sufficient hardness at a high temperature. The hot chip is the most essential condition, and a tool steel that is hard while hot is the thing which makes it possible. It is proper to note here that the new non-ferrous alloy stellite possesses the property of cutting-hardness while hot to a degree far beyond that of any of the hitherto known high-speed tool steels. In competition with the latter, in munition factories in France, much higher speeds have been found possible with an increased output of 50 per cent or more.

It will not do to let the heating of the tool and chip go on unchecked. The local heating of the chip for high-speed work is essential at the instant before the tearing away of the chip, and immediately after that the heat generated must be gotten rid of as best it may. The article referred to says that the most important function of the so-called "lubricant" is to secure the cooling effect. This is only partly true. It would seem, from the view we are here trying to set forth, that the cooling of the chip at the actual cutting point is most undesirable, because that would mean at the moment a stiffer chip, a slower curling away, a lengthening of the distance through which the actual severing operation takes place, a greater pressure on the nose of the tool to curl the chip and roll it away, and a greater power con-

sumption for driving. This is corroborated by the experience of Mr. Taylor, if rightly interpreted. We are told that Mr. Taylor found that a heavy stream of water poured on the chip when it is removed from the steel forging would permit of employing a higher cutting speed, thus increasing the rate of production from 30 to 40 per cent. This might have been expressed in quite a different way. When the chip is so cooled that it is not so flexible and so that, on account of the slower curling of the chip away from the work, the nose of the tool cannot approach so closely to the rupture zone, it is not only permissible, but also absolutely necessary to increase the running speed so as to raise the temperature of the chip again to the point at which it will bend easily, thus reducing the force required per unit of surface traversed.

While the cooling of the chip at the precise point where the initial curling occurs is to be avoided as much as possible, the cooling of the tool at the same point is imperative for the purpose of maintaining the temper, or the necessary hardness, to enable it to stand up under the working pressure. With a speed sufficient to heat the chip at the instant of its curling away, in spite of the flood of lubricant, the simultaneous cooling of the tool is necessary, and the temperature of the body of the work will not be affected sufficiently to require much consideration, especially as such a cut as we here have in mind is not to be regarded as a finishing cut that requires great accuracy. That heat is generated when metal is forcibly torn away is shown by the abrasive grinding wheel. When the particles of metal are successively severed, they come away white-hot. They are so heated, in fact, that they are actually burning, as is shown by the scintillations. So we may suppose that, notwithstanding the flooding of the chip with the cooling liquid, it may be hotter at the critical instant of rupture than we realize from its appearance.

We are aware that the action and reaction of tool and chip, and the heating of both in the cutting operation, is by no means as simple as we have assumed. The heating, we may believe, is not due to the tearing of the metal, but to the friction and compression by which the process is accomplished. The resistance that the cutting tool opposes is not concentrated at the extreme cutting edge—the apex of the angle—but most of it comes on the beveled face back of the cutting edge. For instance, in Figs. 9 and 10, the greater stress comes on the surface of the tool at *A*, where most of the actual work of the tool is done, and the necessity of lubricating and cooling the tool at this point must be self-evident.

Figs. 9 and 10 illustrate the difference in chip-curling effect that may result from differences in the cutting angle of the tool. If the work of the tool is thought of as actual cutting, like the cutting of wood, an acute angle as in Fig. 9 will be favored, but experience shows that an angle even more obtuse than that in Fig. 10 will be more successful. In Fig. 9, the chip curls away more slowly, or with a greater radius than in Fig. 10, and the distance *AC* through which the ultimate tearing apart of the metal continues is greater, which means that a greater force is required to do the tearing.

The heating of the tool and the chip is not to be wondered at when the tool pressure and the rapidity of flow of the chip at *A* are taken into consideration; but another important condition adds largely to the heating effect. This is the rapid compression of the chip under the pressure of the tool and the necessary distortion of the metal in curling. As this curling is accomplished entirely by pressure on the outside of the curve, the inevitable result is the thickening of the flowing chip, as suggested by Fig. 11. Perhaps the best idea of the actual thickening or upsetting of the chip is to be had by standing in front of a lathe in motion and noting the slowness of the chip movement as compared with the circumferential speed of the piece from which the chip is being peeled.

It might be remarked in criticism of the preceding that we have left little or nothing for the sharp edge—the extreme apex of the cutting angle of the tool—to do. That it has comparatively little of the heavy work to do is shown by the condition of a tool after, say, an hour of heavy, high-speed cutting. This "cutting edge" may not really have much to do with the actual severing of the chip from the body of the piece, but it still has its necessary share of the work in shaving off the minute projections of the surface left after the tearing away of the chip.

* * *

CADILLAC MOTOR CAR CO.'S NEW EMPLOYMENT POLICY

The Cadillac Motor Car Co., Detroit, Mich., has issued the accompanying announcement of an important new policy, to all its employes, which doubtless will be adopted by many other manufacturers. It should work no hardship on any person of foreign birth who intends to make this country his home. The policy is in line with that which requires employes of foreign birth to learn to speak and read the English language in order to be promoted. One large western manufacturer has for a long time made it conditional to advancement that its foreign born employes learn to speak and write English; they thereby become acquainted with American institutions and are more worthy of trust and responsibility.

AMERICANS FIRST

The Cadillac Motor Car Company makes this announcement of a new and important policy to all its employes:

FROM and after this date promotions to positions of importance in the organization of this Company will be given only to those who are native born or naturalized citizens of the United States, or to those of foreign birth who have relinquished their foreign citizenship, and who have filed with our Government their first papers applying for citizenship, which application for citizenship must be diligently followed to completion.

Employes of foreign birth who retain their foreign citizenship will not be discriminated against in their present positions or work, but they will not be promoted to positions of responsibility and trust.

A pre-requisite to employment by this Company must be loyalty to our Government and our flag, in addition to loyalty to the Company itself.

All department leaders are authorized to make this order effective immediately.

Cadillac Motor Car Company

Detroit, Michigan
March 23, 1917

* * *

PROPOSAL FOR METRIC SYSTEM IN GREAT BRITAIN

According to the *Railway Review*, the Associated Chambers of Commerce, an organization of British business houses, has drafted a bill which is designed to establish the metric system as a standard of measurement in Great Britain. This bill is now being circulated throughout the country for consideration and criticism. It appears that a considerable part of the opposition to the metric standard originated in the fear on the part of some British manufacturers that the compulsory adoption of the metric system will necessarily involve the immediate scrapping of all their existing machines, patterns, tools and other workshop standards. Such a thing has not happened in any other country which has adopted the metric system, but those who drafted the proposed bill have incorporated provisions which are designed to overcome objections of this kind. A clause is inserted, therefore, which covers the situation in the following language: "Provided that nothing in this act shall affect the manufacture or use of any machinery, tool, pattern, sieve, templet, or other article made by measures other than metric measures." The passage of an act so worded would thus mean that while it would be required to buy and sell goods to metric standards, the existing weights and measures could be used for manufacturing purposes until it became more convenient to change them.

GRIDLEY MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINES—1

DESIGN, CONSTRUCTION, OPERATION, TOOL EQUIPMENT AND ATTACHMENTS

BY DOUGLAS T. HAMILTON[2]

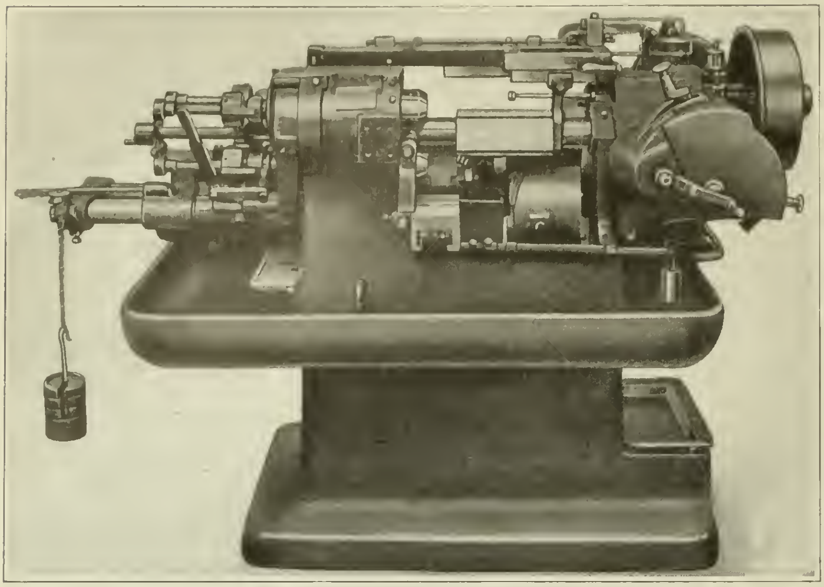


Fig. 1. Front View of Gridley Multiple-spindle Automatic Screw Machine

THE Gridley multiple-spindle automatic screw machine, the first size of which was designed and built in 1908 by George O. Gridley, was constructed around the turret principle originated in the single-spindle machine described in the May number of MACHINERY. There are, however, certain modifications in the multiple-spindle machine that adapt it for handling more than one bar at a time. The turret design differs in that, instead of having independent tool-slides moving in a longitudinal direction, the entire turret moves longitudinally, bringing the various end-working tools into operation on the work. There are other important differences in this machine, which will be dealt with in the following.

Principle of Design

The chief feature in the design of the Gridley multiple-spindle automatics is the spindle carrier, and the mounting of the tool-slide on it, which does not necessitate any overhanging of the turret tools, and consequently enables the machine to stand up under heavy cuts and coarse feeds without perceptible chatter. In construction, this machine comprises four work-spindles, which are held in a spindle carrier; these spindles are rotated by spur gears from a central gear on the shaft that runs the entire length of the machine and passes completely through the spindle carrier. The spindle carrier is indexed to bring the bars successively into line with the various tools on the turret slide, by means of a Geneva stop mechanism, which will be described in detail later.

One of the most important features of this machine is the relation of the turret slide to the spindle carrier. While the turret slide proper does not rotate with the spindle carrier, the latter, in addition to rotating in the casing, also rotates within the turret slide. In other words, the end of the spindle carrier forms a shaft or bearing on which the tool-slide is supported. This insures that the spindle carrier and turret slide will always be in perfect alignment.

The turret slide has four standard tool positions; these, instead of being located on the flat faces of the turret, are located on the four corners, which are machined to provide a narrow base and also to form a T-slot for clamping the tools in position. Thus the turret tool-holders, instead of fitting on a flat face, fit on two angular surfaces, forming an included angle of 90 degrees. It is therefore possible to get more accurate alignment of the turret tools with the spindle than it would be with a T-slot alone, and as all of the turret tool-holders are bored out in position on the machine, accurate alignment between the tool-holders and spindles is easily secured.

Reference to Figs. 1 and 2 will show that the turret slide, in addition to being rigidly supported on the extended end of the spindle carrier, is guided by an arm that moves on a top guide, fastened to a bracket extending from the spindle end to the power end of the machine. Like the single-spindle machine, this machine has one main cam-shaft carrying drums for advancing and returning the turret slide, indexing the spindle carrier, etc. The cross-slides, however, are operated by a separate cam-shaft located at right angles to the first one, and driven from it by bevel gears, as will be described subsequently.

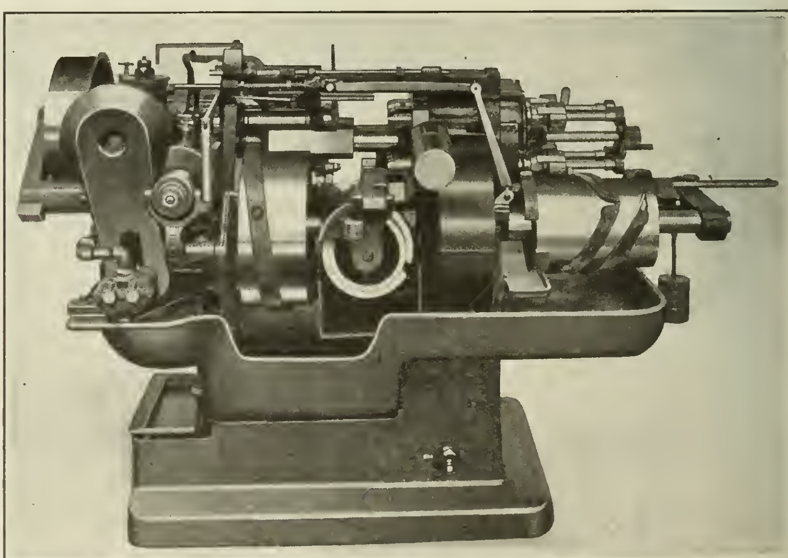


Fig. 2. Rear View of Gridley Multiple-spindle Automatic Screw Machine

[1] For other articles on automatic screw machine practice, see "Gridley Automatic Turret Lathe," in the May, 1917, number, and articles there referred to.
[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

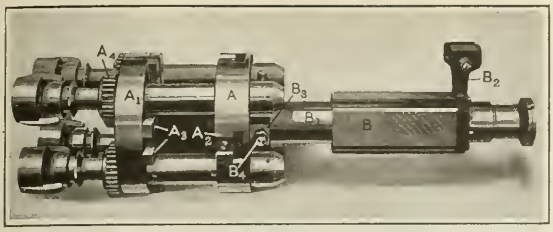


Fig. 3. View showing Spindle Carrier and Turret Slide removed from Machine

As all the turret tools are at work on different bars at the same time, it is obvious that the time required to produce one piece is only that necessary for performing the longest single operation plus the time required for moving the turret slide away from the work, revolving the spindle carrier one-quarter revolution, and moving the turret slide forward again to bring the tools into the cutting position. There are cases, however, where the longest single operation is accomplished from the cross-slide, and in this case, of course, the time required for the cutting-off or forming operations plus the idle movements just mentioned would be the total time to make one piece. With a separate arrangement of stops, as will be described later, it is possible to use all four faces of the turret for carrying end-working tools, and the turret is so designed that one tool can be placed behind the other on the same corner for performing operations on long work or for doing drilling and turning operations at the same time. This is obviously an advantage where a considerable number of operations are necessary to complete the part being made. The turret, of course, is not indexed, but is simply moved back and forth to bring the tools into and out of contact with the work. The spindle carrier is indexed one-quarter revolution for each advance of the turret slide, a piece being finished and cut off at each advance of the slide.

Spindle Carrier and Turret Slide

The spindle carrier and turret slide are shown removed from the machine in Fig. 3, where it will be noticed that these two members are tied together. The spindle carrier, as has been previously mentioned, consists of a drum provided with bearings A and A_1 and an extended central part on which is mounted the tool-slide. Bearing A carries hardened and ground blocks A_2, in which the locking pin enters for locating the spindle carrier in line with the various tools on the turret slide; whereas bearing A_1 is provided with hardened and ground guide blocks A_3, in which the roll in connection with the Geneva stop mechanism enters for indexing the spindle carrier one-quarter revolution. These two bearings, as has been previously mentioned, rotate inside a casing, and carry the four work-spindles, which are driven by gears A_4 from a central shaft A_6, Fig. 6, as will be described later. On each spindle is a gear that meshes with the central gear, and rotates continuously.

The turret slide proper B, Fig. 3, moves back and forth on the extended part of the spindle carrier B_1. The turret B is of square section and is provided with T-slots at its four corners for clamping the turret tools in position. Fastened to the rear end of the turret is a bracket B_2 that is used to guide the turret in correct alignment with the axis of the spindle, this arm being controlled in its position by a guide fastened to the overhead bracket running from the feed end to the spindle end of the machine. The spindle carrier also carries a spider B_3 having four adjusting screws, and lock-nuts B_4, which control the forward movement of the forming slide when it is desired to form to unusually accurate diameters.

Construction of Work-spindles

The work-spindles, as shown in the sectional view in Fig. 4, comprise a steel sleeve C that extends through the work-spindle carrier and is supported in long phosphor-bronze bearings C_1 extending the full length of the carrier. These bearings are keyed to the spindle carrier and are provided with liberal oil-grooves. A sleeve C_2 surrounds the bearings C_1, fitting closely between the cheeks or bearing surfaces of the spindle carrier, and acts as an oil reservoir for the spindle bearings. The front end of spindle C is threaded and the nose cap C_3 is screwed on; this nose cap is of the type which closes the chuck when the latter is forced into it. Located between the shoulders on spindle C and bearing C_1 is a steel and phosphor-

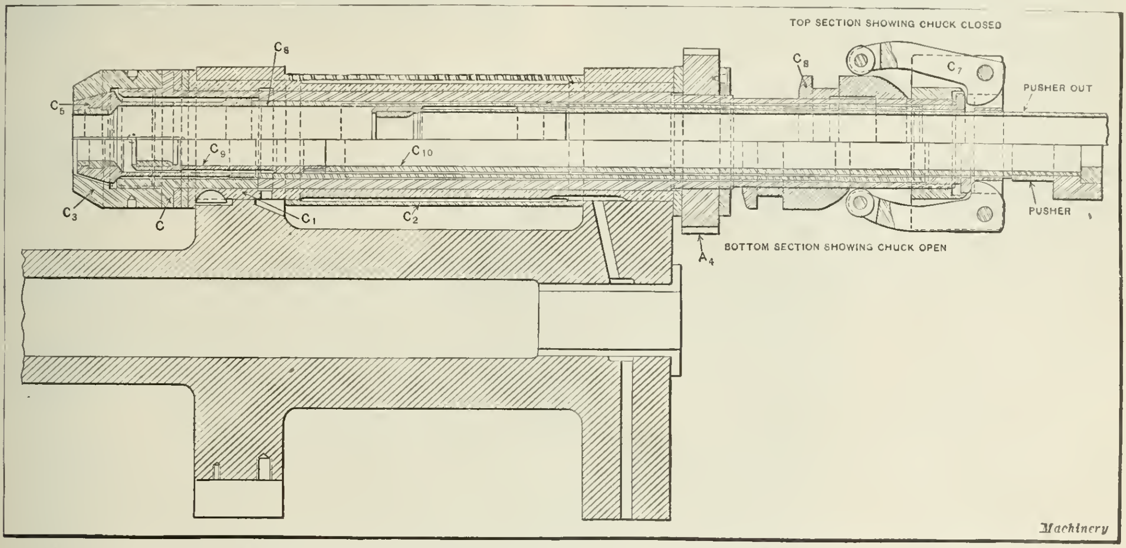


Fig. 4. Section through Work-spindle, showing Chuck-closing and Stock-feeding Mechanism. Note that Stock-feeding and Chuck-closing Mechanisms are shown in Forward and Rear Positions—Upper Section shows Chuck closed and Feed Pusher withdrawn, and Lower Section shows Chuck Open and Feed Pusher advanced

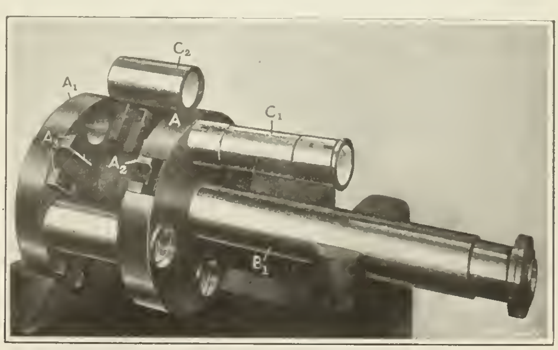


Fig. 5. Detailed View of Spindle Carrier, showing Bearings and Oil Retaining Sleeve removed

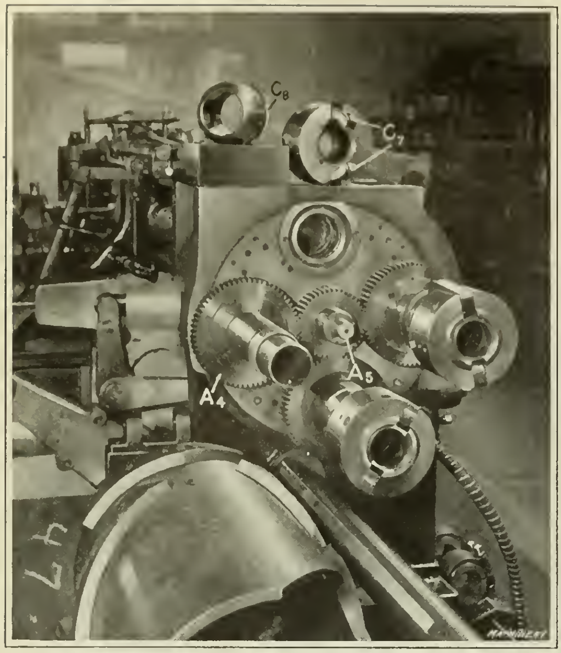


Fig. 6. Dismantled View of Cylinder, showing Driving Gears for Work-spindle

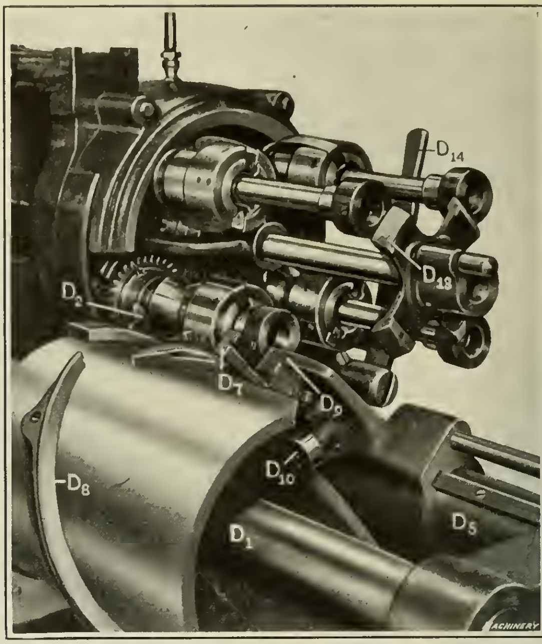


Fig. 7. End View of Machine, showing Chuck-closing and Stock-feeding Mechanism

bronze ring that takes the end thrust. The rear end of the spindle carries the driving gear A_4, which is keyed to the spindle. Between bearing C_1 and gear A_4 is a bronze thrust washer. The construction of the spindle bearings is more clearly illustrated in Fig. 5, where one of the bearings is shown ready to be inserted.

The spring collet C_5, Fig. 4, which is of the push type, carries bushings as illustrated, except on the ¾-inch size, so that one collet can be used for several different diameters of stock. This collet is closed on the work by being forced into the nose cap C_3 by a sleeve C_6 that extends through the work-spindle and has a collar on its rear end against which the short arm of closing fingers C_7 contacts. These closing fingers are carried in a collar that is attached to the rear end of the work-spindle and have rollers on their long arms which contact with the spool C_8 that is moved back and forth for opening and closing the chuck.

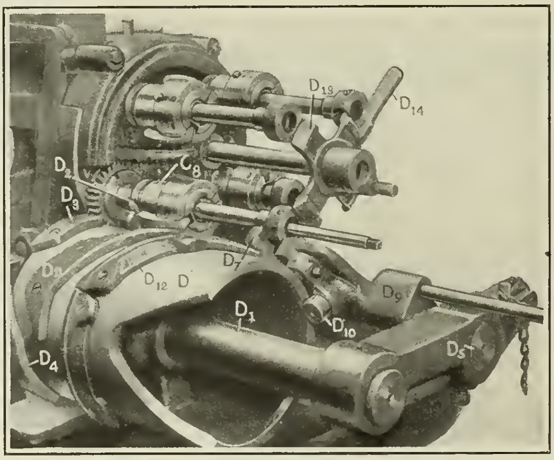


Fig. 8. End View of Machine, showing Feed Pusher withdrawn

The stock is fed forward by means of a feeding finger or pusher C_9 which is provided with bushings on the larger sizes of machines. This is screwed into a pusher sleeve C_{10} that passes completely

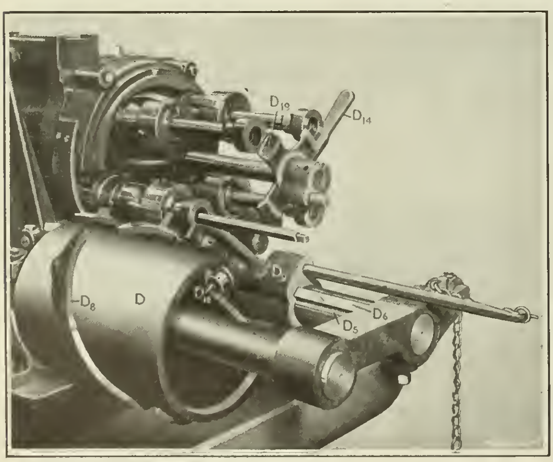


Fig. 9. End View of Machine, showing Feed Pusher advanced

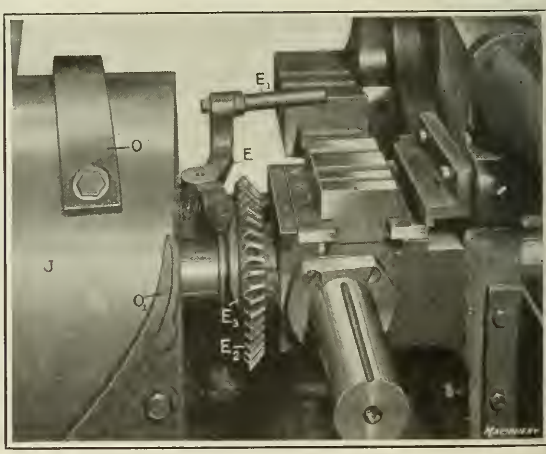


Fig. 10. Swinging Stop for gaging Stock to Length

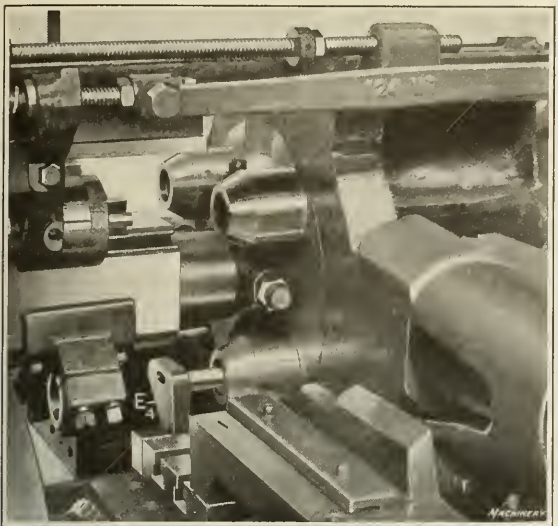


Fig. 11. Type of Stop used when a Tool is in Fourth Position on Turret Slide

through the spindle of the machine; it is withdrawn by a cam on the drum located at the left-hand end of the machine, and is advanced by a weight and cam follower.

Chuck-closing Mechanism

As has been previously mentioned, the collet or chuck is closed by means of a sliding sleeve that receives motion from fingers held in a collar attached to the rear end of the spindle. These fingers, in turn, are operated upon by a spool C_8, which is free to slide on the spindle proper. The forward end of the

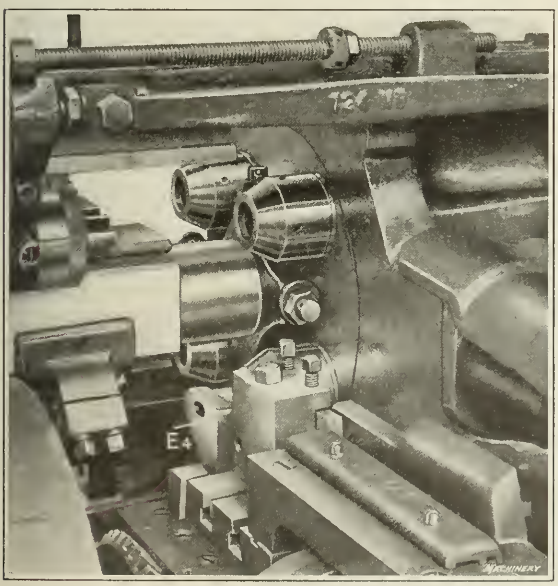


Fig. 12. Stop shown in Fig. 11 in Position when Cut-off Slide is advanced

spool has a groove in it in which a forked lever D_2, Fig. 7, fits when the cylinder head indexes the spindle around to the fourth or stock-feeding position. A drum cam D, Fig. 8, held on the main cam-shaft D_1, carries cams for operating forked lever D_2, cam D_4 acting to force spool C_8 under the chuck-closing fingers, and cam D_{11} withdrawing it. Lever D_2 is retained on shaft D_5, which has a key D_6, Fig. 9, extending its entire length, so that the fork can slide back and forth, but cannot rotate. When the spool is removed from beneath the finger rolls, the latter collapse and allow the chuck-closing sleeve to be forced back by the spring temper in the chuck, thus opening it and allowing the work to be fed forward. When setting up the machine the chuck can be operated by hand-lever D_{14}.

Operation of Stock-feeding Mechanism

The stock-feeding mechanism, as has been previously described, consists of a feeding finger or pusher attached to a tube. This tube, as shown in the sectional view Fig. 4, extends completely through the spindle of the machine and at the rear end is provided with a collar against which the operating arms work. As shown in Figs. 7 and 9, two arms are required for operating the stock pusher. Both these arms are held on shaft D_5, being free to slide upon it but prevented from turning by the key D_6. Arm D_7, which is used for withdrawing, is operated by cam D_8 on drum D, this arm carrying a roll

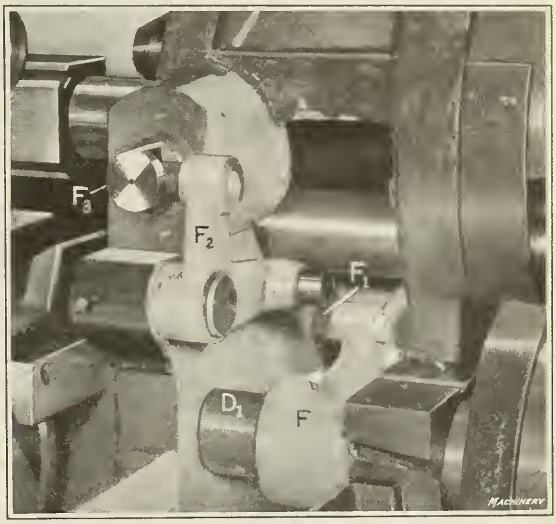


Fig. 13. Detailed View, showing Geneva Stop Mechanism for indexing Spindle Carrier. View shows Position of Arm just after indexing

that contacts with the cam face. Arm D_9, which also carries a roll D_{10}, is used for forcing the pusher forward to advance the stock, the roll being kept in contact with the cam face on the rear end of drum D by a weight. As previously mentioned, the weight is depended upon to advance the stock. Drum D also carries safety cams D_{11} and D_{12}, Fig. 8, for the chuck-closing and stock-withdrawing arms, respectively. In order to prevent the stock pushers from gradually working out of the spindles when the bar becomes short, a star D_{13}

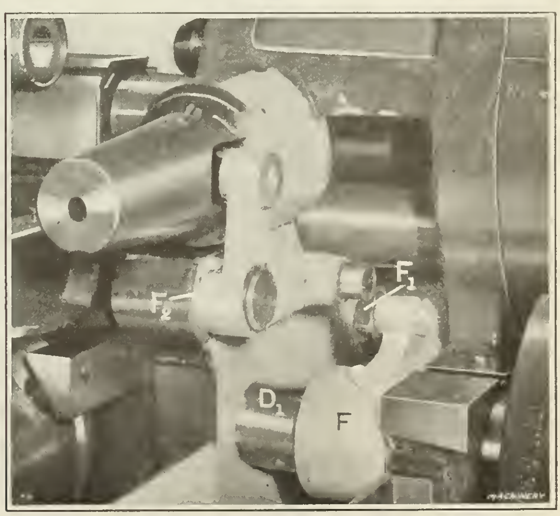


Fig. 14. Another View of Spindle-carrier Indexing Mechanism, showing Guard over Locking Bolt for retaining Spring

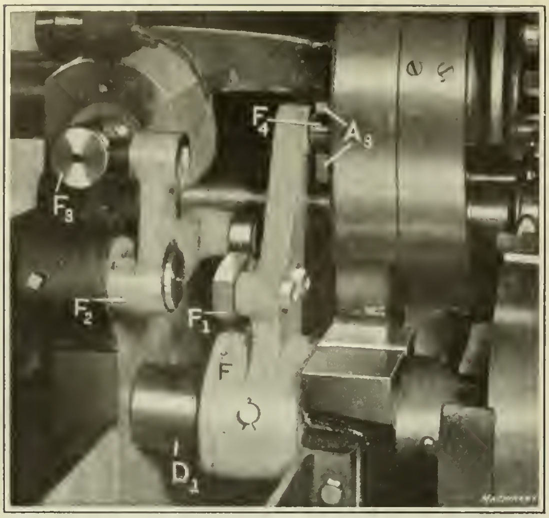


Fig. 15. View showing Indexing Arm about to index Spindle Carrier with Locking Pin withdrawn

having four arms is used as a back stop; when it is desired to remove the stock pushers, this is done by simply taking out a plug and swinging the star stop around.

Operation of Stock Stops

As has been previously mentioned, the feeding of the stock on the Gridley automatics is carried on in the fourth position, and a stop controls the distance the stock is fed out, as shown in Fig. 10. This stop consists of a bellcrank arm E fulcrumed on a post and carrying an adjustable stop proper E_1. The other end of this lever is provided with a cam surface, which is kept in contact, by a spring, with the rear face of the bevel gear E_2 that is used for driving the cross-slide drum. On the rear face of the gear is a cam projection E_3 which swings the stop E into the feeding position when the stock is about to be fed forward.

When it is desired to use an end-working tool in the fourth position, which is interfered with by the stop, a special stop E_4 held on the cut-off slide, as shown in Figs. 11 and 12, is used. This stop is fastened to the front face of the cut-off slide and consists of a bracket having one arm that extends in front of the chuck. When it is desired to use a drill, reamer or other tool in the fourth position, a hole is drilled through the stop bracket, which is elongated so that the tool can pass through the stop and operate on the work. The necessity, of course, for elongating the hole is to allow for the backward and forward movement of the cut-off slide. This particular stop is shown in the position it occupies in front of the cutting-off tool-holder in Fig. 12. When using an end-working tool in the fourth position, it is also necessary to change the cams on the turret slide drum, as will be described subsequently.

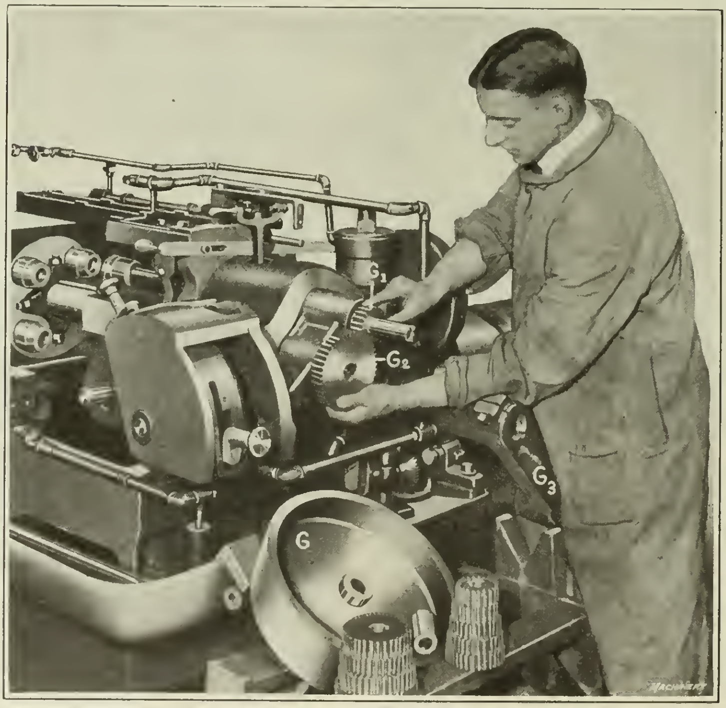


Fig. 17. View showing Operator putting Change-gears into Place

Indexing and Locking Mechanism for Spindle Carrier

The mechanism for indexing the spindle carrier is constructed on the principle of the Geneva stop mechanism. This is illustrated clearly in Figs. 13, 14 and 15. Shaft D_1, which carries the drum for operating the chuck-closing and stock-feeding mechanism, has an arm F pinned to it, as shown. This lever carries a cam F_1, which, through a bellcrank lever F_2, fulcrumed to the frame of the machine and carrying a roll on each arm, withdraws the locking pin F_3. As shown in Fig. 14, this locking pin is enclosed inside a cap, and a heavy coiled spring keeps the locking pin forward when not acted upon by the bellcrank lever.

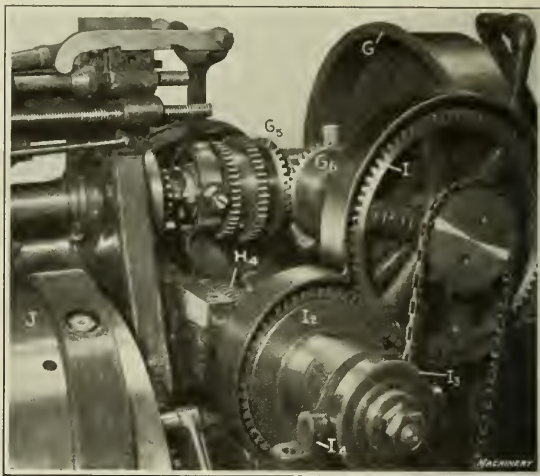


Fig. 16. Partially Dismantled View of ¾-inch Machine, showing Power-feed Mechanism. Note that No Idler Gear is used on Fast-speed Mechanism

The revolving of the spindle carrier is accomplished by lever F which, on its upper end, carries a roll F_4 that enters between the two guide blocks A_3 fastened to the faces of the spindle carrier, as previously described in connection with Fig. 3. This mechanism is so set that the roll on lever F enters between the guide blocks at the precise moment that the locking pin is removed from the spindle carrier. The indexing movement is gradually increased near the center and decreases as it leaves the center, so that there is no jar either in starting or stopping. It is also positive and accurate. The indexing is done on fast speed.

Operation of Main Cam-shaft, Turret Slide, Work-spindles, Threading Spindle, and Forming and Cutting-off Slides

Power for operating the various mechanisms of the Gridley multiple-spindle automatic for the belt-driven type of machine is secured through a pulley G and two change-gears G_1 and G_2, as shown in Figs. 16 and 17; in Fig. 17 the operator is putting the change-gears into place. To remove these two gears it is necessary to release the clamping screw on arm G_3, pull it around, drop it out of the way, and then remove the pulley. The changing of these gears directly affects the spindle speed and, during the slow or working movements, the speed of the cam-shaft, although this member is subject to a separate control by a change-gear box.

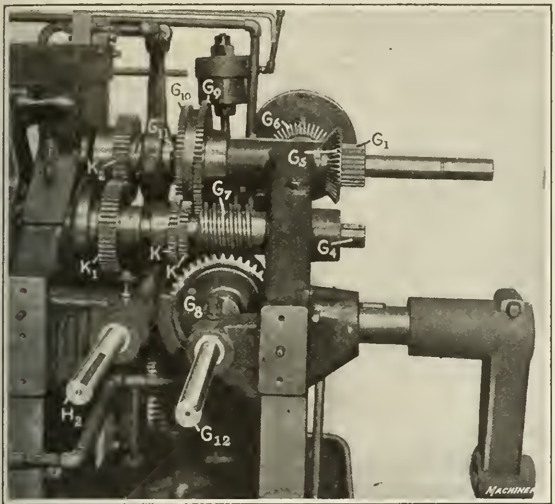


Fig. 18. Partially Dismantled View, showing Gear Drive for Main Cam-shaft, Work-spindle and Threading Mechanism

The gear G_1 on the pulley shaft drives change-gear G_2 on shaft G_4, Fig. 18. The pulley shaft also carries a bevel pinion G_5, which drives the pinion G_6 that controls the fast and slow speed movements, to be described later. Gear G_2 is directly located on the spindle drive-shaft G_4, which carries a worm G_7 meshing with worm-wheel G_8 on the feed-gear-box shaft. The shaft that carries gear G_1 also carries twin threading gears G_9 and G_{10} and a clutch G_{11}. Shaft G_4 extends through the axis of the spindle carrier and drives the work-spindle.

The gear-box shaft G_{12} has a keyway in it, as shown, and a gear (not shown) supported by bracket G_{16}, Fig. 19, slides on this shaft. This bracket also carries an idler gear G_{15}, which is constantly in mesh with the gear on the gear-box shaft. Bracket G_{13}, to which lever H_1 is attached, carries three gears G_{14}, and worm-shaft H_2 carries a cluster of six gears H_3 and a ratchet and pawl, not shown. This shaft continues through the machine, and, as shown in Fig. 20, carries a worm H_4 for driving the worm-wheel H_5 that rotates the main cam-shaft J. The three gears on arm G_{13}, Fig. 19, and the six gears on worm-shaft H_2, provide eighteen changes of speed for the main cam-shaft, irrespective of the speed of shaft

Fig. 19. Operator shifting Position of Gears in Change-gear Box

G_4, Fig. 18. These speed changes are effected by manipulating levers H and H_1. Gear G_{15} is meshed with any of the three gears G_{14}, and the largest of the three gears G_{14} is meshed with any of the six gears H_3.

The functions of the two levers H and H_1, while both controlling the speed of the main cam-shaft, during its slow or working time, differ in that lever H provides for the use of the three separate cams on the turret slide drum. The various sizes of machines are provided with three cams, giving leads in a constant ratio; for example, on the 3/4-inch size, the cams give leads of 1 1/2, 3 and 4 9/16 inches. These cams, of course, cover the same section of the circumference of the cam drum, but the 3-inch cam advances the turret slide twice as far as the 1 1/2-inch cam in the same arc of rotation of the cam drum. The throw of the cam, and the speed at which it is rotated, controls the feed of the turret slide in relation to the speed of the work, so that by changing the levers previously referred to, the feed is varied. This change can be made while the machine is in operation.

The idle movements of the machine are operated at a faster speed than that at which the cam-shaft rotates when the tools are cutting. This is accomplished by a separate driving mechanism, Fig. 20. Miter gear G_5 on the pulley shaft drives G_6. The shaft carrying gear G_6 extends to the rear of the machine and carries a gear I, which through an idler I_1 drives gear I_2 on the worm-shaft. This shaft carries the Johnson clutch I_3, which can be operated by hand-lever I_4 or by dogs held on turret drum J. The high-speed dog is set at the high point of the lead cam, and the slow-speed dog is adjusted in the key-slot in cam drum J, so that the drum runs at high speed. Now when the Johnson clutch is brought into engagement with the fast speed gears, it drives the worm-shaft so fast that this shaft runs away from the pawl on the outer end of shaft H_2, Fig. 19. Gears I, I_1 and I_2 then drive the cam-shaft at high speed to take care of the idle movements.

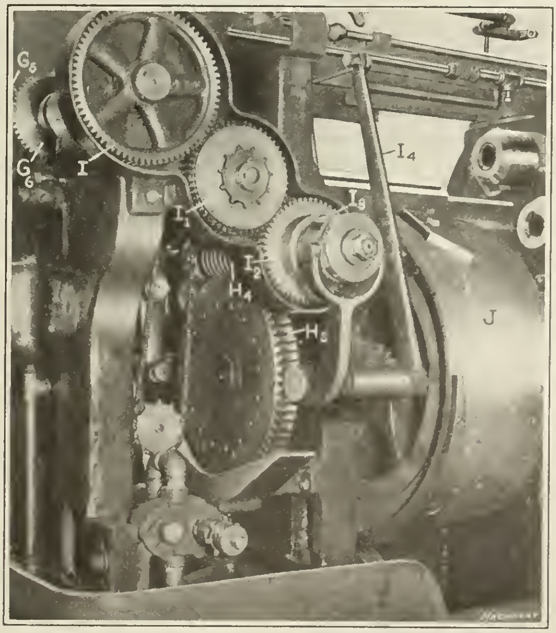


Fig. 20. Partially Dismantled View, showing Gears and Clutch for operating Main Cam-shaft at Fast Speed for accomplishing Idle Movements

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HIGH-WATER MARK FOR MACHINE TOOLS[1]

The war period has witnessed an unprecedented increase in the number of American machine tool builders, but this increase has been in proportion to normal requirements except in the manufacture of engine lathes. Figures recently compiled by MACHINERY show that 110 manufacturers had in the last three years taken up the production of engine lathes, in addition to about 40 such manufacturers previous to the war. Of the 110 new manufacturers, 29 have discontinued the production of lathes, 24 expect to discontinue, and 57 expect to continue, more than doubling the number in business before the war. Of the 110 concerns, 67 were building standard lathes, and 43 single-purpose or shell lathes; 48 of the 110 were building on contract for established lathe manufacturers, or for dealers, and 62 for the general market.

It is not easy to shift from one product to a radically different one and back again; but some manufacturers have made money by doing this, and have now abandoned the lathe business for their original product, or for some other. Few of these have been so fortunate as a New England concern identified for more than a generation with a well-known product in no way related to machine tools. This concern is said to have received orders for about $250,000 worth of lathes from one dealer and for another $25,000 worth on their own account. On all this business they realized a handsome profit, and when they decided to give up the manufacture of lathes they made an additional profit on the sale of planers, milling machines and other tools which were bought to handle the lathe work, and which had advanced in price so that they could be sold second-hand for more than they cost new at the time they were bought.

Although the sales of lathes far outnumber those of any other machine tool, there is no line in which there is such strenuous competition, and as we return to normal conditions it will be increasingly difficult for new and unknown concerns to turn over their product at a profit in competition with old and well established firms who have up-to-date manufacturing and selling organizations, and whose product is well known throughout the industry. Lathes sold themselves during the height of the war demand for machine tools, and this has caused some inexperienced manufacturers to feel that the selling end of the lathe business will continue to take care of itself. Most of them have produced only one size; but to meet competition and secure satisfactory agents they must design and build several sizes so as to have a fairly complete line, and each size must be built in sufficiently large quantities to keep down production costs. The whole proposition will then assume a different aspect, because they will require added equipment which was not considered necessary before, and a total investment far greater than they now have.

Newcomers in the machine tool field will find it more profitable to use their capital and efforts in lines that offer a better future and less competition. There are still abundant rewards for ingenuity and enterprise in the machine tool industry. Its development will keep right on.

[1] By Alexander Luchars, publisher of MACHINERY.

* * *

SPECIALIZING IN MECHANICAL WORK

Successful specialists in mechanical work not only know their own work, but have a general knowledge of other branches bordering on or closely allied thereto. In fact, specialization usually increases the ability to focus on one line of work a general fund of knowledge. For instance, a man who is an expert in originating mechanical devices has, as a rule, developed his inventive faculties by studying the details of a great variety of machines and mechanical movements. This is also true of the expert tool designer, who is an expert because he possesses a broad knowledge of general manufacturing requirements. A competent machine designer not only knows how to build a machine on paper, but possesses a general knowledge of manufacturing methods. The experienced designer must understand the work which is to be done in the pattern-shop, foundry, machine shop and tool-room in producing the machine or mechanism that is drawn on paper. Machine design involves not merely the designing of a machine that will perform the necessary work, but also the arrangement and shaping of the different parts so that the work of manufacture is not only practicable, but capable of being done on an efficient basis. Hence the most successful specialist is the man that has the broadest general knowledge combined with an extensive specific knowledge of the work with which he is occupied. The machinist, toolmaker, foreman or designer who appreciates the present-day requirements in the shop and drafting-room is not content with a one-sided experience and a mechanical education which is bounded by his own limited observations. He recognizes the value of a broad general knowledge obtained by reading, in addition to the knowledge obtained by practical experience.

* * *

MANUFACTURING PRINCIPLES

It is not an uncommon impression that the shop which is manufacturing an ingenious machine or device employs numerous interesting tools and methods of construction. This is not necessarily true. The rule is that any manufactured device is generally made by simple standard methods unless it is produced in large quantities. Then there is afforded the opportunity for the development of special machines and methods, jigs, fixtures, etc.

Some of the simplest products made in large quantities are produced by the most ingenious methods and machines. When a product is turned out in hundreds of thousands or millions annually, the manufacturer is warranted in spending large sums in the development of special machines or processes for reducing costs. A machine that reduces the cost of a product one per cent may pay for itself several times over in the course of a year's use.

In the manufacture of motor cars, the same rule holds. High-priced motor cars made by concerns that turn out only a few hundred yearly are made with the aid of ordinary machine tools, and very few special machines are employed. Much of the work is done by hand, and the so-called refinements, especially, are generally produced by skilled hand work. On the other hand, the manufacture of low-priced cars made in large quantities affords opportunity for the development of highly specialized plants, using special tools and machinery and having the work routed in such a manner as to produce the largest possible amount with the least waste of time.

STOPPING A SHOP LOSS

BY CHARLES C. LYNDE[1]

In one of the larger factories in an Eastern town, high-priced tool steel had been disappearing for some time and all efforts to trace the theft to some of the employes in the department where the shortage was reported were unsuccessful. When detectives were employed in the place of regular workmen and under the guise of "efficiency experts," nothing vanished. One man was kept on for over a month in the hope that he might catch someone in a renewal of the thefts, and after he had worked for about three weeks, the steel again began to disappear nearly every night, but he had to give up without producing any tangible evidence. The management did not want to stop and search all the men as they left the plant, fearing that this would humiliate those who were not guilty and possibly warn the culprits if they were unable to search all the men from the "tainted" department the first evening, or if the men happened to be leaving without any of the steel at the time of the search. Finally, when the daily loss was beginning to affect the nerves of the superintendent and the tool-room foreman, a plan was devised for detecting the fraud.

The men working in the suspected department entered the plant through a narrow aisle, along one side of the clock house, and stopped midway of the passage to time-stamp their cards. A small paymaster's window was opposite the time stamp, so that the timekeeper could watch the men as they registered in and out. One Saturday night, when the plant was deserted save for the watchman, the superintendent, foreman and timekeeper took to the factory, in the superintendent's automobile, the component parts of a platform scale of the recording type. A section of the clock-house floor was taken up and the scale mounted across the passageway, with its platform level with and replacing the section of floor removed; the dial was placed inside the timekeeper's office. A trip lever attached to the platform was also placed in the office. Unless this lever was released, the platform was rigid, and so the swaying of that section of the floor, which might have aroused suspicion as the men walked over it, was prevented. The matting that had been in the aisle was placed over the platform, completely hiding from casual inspection all traces of the work. The timekeeper then practised, with the superintendent, the releasing of the trip so gently that it could not be noticed by a man standing on the platform directly in front of the window.

The next Monday morning, instead of having the time cards in the usual rack by the clock, a notice was posted there that temporarily each man would get his card at the window in the morning and would turn it in there at night—the cards to be used meanwhile in figuring a cost-cutting scheme. As each man went to the window to get his card, the timekeeper gently released the latch on the scale and the man's weight was registered on the dial within the office. The timekeeper then called out the man's check number, and as he stamped and handed out the card, the check number and scale reading were entered in a double record by a man seated out of the sight of the entering workmen. That evening, the tool-room force was instructed to turn in its cards at the time office instead of merely ringing out on the clock. As this was done, the men's weights were recorded with their check numbers, as in the morning. A comparison of the records showed that most of the men checked out from one to three pounds lighter than they had checked in—but that three men had gained in weight, during their day's work, from nine to fourteen pounds. This record was taken daily for a week. On some days none of the men gained in weight, while on others the scales showed that some of the men were carrying away more than they had brought in.

At the end of the week the men were asked to work overtime—to get the plant's other employes out of the way—and the foreman planned the work so that all of the men could not leave at once. As the jobs were finished, the men were told that they would collect their wages for the week at the pay window in the time office as they turned in their cards. The first of the three men found over-weight when leaving was told at the window that there seemed to be some discrepancy in his account and was asked to step into the superintendent's office to help check up the week's work. The same excuse was made to the two other men under suspicion, save that each was assigned a different office to which he should report.

The superintendent, having been 'phoned that his suspect was coming, took out his copy of the week's scale record and got ready for his caller. On entering, the man was at once accused of taking the tool steel, the superintendent saying bluntly: "Mike, we want you to return to the company, tonight, the forty-two pounds of tool steel you have carried away from here this week." And in refutation of the man's indignant denial of the theft, the superintendent merely read off a detailed account of the number of pounds taken each day, with the dates of theft, winding up with an offer to reinstate the man to his old position if he would confess his part in the theft, make full restitution, and tell who else was implicated. The first two conditions the man gladly accepted, but would not admit that he knew of any others involved in the disappearance of the steel.

The second suspect, sent to the factory manager's office, on being asked to return at once some fifty-odd pounds of tool steel, blurted out: "So ye caught Mike and Joe, and they peached on me!" And then raved on, telling what he would do to them when the opportunity offered. But while he was in the midst of his denunciation two officers, stationed in an inner office, were called in and given charge of the man.

The third man, sent to the head time office, was the only one who happened to be trying to get away with any of the tool steel that night. On his way to the office he became suspicious and hid the dinner pail, in which he had secreted the steel. Then, a little farther along, his fears overcame his desire for the week's pay and he sneaked out of the plant without calling for the money, or even returning for the dinner pail.

The first man was put on probation after he had pointed out the shop in a nearby town to which the stolen steel had been sold and had paid the market price for the steel he was checked up with having carried away, as well as one-third of all previous losses. The second man was brought to trial for larceny and sentenced. While the only trace ever found of the third was his dinner pail, filled with tool steel, which was discovered in the yard a few days later. As no material disappeared after this, the recording scale was taken out as secretly as it was installed and the former time system restored, without the other employes even suspecting that a check had been kept on them.

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* * *

THE STUMPF UNIFLOW ENGINE PATENT LITIGATION

The decision of the U. S. District Court for the Western District of New York, which has just upheld the Stumpf uniflow engine patents, in a suit brought against a Buffalo concern for infringement, illustrates some interesting points regarding patentable inventions. It was claimed by the defendants that engines with admission valves at the end of the cylinder and engines with central exhaust ports controlled by the piston have been known for many years, and that some patents already expired have, in fact, been issued covering engines of this kind. The plaintiff, however, claimed that the combined use of an inlet port at the cylinder end, an exhaust port at a distance from the inlet port, means for heating the steam within the cylinder near the inlet port on account of the admission end of the cylinder being hot and dry, a relatively cold chamber into which the exhaust port leads, and a piston adapted to uncover the exhaust port when near the end of its working stroke and cover the exhaust port during the remainder of the stroke, constituted the invention involved in the uniflow engine, and his view was upheld by the court. The fact that other engines had elongated pistons, others central ports, and still others steam jackets, was not held to invalidate the Stumpf invention, inasmuch as in this invention these various elements had been combined in such a way as to reduce the internal loss of the steam engine materially and make a high ratio of expansion in a single cylinder possible.

REORGANIZATION OF A RUN-DOWN PLANT

INCREASED PRODUCTION SECURED THROUGH REARRANGEMENT OF DEPARTMENTS AND EQUIPMENT

BY EDWARD K. HAMMOND[1]

Fig. 1. General View of Receiving Room. Attention is called to New Freight Elevator seen at Extreme Right, and also to Bins for Storage of Small Castings, Machine Parts, etc.

If any man with a broad knowledge of the conditions existing in our manufacturing plants were asked whether he thought that the average shop is getting the greatest possible return in product and profit, his answer would undoubtedly be that it is not. So far there would be uniformity of opinion, but if the questioner went a step farther and inquired as to the reason why the average shop is failing to take the maximum advantage of its opportunities, there would probably be diversity of opinion. This diversity can be explained by the different ways in which men view the same problem, and also by the fact that people have formed their opinions by a study of different shops in which conditions vary.

Viewing the subject broadly, it is possible that there is no one cause of impaired efficiency that has a greater effect than poor arrangement of equipment in different departments of a factory and lack of system in laying out these departments in relation to each other. In most instances, this condition is simply due to a lack of foresight in laying out the shop and in providing for expansion. As the demand for the company's product increases, additional manufacturing facilities are provided, space being made and machines set up without giving the proper attention to the relation of these new departments to those previously organized, and to the work involved in transferring material and product from one department of the factory to another. Where such a condition exists much time is lost in transferring work through the shop, and it is impossible to secure the maximum production.

Experience of Rivett Lathe & Grinder Co.

The bench lathes and precision grinding machines made by the Rivett Lathe & Grinder Co., Brighton District, Boston, Mass., have won for themselves a favorable reputation in the mechanical world. It goes without saying that this reputation is based upon sound principles of design, the use of materials well suited for the different purposes to which they are applied, and the employment of highly skilled workmen, which is especially important in building precision machines of this kind. Such a reputation should be of great value to the sales department of any factory, but, despite this advantage, the Rivett Lathe & Grinder Co. had not been making money for several years. For this reason it was decided to make a radical change in the management of the factory. A. F. Orcutt was appointed general manager, with authority to take any steps that his judgment led him to believe would ultimately be the means of increasing the earning capacity of the plant.

A brief consideration of existing conditions made it apparent that no great improvement in manufacturing efficiency could be effected until there had been a rearrangement of equipment in the factory. It was the old story of a plant that had added to its equipment as the business grew, but beyond grouping the different kinds of machines in departments, there had been little effort at systematic arrangement. In several rooms the machines were distributed in such a way that it was exceedingly difficult to find passage for the trucks that carried the raw material to the machines and removed the finished product. Also, the arrangement of lineshafts, countershafts, etc., was such that the power transmission efficiency was low and it was difficult to drive the machines to their full capacity. Another source of loss arose from making a practice of building machines in very small numbers—say ten in a lot—instead of in sufficiently

Fig. 2. View in Lathe Department. Note Systematic Arrangement of Machines and Countershafts, also Open Aisle Space to facilitate Trucking

[1]Associate Editor of MACHINERY.

high numbers so that advantage could be taken of every possible saving in the process of manufacture.

After reaching the conclusion that these were two of the greatest sources of loss, it was decided to make them the starting point in carrying out the scheme of rearrangement. In all work of reorganization, it is probable that opposition will be encountered—or, at best, lack of hearty cooperation—from the old employes. After having time to become familiar with conditions in the factory, it became apparent that there were a number of unusually efficient employes in the plant who had been failing to produce results simply because the methods of manufacture under which they were working made the attainment of such results practically impossible. This was one of the most encouraging features, because with such men it was merely necessary to point out the way and they would have the ability to produce results. A careful study was made of the rank and file of employes in the shop, and as a result, some men were let go who showed themselves to be possible trouble makers. Then a campaign for greater efficiency was started among the remaining employes by getting them together, explaining just what steps were to be taken to improve conditions in the factory, and laying particular stress on the fact that this program not only included the provision of means for obtaining greater manufacturing profits, but also the bettering of conditions under which the work was done. This bid for the cooperation of the men proved the means of gaining their support, and enabled the work of reorganization to be carried on with far greater dispatch than would otherwise have been the case.

Fig. 4. View in Finished Stores Department to which are sent All Finished Parts required in assembling Complete Machines. All Furniture is made of Metal, and is Fireproof and Practically Indestructible

Rearrangement of Mechanical Equipment

Before starting to change the arrangement of machinery in the shop, floor plans were laid out to scale, and paper dummies representing each machine were then cut out to the same scale. These dummies were arranged in the different departments, and conferences were held with the respective department heads concerning the best way of laying out the equipment. After a tentative arrangement of the machinery had been made for each individual department, a general conference was held at which all department heads were present, and at this time there was a further discussion of all the conditions that might effect efficient transportation of work from department to department. Not until after the conclusion of this general conference was a single dummy pasted down on the floor plans. Then working from these plans, the drafting-room laid out complete floor plans showing the arrangement of all the equipment; and corresponding plans were drawn to show the arrangement of all the shafting on the ceiling of each shop. These shafting lay-outs were made on tracing cloth and their accuracy in relation to the different machines was checked by laying the tracings over the floor plans. In this connection it is of interest to note that the millwrights worked from these lay-outs in setting up the equipment and everything lined up without the least trouble.

General Summary of Departmental Lay-out

The plans made for rearranging the equipment were based on three general principles: First, to provide convenient and efficient means of receiving raw materials and transferring such materials from the receiving room to the finished stores department or to the shops; second, to provide for systematic routing of work from department to department and for the maintenance of open aisles in all shops, so that the work of transportation could be done as rapidly as possible; third, to furnish transmission equipment that would enable the machines to be driven to their full capacity without unnecessary consumption of power.

Outside the wing of the factory that adjoins the railroad, there is a receiving platform on which are discharged raw materials and supplies, and from which machines are loaded for shipment. In this connection it was found possible to make a material saving. Under the old management a firm of contractors in Boston had handled trucking on a basis that involved an average expenditure of $300 a month. So a decision was reached to purchase a

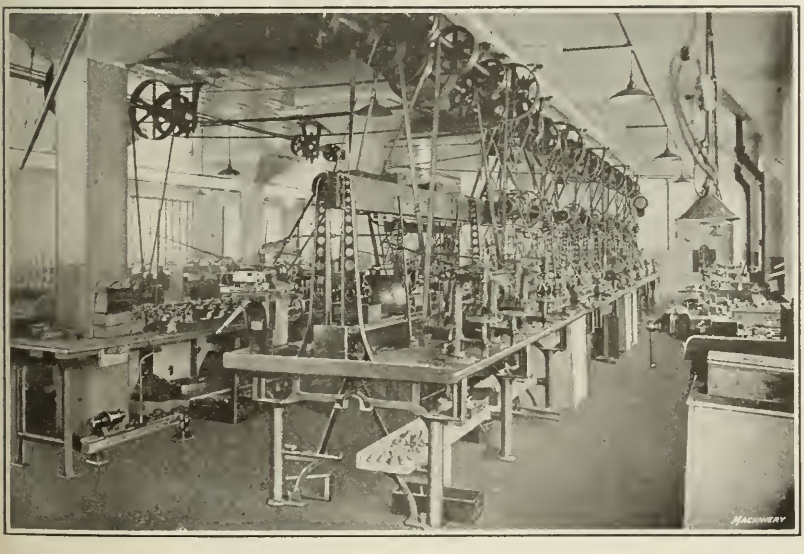

Fig. 3. View of Department equipped with Work Benches and Bench Machines for handling Small Work. Everything is systematically arranged, making Confusion Practically Impossible

motor truck in order that the company could itself transfer shipments between the plant and docks, and make local deliveries. Eventually a Pierce-Arrow truck was bought for this purpose, and it is earning at present a handsome return upon the expenditure involved in its purchase.

Fig. 5. General View in Assembling Department. Attention is called to the Large Number of Machines of One Type that are in Process of Manufacture

To facilitate the transfer of materials and product from floor to floor of the factory, a freight elevator was provided at the shipping room, space for this elevator being made by building a brick extension on the outside of the building. The shop is three stories high and arranged somewhat in the form of the letter T. The departments are arranged as follows: Running along the top of the cross-bar of the letter T is the shipping platform, and on the main floor in this section of the building there is storage space for castings, bar stock, etc.; also, there is a sawing department for cutting up bar stock into workable lengths. On the second floor is located the automatic screw machine department and the shipping room, while the third floor is given over to the grinder room and to the inspection and finished stores departments. In the section of the building corresponding to the upright of the letter T, the ground floor is given over to a department in which planers and boring mills are located, the second floor is devoted to lathes and milling machines, while on the third floor there is a bench machine department for handling small work, and the remaining space is occupied by the assembling department.

Having made this brief statement as to the lay-out of the shops, we are in a position to discuss the manner in which work is routed through the factory. It has already been mentioned that castings and bar stock come to the receiving room, where they are entered on books maintained by this department. Heavy castings are placed directly on elevating trucks and sent through to the planer department to be machined, while small castings, which come to the shops in larger quantities, are sent through into the stock-room, from which they are drawn out on requisition. Instructions were given the foundry, from which castings are bought on contract, as to the exact metal mixture that ought to give a grade of iron suitable for parts of the Rivett machines, and this has been the means of greatly increasing the quality of castings received.

The bar stock taken into the factory at the receiving room goes to the sawing department, where it is cut up into the desired lengths for working, and these short bars are then sent up to the automatic screw machine department located on the second floor. The product of this department is then sent through the inspection room to the finished stores department on the third floor, from which parts may be drawn out on requisition by the assembling department. Bed castings and other castings machined in the planer department on the ground floor go up to the inspection department on the top floor of the building, and the same is true of parts machined in the lathe and milling machine departments located on the second floor. But there is this point of difference; heavy castings go through the inspection department and are sent straight out to the assembling floor, while smaller parts, after being inspected, are sent to the finished stores department, from which they are drawn on requisition by the foreman of the assembling room.

After being assembled, the finished machines are sent to the inspection room, and after being passed by the inspectors, they go down in the elevator to the shipping room located on the second floor. Having the shipping room on the second floor and finished stores on the third floor may seem somewhat illogical, as the natural arrangement would be the reverse. But it was found impracticable to have the third floor of the building support the weight created by an accumulation of finished machines. This arrangement is not inconvenient, however, because the elevator facilities make handling of both the finished machines and the product a simple matter.

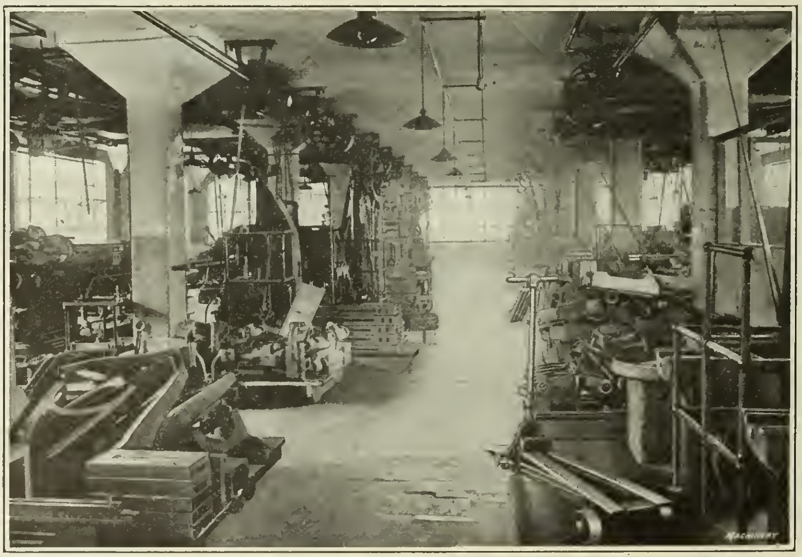

Fig. 6. General View in Factory under Old Management, which shows Considerable Evidence of Lack of Systematic Arrangement of Equipment

Maintenance of Open Aisles through Shops

There are few steps that can effect greater savings in han-

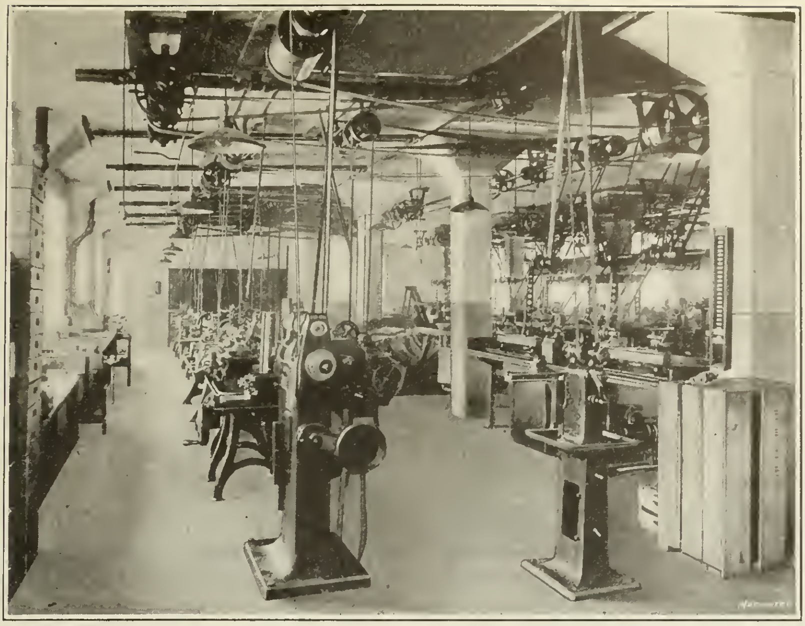

Fig. 7. Illustration showing Conditions that existed under Old Regime. Particular Attention is called to Lack of System in arranging Lay-out of Machines, Tangle of Belts and Dirty Ceiling, which greatly impair Chance of obtaining Sufficient Illumination

dling material than the maintenance of open aisles through which loaded trucks may be pushed without interruption. In working out the arrangement of equipment in the different shops, it was decided to leave space for aisles of ample width, and the aisles are indicated by white lines three inches in width, which are painted at each side of the aisle space. It is a rule of every department that no work or material shall be allowed to extend over these lines, and once every two weeks the shop painter goes over the lines so that they are plainly visible.

Arrangement of Lineshafts and Countershafts

All lineshafts in the factory are carried by hangers mounted on three- by six-inch timbers of the best quality available in the market. These timbers are bolted to the ceiling and provide a foundation for accurate shaft alignment. There is no noticeable vibration, and the proper driving conditions may be obtained for every machine, so that it may be driven to the limit of its productive capacity. This stands out in marked contrast to the cases that are too often seen where shafting vibrates considerably and where it is only too apparent that conditions of the driving equipment make it impossible to secure anything like the normal capacity from the majority of the machines.

Painting

All progressive manufacturers agree that good light is an essential of efficient shop work, and in order to secure good light it is necessary not only to have means for taking advantage of daylight and for producing artificial illumination, but the walls and ceilings of each room in the factory should be painted a light color so that distribution of the light may be as effective and as uniform as possible. Realizing the importance of this condition, it was decided to spend plenty of money on paint, as it was felt that an expenditure in this direction was far more desirable than loss of money through spoiled work and failure to obtain the maximum amount of work from each machine. As a result, a painter is employed who continually goes over the shop. He paints the walls and ceilings—and renews the aisle lines when necessary—and this man is never afraid of "working himself out of the job," because his orders are to start over at the beginning as soon as he has completed one round. This may look like an unnecessary expense, but many manufacturers who have tried the scheme out find that expenditure on light colored paint applied to the shop walls is usually a paying proposition.

Manufacturing in Large Units

Possibly one of the greatest losses of possible profits that was suffered by the Rivett Lathe & Grinder Co. under the old management was due to manufacturing machines in too small numbers. Practice varied with different machines, but the number made in one lot ranged from ten to fifty and was usually nearer the lower figure. Now the minimum number of machines carried through the shop is fifty and the number in a lot runs from fifty to two hundred, according to the machine and the nature of the work involved in the manufacture of its parts. Operating in this way, it is possible to take advantage of many savings which are impossible in cases where only a small number of machines are manufactured at a time.

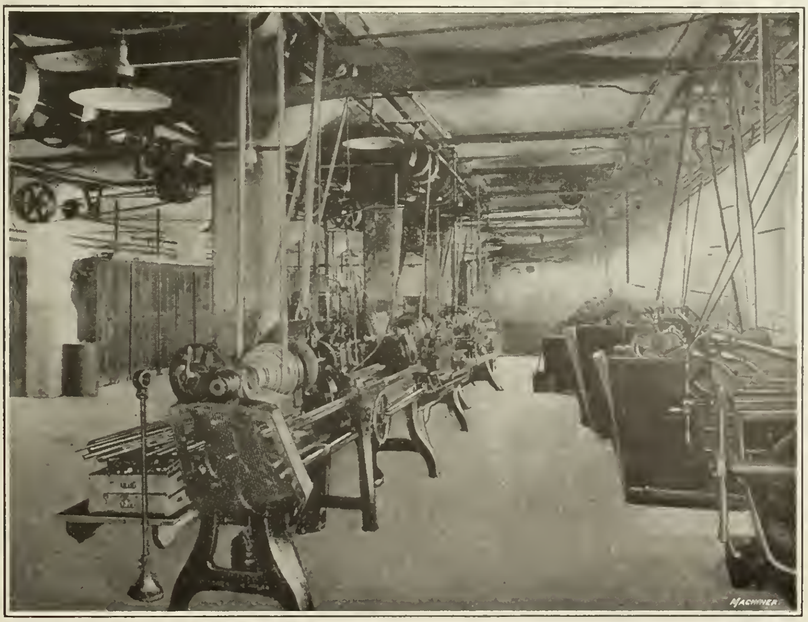

Fig. 8. View in Automatic Screw Machine Department as conducted under Old Management. Here also there is Apparent Lack of System, and General Conditions are Such that Effective Illumination and Rapid Handling of Work are greatly impaired

WORKMEN'S COMPENSATION ACTS

LAWS COVERING INDUSTRIAL CONDITIONS

BY CHESLA C. SHERLOCK [1]

THE workmen's compensation acts necessarily cover a large field, so that an attempt to discuss them even briefly would require considerable space. This discussion, therefore, will be confined to a consideration of the compensation acts as they apply to industrial conditions. The ideal way of treating this subject would be to print the various statutes and then give the courts' views of their several differences. But inasmuch as this is impossible, the English workmen's compensation act is taken as a model upon which the illustrations of the law are based. Practically all American compensation acts, except for a few minor technicalities, are identical with the English law.

Prior to the enactment of the workmen's compensation law in England, an injured employe had only the common law on which to rely. It was ordinarily necessary for him to bring suit against his employer and run his chances of a recovery. The common law had allowed employers to raise up defenses that very often cut off the employe's chance of a recovery. Then, again, a recovery that is based upon litigation is bound to be slow and expensive. Oftentimes, the litigants died before their respective rights were settled by the courts. Toward the end of the nineteenth century, the fact was quite generally accepted that the cost of injuries received in the production of wealth was a part of the cost of production and should be borne by the consumer along with other similar costs, instead by being borne by the injured employe.

The result was the English workmen's compensation act, which was passed in 1897. This law has been modeled by practically every country in the civilized world; it is in force in some twenty-five or thirty different jurisdictions. Article I, Section 1, of the act provides:

> If in any employment (where act applies) personal injury by accident arising out of and in the course of the employment is caused to a workman, his employer shall, subject as hereinafter mentioned, be liable to pay compensation.

Section 2 provides that:

> (*a*) The employer shall not be liable under this act in respect of any injury which does not disable the workman for a period of at least one week from earning full wages at the work at which he was employed.
>
> (*b*) When the injury was caused by the personal negligence or willful act of the employer or of some person for whose act or default the employer is responsible, nothing in this act shall affect any civil liability of the employer, but in that case the workman may, at his option, either claim compensation under this act or take proceedings independently of this act; but the employer shall not be liable to pay compensation for injury to a workman by accident arising out of and in the course of the employment, both independently of and also under this act, and shall not be liable to any proceedings independently of this act, except in case of such personal negligence or willful act as aforesaid.
>
> (*c*) If it is proved that the injury to a workman is attributable to a serious and willful misconduct of that workman, any compensation claimed in respect of that injury shall, unless the injury results in death or serious and permanent disablement, be disallowed.

Section 3 of Article I provides that any question as to the amount of compensation, as to whether the injured person is a workman or not, or anything else affecting the parties under the act that cannot be settled by agreement, shall be settled by arbitration. As Sections 4 and 5 do not have any bearing upon industrial questions, they have been omitted.

What Constitutes an Accident

Under Section 1 recovery is based upon injury by accident. Probably 90 per cent of the first cases brought under the act were to determine the meaning of the phrase "injury by accident." Lord Halsbury has held that it is interpreted according to its ordinary and popular meaning; Lord Macnaghten has followed the same reasoning in another case. Another court held that the word implied something "fortuitous and unexpected." The House of Lords defined an accident as "an unlooked-for and untoward event which was not expected or designed." Elsewhere they defined it as "any unexpected personal injury resulting to the workman, in the course of his employment, from any unlooked-for mishap or occurrence."

In interpreting these definitions, the courts have held a nervous shock caused by a fatal injury to a fellow workman to be an accident. So a strain produced by over-exertion in attempting heavy work is now considered to be an accident. In the case of internal injuries caused by strain or over-exertion, however, such injury is not considered to be an accident. Disease is not regarded as an accident, and where the real incapacity is the result of disease instead of the injury, there will be no recovery. It should be remembered in this connection, however, that compensation is not based upon the extent of the injury, but upon the extent of the incapacity resulting from such accidental injury. Hernia, or rupture, is held to be an accident within the meaning of the act. Said Lord Macnaghten: "If a man, in lifting a weight or trying to move something not easily moved, were to strain a muscle, or rick his back, or rupture himself, the mishap, in ordinary parlance, would be described as an accident. Anybody would say that the man had met with an accident in lifting a weight or trying to move something too heavy for him." A stroke of apoplexy said to have been brought on by a strain is not an accident. Death from erysipelas of the face, three months after an injury to a hand, is not an accident. Death from heart disease is ordinarily not an accident. Typhoid fever, enteritis, colic, eczematous sores, dermatitis, abscesses, paralysis, and cardiac breakdowns are not accidents. But where a disease is a consequence of an accident, although not the natural result or even the probable result of such accident, it is deemed an accidental injury within the meaning of the act. However, there is ordinarily no recovery for a purely occupational or industrial disease or disease arising independently.

Injuries Arising in Course of Employment

The injury must arise out of and in the course of the employment in order for a recovery to lie. It is not sufficient for a workman, according to the English decisions, to show that his injury arose out of his employment. He must also show that it arose in the course of the employment. These two requisites must be strictly followed. Because of the difficulty in determining just what this phrase means, the courts have said that each case must, in a measure, depend on its own circumstances. The American courts, as in the interpretation of the words "accidental injury," have quite uniformly followed the English rule in this particular. In fact, all through the law of compensation, the courts of the two countries stand shoulder to shoulder, so that it would be hard to distinguish between their decisions.

Said one court: "The words 'out of' point, I think, to the origin or cause of the accident; the words 'in the course of' to the time, place, and circumstances under which the accident takes place. The former words are descriptive of the character or quality of the accident. The latter words relate to the circumstances under which an accident of that character or quality takes place. The character or quality of the accident as conveyed by the words 'out of' involves, I think, the idea that the accident is in some sense due to the employment. It must be an accident resulting from a risk reasonably incident to the employment." As one authority puts it: "The risk must be one peculiarly incident to the employment, and not one incurred by everyone, whether in the employment or not." For instance, where a workman, while driving an engine on his employer's farm, was stung by a wasp and died from blood poisoning, the risk is not one peculiarly incident to the employment. Where a workman in a mill was injured while removing his socks in order to do his work better, such

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injury is not one arising out of and in the course of the employment. "If there be any risk in a man's taking off his own socks, it is a risk common to all who wear them. It is no greater to a man who works in a spinning mill than to one who does not work in a spinning mill." Where one is injured by lightning, it was held to arise out of the employment, in a case in which the workman, because of the character of his place of work, was peculiarly liable to be struck. But an employe working in a street is no more liable to be struck by lightning than any other person, and no compensation can be recovered therefor.

In order that the injury may be one arising out of the employment, the workman must be acting within the scope of his employment at the time of his injury; compensation is not recoverable where the danger is voluntarily incurred in doing acts wholly outside the scope of employment. "Compensation will not be allowed where a workman goes to satisfy the requirements of nature into a dangerous and unauthorized place, or on premises not under the control of the employer."

The fact that the workman does the act causing the injury in a wrong or dangerous manner will not, of itself, defeat compensation; or where the act was within the scope of employment, but the workman had been expressly forbidden to do that act, recovery will not necessarily be defeated. The real distinction here is drawn as to whether or not the servant was actually doing the work he was employed to do or something substantially different. It has been held that mere disobedience of orders will not defeat the employe's right of recovery. In one case, the workman was forbidden to oil the machinery when it was in motion. In doing this he was injured and was allowed to recover. In another case, a workman was forbidden to sit down when at work, but was allowed to recover. It is obvious, however, that if the disobedience amount to a serious and willful misconduct on the part of the workman, there can be no recovery.

Extent of Injury

Section 2 (*a*) provides that there can be no recovery for an injury unless such injury shall be sufficient to incapacitate a workman from receiving wages for at least one week. As the act was originally passed it provided two weeks as the minimum time, but it was amended in 1906 to read as it does now. This section is self-evident to all, and the courts have quite generally held that the interpretation which would be placed upon this section by an ordinary person after reading it is the one that will be followed by the courts.

Choice of Remedies

According to Section 2 (*b*), an employe has the right to proceed under one of two courses. He may either recover under the act or bring suit under the common law. It will be observed that the option rests upon the employe in this respect. In many of the states the law is made mandatory on the employer and optional as to the employe; in others, it is optional as to the employer up to a certain time designated in the statute and fixed as to the employe. In these latter jurisdictions, it has been held that the employe's only right rests entirely upon the compensation act. This is a detail, however, that is covered by the respective statutes in each state operating under the compensation law. Some question has arisen as to the effect of the word "workman" as used in this section of the act. Suppose the workman dies of his injuries. Does his cause of action or right of election die with him? The courts have been of the opinion, and justly, that the rights of the workman pass to his dependents or legal representatives. However, if the workman has made an election or taken affirmative steps toward an election, such decision will, ordinarily, be binding on his dependents or representatives.

A workman receiving compensation for injuries is not entitled to wages also; neither is a workman entitled to part compensation and part damages. He must take one or the other. As to what amounts to an election, the courts have been of the opinion that each case must be a law unto itself. The real criterion is the actual intention of the workman or his representatives. Oftentimes, this intention is inferred from the overt acts.

Misconduct of Workman

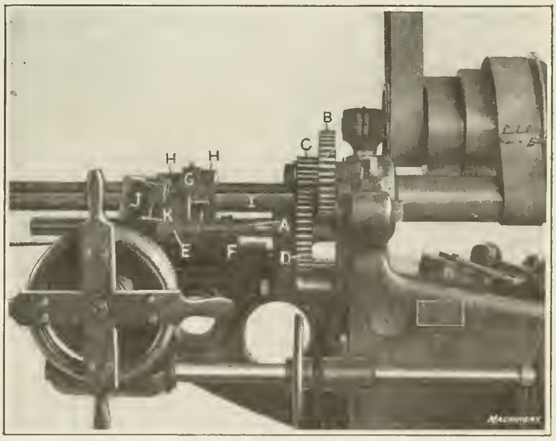
Recovery of compensation is denied if there is a "serious and willful misconduct" on the part of the workman. According to the English interpretation of this phrase, the act itself must be serious and not merely the consequences thereof. Intoxication has been held to be serious and willful misconduct. In their decisions, American courts have said that the phrase means something more than mere negligence or even gross negligence. They seem to adopt the view that "serious and willful misconduct" involves conduct of a quasi criminal nature, or doing the act with a wanton and reckless disregard of its probable consequences to others. A Massachusetts decision said that it closely resembled the wanton or reckless misconduct which will render one liable to a trespasser or mere licensee. A California case said: "It cannot be doubted that a workman who violates a reasonable rule made for his own protection from serious bodily injury or death is guilty of misconduct, and that where the workman deliberately violates the rule with knowledge of its existence, and of the dangers accompanying its violation, he is guilty of willful misconduct."

* * *

THREAD CUTTING ON OLD HORIZONTAL BORING MACHINE

BY ROBERT MORRIS

The illustration shows an old Binsse horizontal boring machine which was used for boring transmission cases in a shop in northern New York. Some of the holes in the transmission cases had to be threaded, so after boring they were tapped. As this method of doing the work proved inaccurate, it was decided to bore and thread the holes at one setting. The threads to be cut were not more than one inch in length and of only one pitch, 16 per inch. The lead-screw *A* was U. S. standard, with about eight threads per inch. A gear was mounted on the spindle of the machine to mesh with a gear *B* of the same size. On the same spindle with *B* and keyed to it was a pinion *C*, one-half the size of gear *D*, secured to the lead-screw; this gave the proper reduction to obtain the correct feed of the bar for threading. The lead-screw rotated all



Horizontal Boring Machine arranged for Thread Cutting

the time, but the nut *E* was split and was held open by a spring. The nut was secured to a slide *F* with an arm *G* reaching up and embracing the boring-bar *I*. On each side of the arm were collars *H* fastened to bar *I* with set-screws. These allowed the bar to rotate but prevented end play. The holes were first bored with the boring-bar, in the usual manner; as the half-nuts were held open by the spring, the bar was free to feed endwise either by hand or by the power feed. When the hole was bored to the correct size for threading, the horseshoe-shaped piece *J* was swung down on the half-nuts and closed them on the lead-screw. The piece *J* was pivoted on pin *K*. With a tool like a chaser, having several teeth, the holes could be threaded at a single pass. The metal was an aluminum alloy.

ZINC PLATING AS A PROTECTION AGAINST CORROSION

BY J. W. WUNSCH[1]

The corrosion of iron and steel, its inhibition and prevention, are questions of extreme importance that today are confronting engineers and manufacturers of machinery. The causes, effects, and substance of corrosion have been live topics of discussion among metallurgists and founders, but the problem of protection against corrosion, which concerns machine builders more directly, has not received the attention its importance would justify. We are all informed, in a general way, that oils, paints and the plating of non-ferrous metals prevent the rusting of iron and steel, while "they are on," but few persons know the comparative efficiency and actual worth of the various preventives. This article is not a treatise on corrosion, but a statement of the general principles, processes of application, and comparative efficiency of zinc plating, or galvanizing.

It is a well-known fact that zinc forms a cheap and excellent coating for the protection of iron and steel against corrosion. It has the inherent advantage over tin and lead of being electro-positive to iron, and is attacked in preference to iron when the two metals, in contact with each other, are exposed to the corrosive elements. Tin and lead form an efficient preventive of corrosion only when they completely envelop the article; that is, when no part of the iron or steel is exposed to corrosion. Any exposed part will quickly corrode and the rust will readily work under the plated part, causing the entire article to become corroded in a short time. With zinc plating, however, even when the coating is imperfect and a part of the metal is exposed, the iron will be protected from corrosion, to a great extent, so long as the zinc remains in sufficient quantity to make an effective couple. The earliest recorded application of the zinc-plating principle is that employed by Sir Humphrey Davy in 1824, who attempted to protect the copper sheathings of ships by means of zinc bars attached to them.

There are three general processes for the deposition of zinc on iron and steel, namely, hot-dip zincing, or hot galvanizing; sherardizing; and cold-zincing or electro-galvanizing. In spite of its name, galvanic action has no part in the first process. Until quite recently, this method of zinc deposition was used almost exclusively for large and medium size work, and is still employed mainly in the galvanizing of sheets, wire netting and bulky articles. The process is carried out as follows: The articles are first thoroughly cleaned, usually by pickling them in sulphuric acid and then scrubbing, washing and rinsing in clean water. They are then dipped in a bath of molten zinc, which must be kept at a temperature somewhat above the melting point of zinc, 774 degrees F. The hotter the zinc the thinner is the coating, but excessive as well as low temperatures are attended with many serious disadvantages and should be avoided. In the plating of sheets and other thin flat articles, it is common practice to use moderate temperatures, and the excess zinc is cleared off by passing the articles between rollers.

The sherardizing process of zinc deposition was invented by Sherard Cowper-Coles, who found that metals embedded in zinc dust and heated to a moderately high temperature, although considerably below the melting point of the zinc, become coated with a layer of the metal. The zinc dust commonly employed is a by-product obtained in zinc manufacture, and consists of pure zinc mixed with the zinc oxide. In carrying out the process, the articles are placed in an air-tight vessel, with the zinc dust, which has previously been thoroughly dried, and subjected to a heat varying from 250 to 330 degrees C. The longer the articles are treated, the heavier will be the zinc deposit; the duration of the process ranges from one-half hour to three or four hours. If an air-tight receptacle is not available, a small percentage of powdered carbon is added to the zinc dust, to prevent an increase in the amount of zinc oxide, which, if present in excess, tends to make the deposit dull.

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Electro-galvanizing Method

In the electro-galvanizing process, which is of comparatively modern development, the zinc is deposited electrolytically from a bath containing approximately a 10 per cent solution of crystallized zinc-sulphate. The essential elements of an electroplating plant are: the plating solution, or electrolyte; the receptacle for holding the latter and fittings; the anodes, which are zinc bars suspended in the electrolyte in proximity to the article to be plated and connected to the positive pole of a dynamo; and the cathode, which is in contact with the article and is connected to the negative pole of the dynamo. The electro-zincing of sheets, large iron receptacles, etc., is mainly done in still plants, which are essentially like the elementary apparatus just described. Work that is plated in still-solution tanks has a white frosty appearance, but can be easily brightened by giving it a scratch brushing. A good deposit should be obtained in a still-solution apparatus in from one-half hour to an hour.

Mechanical plating plants may be divided into two types, the plating barrel, for plating small work in bulk, and the conveyor type plants, or "moving" tanks, for large work. Material that is plated in a rotating barrel will not have the frosty appearance of work plated in the still tank, for the reason that the tumbling motion imparted to it causes a burnishing effect while the deposit is going on, which results in the work coming from the barrel in a bright condition.

In its elementary features, the plating barrel may be described as a drum made of a non-conducting material, perforated, supported in bearings, and rotated in a tank containing the electrolyte. The positive pole of the dynamo is connected to the zinc anodes, which are hung around the barrel. The negative pole is connected to the cathode conductor within the barrel, which is in intimate contact with the material. The plating barrel may be filled with work to a depth of three-quarters of the diameter, if it is of the totally submerged type, and about two-fifths the depth, if it is of the partly submerged type. These machines are rotated at from four to twelve revolutions per minute, depending on the grade of work. Plating barrels are made in various sizes up to a capacity of about 200 pounds of small work, such as nails, conduit boxes, etc.

The mechanical conveyor-type of plant, in its essentials, consists of a tank fitted like the still tank, and which, in addition, is equipped with a continuously moving conveyor mechanism of an endless chain or feed-screw type. The articles are hung on racks, which are fastened to the conveyor chain or screw, carried through the solution, and returned to the starting point. The time of travel is adjusted to suit conditions and requirements; in average practice, the rate of travel through the solution is about one foot a minute. The constant movement of the work through the solution permits a higher voltage to be used than in the still tank, thus employing a greater ampere current with the consequent acceleration of the plating. Outputs ranging to 115,000 valves plated in a day of nine hours have been obtained from a single installation. Recent mechanical developments of this type are special equipments for galvanizing pipe, bar iron, angles, and other structural shapes. They are automatically carried through the tank, being turned as they advance, so that an even coating is procured. The pipes are then washed, drained, and delivered automatically. Flat and round wire and wire cloth are galvanized in continuous lengths, washed, dried, and reeled up automatically.

The voltage employed in electro-galvanizing ranges from five to fifteen volts, depending on the class of work, the quality of the solution, and the speed of operation. Higher voltages will cause the work to "burn" and must be avoided. The amperage necessary is directly proportional to the surface to be plated; 1000 ampere-hours will deposit 42.8 ounces of zinc. It is common practice to allow 10 amperes for every square foot to be plated. A good deposit, in a mechanical plating apparatus, requires from one-half hour to two hours. The actual length of time of deposit depends on the class of work, current density, and the thickness of the deposit required.

The electro-galvanizing process is without question the most efficient and desirable from every consideration. Although the

hot-dip process is still used extensively for certain kinds of work, and will doubtless be used for some time in the future, the writer is convinced of the eventual supersedure of the other processes by the electrolytic process. Some inherent advantages of the latter over hot galvanizing and sherardizing are as follows:

It deposits a uniform coating of chemically pure zinc; hence much less zinc is required.

The adhesion of the deposited metal is better (482 pounds per square inch, against 280 pounds per square inch) and more flexible, so that plated sheet metals can be spun and plated wire bent without cracking the coating.

The temper and tensile strength of the material are not affected. Tempered articles, such as automobile hardware, frequently lose in tensile strength and temper when subjected to the heat of the molten bath (774 degrees F.) of the hot-dip process.

Bolts, nuts, and similar articles with small recesses are coated so smoothly that they require no recutting.

These advantages are confined to the efficacy of the electroplated deposit in comparison with the product of the other processes of zinc deposition, and they, alone, are of interest to the engineer or manufacturer. There are, however, many other advantages of extreme importance in the operation of a plating shop. Among these are: economy of metal and time, decrease of upkeep expense, perfect control of process, and the elimination of the necessity of expert and high priced operators.

Decisive Test for Determining Zinc Deposit on Plated Article

A simple decisive test for the comparison of galvanized products and the quali-quantitative determination of the zinc deposited on a plated article is the copper-sulphate dip test. This determination may be readily made by anyone, as it does not require any special skill. The article to be tested is thoroughly cleaned in water and immersed for one minute in a saturated solution of copper sulphate (bluestone). It is then withdrawn, quickly washed in water, and briskly rubbed dry with a towel. The chemical action is very simple, the sulphate tending to dissolve the zinc and plate the copper on the exposed iron ($CuSO_4 + Zn = ZnSO_4 + Cu$). If the article shows no copper plating that cannot be effaced with the cloth, it is said to have withstood a one-minute test. These one-minute dips are continued until a distinct copper plate appears on the iron or steel. An article that is plated for other than esthetic reasons should stand at least two one-minute tests, as described.

* * *

ENGINEERS AS EXECUTIVES

Both the Pennsylvania R. R. and the Baltimore & Ohio R. R. recently appointed as general managers of their respective systems men who are engineers by training and experience. The selection of engineers for executive positions is becoming more and more recognized as a valuable aid in obtaining efficiency and high standards in management. Unfortunately, in many industrial undertakings in the past, the leading executive positions have appeared to be closed to engineers, the assumption being that the engineer is not fitted to handle executive and financial problems as well as engineering problems. It is obvious, however, that training along engineering lines promotes clear thinking and requires decisions in which mistakes are not permissible, so that an engineer of good judgment can be trusted to arrive at proper decisions in any executive position if he is otherwise qualified to handle the work.

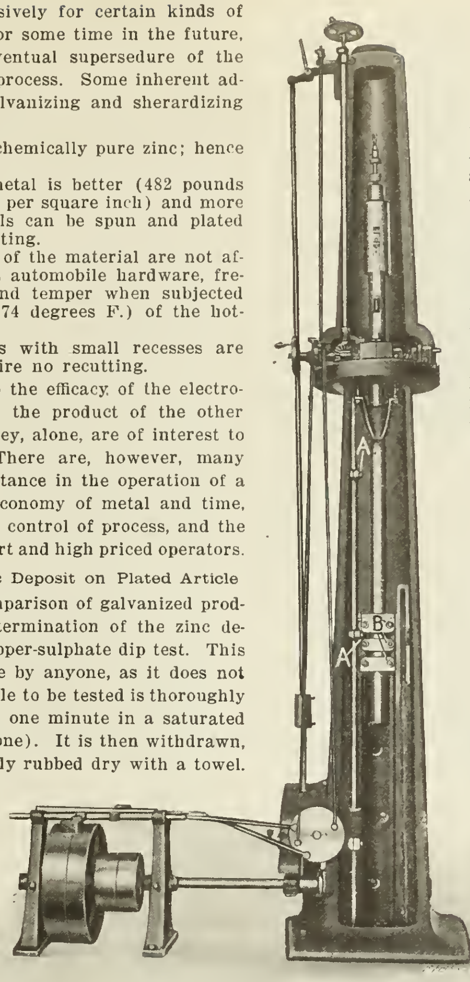

Fig. 1. Keyseater designed for slotting Recoil Cylinders

SLOTTING RECOIL CYLINDERS

BY W. J. LARSON [1]

The Catlin keyseater shown in Fig. 1 was built especially by the Chattanooga Machinery Co., Chattanooga, Tenn., for a Western factory manufacturing recoil cylinders. It has a maximum stroke of 84 inches and cuts a length of 54 inches. The gage must fit the entire length of the cylinder, though a tolerance of ± 0.001 inch is allowed, and all surfaces must be smooth. The cylinder to be bored is shown at *E*, Fig. 2, and a finished cylinder at *F*. The bore must be perfectly straight and its diameter must not vary more than 0.001 inch. After the bore is brought to the right size by means of a wood back reamer, the ends of the cylinder are turned to fit the collars on the keyseating machine and the profile of the finished cylinder is marked off on the upper end by means of the gage shown at *D*, Fig. 2.

The proper length of stroke is obtained by setting the dogs *A*, Fig. 1; then the cutting head is assembled to the bar. The proper height of the bar is obtained by loosening nuts *B* and adjusting the bar by means of the eyebolt that is screwed into the cutter-head after removing the adjusting screw. The roughing cutter is then assembled in the cutting-tool holder, which, in turn, is assembled to the slotting bar. The indexing mechanism is shown in Fig. 3 and the cutter-bar in Fig. 4.

The cylinder to be slotted is passed over the end of the cutter-bar and fastened in the clamping collar *A*, Fig. 3. As the head, Fig. 4, is forced downward, the spring *A*, acting through the tool-holder plunger *B*, and the resistance of the metal force the cutting-tool holder *C* up the wedge *D*, pushing the tool outward, and causing it to cut a slot of uniform depth. On the return stroke the tool-holder is forced down from the wedge and back into the bar away from the work. The depth of the cut depends on the position of the wedge, which is easily adjusted by the screw *E*. Spring *A* and plunger *B* keep the cutting tool *F* in its proper place and prevent it from boring into the work. Three tool-holders are used. One has, in the center of its upper end, a slot that is parallel to the side; one has a slot forming an angle of 3 degrees to the right hand; and one has a slot forming the same angle to the left hand. All the cutting tools are made of high-speed steel and are hardened and ground. The wedge *D* is a casehardened steel forging.

After the tool is fed to its proper depth, circular feed is engaged to cut from the side of one rib to the next rib, leaving 0.01 inch for the finish cut. The same operation is repeated between the other two ribs. The roughing tool is then removed, by simply removing the pin that holds the cutter in position, and the

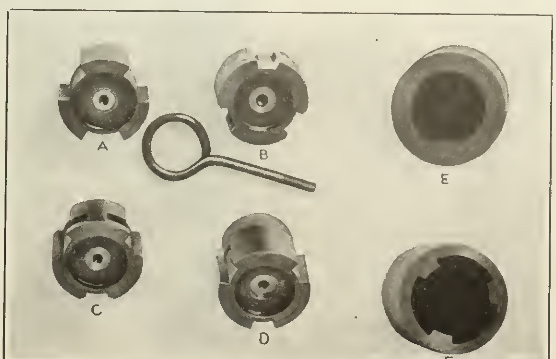

Fig. 2. Recoil Cylinders and Gages used to test Slotting

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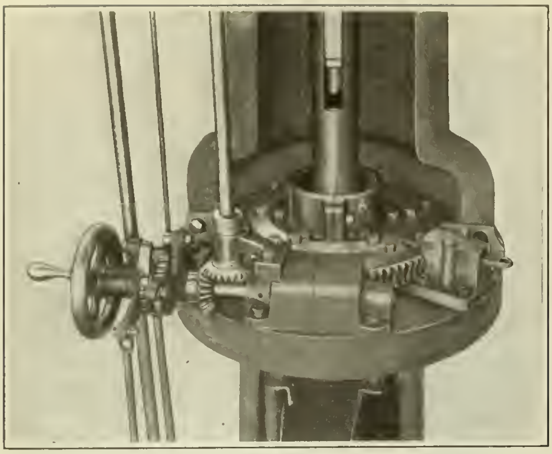

Fig. 3. Indexing Mechanism of Catlin Keyseater

left-hand side tool is assembled in its place; when the three left-hand sides are machined, this tool is replaced by the right-hand side tool and the right-hand sides are machined. The cylinder is now roughed out, and the next operation is to finish the diameter between the ribs. In the roughing operation it is necessary to have the bushing of the cutting tool 0.004 inch smaller than the bore of the cylinder; in the finishing operation, the bushing should not be more than 0.0005 inch smaller than the bore in order to make a perfect job.

To change the cutter-head so as to put in the finishing tool is a simple operation; by turning, the draw-in rod is tightened or loosened, which is a handy arrangement. After the roughing head is removed and the finishing head is assembled, the radius cutter is placed in the cutting-tool holder and the sharp corners removed so that they will not cut the bushing. The finishing tool is then put in place and fed to its proper depth, measuring from the center of the opposite rib, or what is left of the bore. After the diameter is finished between the ribs, the side tools are used and the three sides are machined until they are equally spaced; when tested with gage *A*, Fig. 2, all three sides must bear against the gage. The opposite side tool is now used and one rib is finished, using gage *B*, which fits one rib only. Gage *C* fits the arc between the ribs; and after that has been in all three arcs, the master gage *D* should go in, which fits all the slotted surfaces.

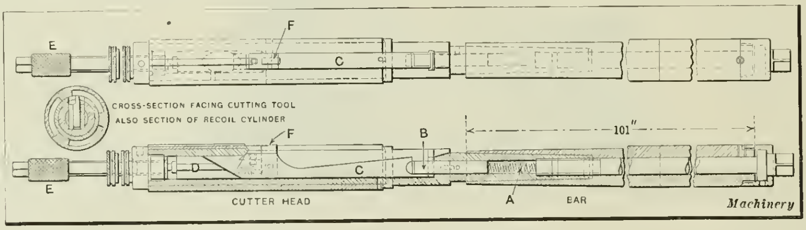

Fig. 4. Cutter-bar of Keyseater

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The shipbuilding industries will, of course, remain exceedingly busy for many years after the war is over. The extent to which orders have already been placed, however, will be surprising to many. The Danish shipbuilders, Burmeister & Wain, have their entire capacity, amounting to about one 10,000-ton ship a month, definitely ordered up to 1922. It is interesting to note that not a single steamer is included in these orders, all of these vessels being Diesel-driven motor ships. According to *Marine Engineering*, inquiries are being made at the present time with the view of building in America two hundred wooden motor ships, each of 2000 tons' dead-weight capacity, and nearly as many vessels of about 4000 tons' dead-weight capacity. J. A. Cole, chief engineer of the *Abelia*, says in *Motorship:* "Modern marine Diesel engines have reached such a stage of reliability that there is not the slightest doubt that in a few years' time they will be in advance of the steam engine. At present there are motor ships crossing the Atlantic, keeping as good time as steamers, and coming through heavy weather without hitch to the motors."

LATHE ACCESSORIES IN A SMALL SHOP

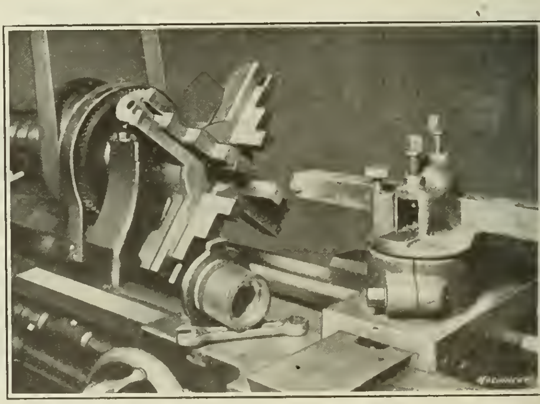
A small shop owner in Syracuse has certain ideas in regard to the construction of lathe chucks, toolposts and chuck adapters. For this reason he makes his own chucks and orders his lathes without toolposts. The chuck is much the same as any other independent chuck except that the body, instead of being made round, is cast with four arms which are provided with jaw slots and screws for operating the jaws as usual. This construction provides ample strength and reduces the weight. The shape of the chuck and light weight make it convenient to put on the spindle. It can also be conveniently loosened by placing a block in the path of one of the arms and turning the spindle backward, pulling the belt by hand.

The upper part of the toolpost is cast with a slot sufficiently large to accommodate the largest turning tool used in the lathe. Two large binding screws hold the tool rigidly in place. The toolpost is also cut away in front to accommodate a boring tool or boring-bar, which can be put in place quickly. The boring tools are held rigidly by the forward screw. The lower part of the toolpost is machined to a circular shape about three or four inches in diameter. This end of the toolpost fits snugly in a bored hole in the cross-slide casting which is split and furnished with a binding screw for tightening it. For minute adjustment of the cutting edge up or down, the tension on the lower split portion is released and the thumbscrew in the upper portion is turned forward or backward, raising or lowering the tool to suit the requirements.

The adapter bushing shown is useful in a shop where there are lathes of different makes and a variety of spindle noses. These adapter bushings make it possible to use a chuck made for one lathe spindle on another lathe with a different size spindle. The lug provides a convenient means for removing the adapter from the spindle or the chuck as the conditions may require.

V. B.

The cross form of chuck reduces the cast iron required for the chuck body somewhat, but the design is one that a "safety man" would not favor because of the obvious danger of the projecting arms. Chucks, in general, should be made with a smooth periphery, and projecting screws or lugs should always be avoided. As a matter of fact, the saving of metal in the form of chuck shown is more apparent than real; a well designed chuck of the conventional form is made with a comparatively thin wall of metal between the jaws, and the rim is also made thin and light. The bulk of the metal is immediately around the jaw slots, and the thin wall of metal between the jaws and in the rim adds but a few per cent to the total weight. The extra weight of the common chuck body is well worth the cost because there is less likelihood of injuring the user, which is a consideration of prime importance in design.—Editor.



Cross Form of Chuck, Adapter Bushing and Special Toolpost

FAILURE OF THE CARBURIZING PROCESS[1]

The carburizing or cementation process of adding carbon to iron or ferrous alloys is so ancient that its origin cannot be traced. Metal workers for many centuries made good steel by selecting the materials and process; but they did not know that it was the carbon they added to the metal that gave the desired results. In fact, it was only in the last decade that this fact became known. But the cementation or carburizing process used by the ancient steel makers is still used for many purposes, especially for making the blister bars used in crucible-steel manufacture. The modern electric melting furnace, however, is rapidly displacing the crucible process and has revolutionized the making of the higher grades of steel. With it, the impurities can be reduced to lower percentages and a more homogeneous steel can be made. More important still, the cost of making these high grades of steel is less than with the crucible process.

The carburizing process is also used in the manufacture of some important machine parts. Probably the automobile industry uses more carburized parts than all others put together, although this industry is credited with being the originator of many new processes and methods for manufacturing steels of greatly improved quality, as well as having brought into practical use many alloys that have doubled and trebled the power of the steel to resist alternating and rotary vibrational and torsional strains, as well as the wearing properties, elastic limit, etc. Any of these alloys, when properly worked and heat-treated, will give better results than carburized steel. Many of the better grades of carbon steel can also be made to develop better wearing surfaces and greater resistance to strains. For instance, in the transmission of a car made in 1907 two of the gears were of air-hardened steel and the other of carburized steel. To withstand the strains to which these gears were subjected, the latter was made 7/8 inch wide, while the others were only 9/32 inch wide. Not only did the use of the air-hardened gears reduce the cost, for only one-third the weight of steel was required, but it was also possible to reduce the weight of the frame, axles, wheels, tires, and all parts that had to carry these parts. In addition, it would be possible to reduce the horsepower of the engine, and thus lessen its weight, as well as the weight of the driving shaft, driving gears, and other moving parts.

Of course, a low-carbon steel can be machined more rapidly than one that is high in carbon, which is one of the reasons why the carburizing process has remained. Stellite and the improved high-speed steels, however, have reduced the difference in machining time to a small percentage, so that this argument is rapidly losing its force. Besides, against the argument of the saving of time in the machine shop must be figured the cost of the carburizing material and furnaces, fuels for the operation of the furnaces, the time required for packing the steel parts, charging the furnaces, and removing the work from the furnace, and for quenching and reheating the parts for the second hardening. When that is done, it will be found that the carburizing process is rather expensive.

Wearing Qualities of Carburized and High-carbon Steels

The principal argument advanced in favor of carburized parts is that they have a hard outer surface that will resist wear to the greatest degree and a tough center that will prevent breakage. However, these are not found to be the facts. Hardness alone is not the property that will give the greatest wear to two surfaces rubbing against each other. Bronze gears running in mesh with carburized steel gears outwear the steel gears, yet the carburized steel gear teeth are much harder than the bronze gears. Also, gears made of Hadfield's manganese steel will wear longer than four or five carburized steel gears, yet it does not show nearly the degree of hardness of a high-carbon steel. Extreme hardness in the steel carries with it a brittleness that causes the steel to wear away more quickly than when it is drawn back enough to show the troositic structure, and this reduces the brittleness to a certain degree of toughness. Glass is considerably harder than a steel file, but the former is so brittle that the file breaks away particles of it until it is cut to the desired size or shape. The same thing occurs when a hard steel gear or other part is worn away by a softer but tougher metal, so that toughness is more important than hardness. It is possible to select steels that will give the correct degree of hardness and toughness when they are merely hardened and tempered, and thus do away with the expensive and crude carburizing process. We will then have machine parts that are as strong at the center as on the outside and can reduce the sectional area or the weight of steel used for a given performance.

Straight carbon steel will resist twice as much load as the core of the carburized steel before it will stretch enough to take a permanent set, but the elongation and reduction of area of the soft steel will be double that of the harder steel. This might indicate that the softer steel will withstand the greatest transversely applied or torsional load, but this torsion is as bad a feature as breakage in a piece that must fit others to work in unison with them. As distortion will either cause the piece to break or will break the pieces with which the distorted piece comes in contact, nothing is gained by having a soft ductile center and a hard outer shell. It is folly to claim "a tough center that will prevent breakage." The steels containing from 0.12 to 0.18 per cent carbon, which are generally used for carburized parts that contain approximately 1 per cent carbon in the outer shell, seldom have an elastic limit of more than 40,000 pounds per square inch, and this cannot be increased much more than 5000 pounds by any heat-treatment. If a steel with a high enough carbon content to give the best shearing surface is used, the elastic limit can be raised to more than 100,000 pounds per square inch.

One series of transverse tests was conducted with pieces ½ inch round and 12 inches long, loaded at the center between 10-inch supports. The best results obtained with carburized 0.20 per cent carbon steel was a load of 1760 pounds, with a deflection of 0.5 inch, while a straight oil-hardened 0.50 per cent carbon steel withstood a load of 3025 pounds with a deflection of 1.55 inch. Both were practically the same steel except for the carbon content. The carbon content of the outer shell of the carburized steel was raised to 1.22 per cent, while at a depth of 0.2 inch it decreased to 0.30 per cent.

Failure of Carburized Ball and Roller Bearings

In the early days of the bicycle, ball and roller bearings first came into general use. Then the cups, cones, races, and even the balls and rollers were carburized. Manufacturers soon learned, however, that the hard outer shells of the balls would compress against the soft centers and cause them to deform; then the bearings soon failed. Many of the balls would also break and crack between the hard outer shell and the soft core, causing the shell to peel off. When the manufacturers resorted to a straight carbon steel and gave the balls a uniform hardness clear to the center, they found that a given size of ball would carry a much larger load. Later they found that chromium steel was best for this purpose.

In the carburized cups and cones, a groove formed where the balls applied their greatest loads. This was caused by the metal in the soft core flowing away from the compressive force applied by the load carried by the balls as they rolled around the cup and cone. This groove was equalized until the hard carburized shells on both sides of the cups were pressed together; but after a time the carburized shells peeled off and destroyed the bearings. These troubles were overcome when the manufacturers abandoned the carburized process and made all their ball-bearing parts from steel that had the correct chemical composition to start with. They would then heat-treat the parts correctly and have a uniform hardness and chemical composition clear through the steel. Attachments for taking up wear were abolished and the present high-grade ball bearings outwear automobiles. At that, they carry more than twice the load they did in the bicycle days.

That many parts of roller bearings are still being carburized is due to the fact that a roller has a comparatively larger bearing surface than a ball. As a consequence, the weaknesses of carburized parts have not developed as quickly as with ball

[1]Abstract of a paper by E. F. Lake read before the Steel-treating Research Club of Detroit, April 27, 1917.

bearings. Nevertheless, there is a steady growth in the number of roller-bearing parts that are being given a straight hardening and tempering without carburizing.

Carburizing Difficulties

In carburizing steel, there are many difficulties encountered and it is doubtful if all are overcome in any given batch of metal. Probably the most troublesome is the breaking of the carburized shell away from the core. If a steel is correctly carburized, there is no distinct bark to shell off, as the carbon content will gradually reduce from something like 1.25 per cent on the outer surface to the 0.10 to 0.20 per cent steel in the core. In commercial work, however, there is nearly always a distinct demarkation between the zone of high carbon and the core. When hardened, a high-carbon steel increases in volume much more than a low-carbon steel; therefore, there is considerable stress between the high-carbon and the low-carbon parts of a carburized piece every time it is hardened. This often results in rupture parallel to the outer surfaces, which is seldom seen until the carburized part has failed. One series of tests with nickel steel showed that the specific gravity is greater when the steel is carburized than when it is hardened without carburizing. This is directly the opposite of the effect obtained with carbon steels. Therefore; if the stresses are great enough they will burst the outer shell and develop cracks that can be seen.

Another difficulty is the segregation of carbon, which can easily be caused by raising and lowering the temperature of the furnace during the period of carburization. This nearly always occurs in coal-fired furnaces and often occurs in furnaces that are fired with the best of fuels. It might be caused by a carburizing mixture that was not uniform. Microscopical examinations of one test also showed the segregation of cementite to be most frequent in the pieces that were in the top of the carburizing box. Such segregation often causes thin plates to flake off from the surfaces.

A third and the most serious difficulty is grain-growth. Carburizing steels that contain below 0.18 per cent carbon are very likely to have this fault. The grains begin to increase in size as soon as the transformation point is past, which in this steel is around 1550 degrees F., and continue to grow until the highest temperature is reached during the carburizing process. In commercial work this is often 1750 degrees F. and is seldom below 1700 degrees. This brings us close to the point of crystallization, and when that occurs the steel will retain the coarsened grain structure. If not, and the work is quenched from the carburizing furnace, the coarse grain is likely to remain in the core, even though the work is again heated to a temperature high enough to harden the high-carbon outer shell. Therefore, it is only with the utmost care that the core can be made much better than a filler for the shell.

A steel that is high enough in carbon to begin with and then is simply hardened and tempered correctly, does not present these three difficulties. It is, therefore, much more uniform in strength, toughness and wearing qualities.

* * *

WHY PRESSED STEEL PARTS BREAK DURING MANUFACTURE

BY ERNEST A. WALTERS[1]

Pressing steel is the act of forcing the metal into the desired shapes and forms through one or more operations. The work is done in dies by power presses capable of exerting the necessary pressure to produce the article in serviceable form. In designing the dies and punches, much thought must be given to the steel that is to be drawn. It is always necessary to consider the points from which the steel is flowing and those to which it is to flow, and proper distribution must be made by equally and mechanically balanced dies and punches from the first to the last operation. At all times the fundamental principles governing sheet-steel drawing must be taken into consideration and the aim must be to make an article in the least number of operations.

Many difficulties that require thought and experience for their solution are met in the operation of power presses. It is a good practice to keep a record of these, so that should the same difficulty be met again, the cause will be recognized and its remedy known. The troubles encountered in press work may be divided into three classes: die troubles, steel troubles, and press troubles. Some of the most common of these are given in the following:

Die Troubles

Poor and careless die setting.
Rough radius, causing too much friction.
Dies too tight in one or more points.
One or more radii too sharp.
Drawing on grain of steel, causing it to open.
Lack of air-hole in punch or die or both.
Deep scratches and slug marks caused by previous operation.
Steel strained in one or more points in previous operation.
Hitting bottom of die too hard, causing metal to flatten, harden, and crystallize.
Pressure pad holding too tight at one or more points.
Too great a reduction in one operation.
Protruding screws or dowel-pins.
Use of poor or improper oil.
Defective or poor knock-out construction.
Defective or poor stripper construction.
Use of heavy or wrong thickness of steel.
Burr too large on blank, causing opening in grain.
Edge of blank hardened and crystallized by dull blanking punch.
Punch or die with chip broken off, causing sharp edges to tear.
Screw-holes in upper or lower or both pressure pads.
Die or punch too soft, causing one or more points to upset or enlarge.
Shifting of gages that should be doweled.
Bent or distorted punch.
Drawing from too great an area of stock.
Loose sections in die or punch, causing it to tip when pressure is applied and fracture or cut the steel.
Hole to be drawn out punched out of center in previous operation, causing crack or break.
Punch or die worn out of shape in this or previous operation, causing too great a difference when proper relation must be maintained, thereby producing strains, cracks, and breaks.
Dirt, slugs, or chips accumulating in die or punch.
Too much oil in corners or bottom of stamping.
Steel being drawn between die sections and pressure pad with open screw- or core-holes.
One or more sections too high, causing too much pressure at those points.
Stamping having too many wrinkles from previous operation.
Die slightly shifted out of line with punch.
Die or punch loose, due to vibration.
Die having improper clearance.
Rubber bumper or spring regulating pressure pad improperly adjusted.
Broken springs under pad in die or punch.
Die and punch not parallel, causing unequal drawing and pressure conditions.
Stamping not drawn deep enough on previous operation.

Steel Troubles

Laminated steel.
Badly pitted steel.
Steel too hard.
Steel too soft.
Over-annealed or burnt steel with scale.
Rusty or dirty steel.
Steel not annealed properly, too hard.
Use of dry steel that should be properly oiled.
Steel left in pickling vat too long, causing it to corrode and weaken.
Chilled steel, too cold.
Steel covered by particles of sand and emery dust.

Press Troubles

Press running at too great speed, causing steel to tear by sudden shock.
Gibs on press too loose.
Adjusting ram collar loose, causing lost motion.
Ram not square with bed of press.
Break on drum too loose.
Bolster plate too weak and springy.
Bolster plate improperly bolted, causing it to become loose and shift through pressure and vibration.
Press not having proper foundation, causing blank to shift through vibration.
Cap on pitman at crankshaft loose, causing lost motion.
Poor operator, allowing press to repeat.
Clutch trouble, allowing press to repeat.
Inadequate light, causing poor operating through poor vision of operator.

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WORK-HOLDING FIXTURES FOR BLANCHARD SURFACE GRINDER[1]

USE OF MAGNETIC CHUCKS AND FIXTURES IN GRINDING

BY DOUGLAS T. HAMILTON[2]

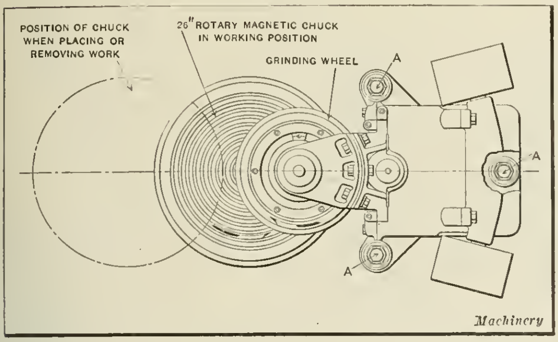

Fig. 1. Diagram showing Loading and Unloading Positions of Chuck on Blanchard Vertical Surface Grinder

THE design of the Blanchard vertical surface grinder adapts it particularly for grinding a large number of small parts. For holding plain parts having flat surfaces, the regular magnetic chuck furnished with the machine is used. When the work is of irregular shape, however, it is necessary to build special fixtures to support the work properly. As far as possible, the pieces are held magnetically, but in some cases this cannot be done. When the part is of such shape that a fixture cannot be designed to hold it magnetically, it is necessary to adopt some means of clamping. It is evident that on this type of machine the part need not be held down as rigidly as on a milling machine, because the wheel tends to hold the work down to a certain extent. The design of fixtures for Blanchard vertical surface grinders should be such that grit or water will not interfere with the operating or

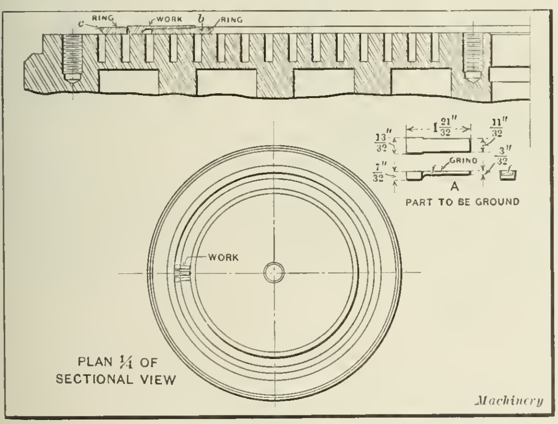

Fig. 2. Fixture used for holding Bolt Stop Springs for Military Rifles

clamping mechanism, and they should also be designed so that they can be removed and placed quickly on the chuck to facilitate cleaning. In the following article attention will be directed chiefly to those types of fixtures in which the magnetism of the chuck proper is used for holding the pieces either directly or through a fixture, the fixtures being designed so that the lines of force are localized at the desired point in order to obtain the greatest possible holding effect.

There is one point about the Blanchard vertical surface grinder that may not be generally recognized, and that is the fact that the work-table can take various positions in relation to the grinding wheel. Normally, as shown in Fig. 1, the wheel reaches slightly past the center of the rotating chuck. The chuck, however, need not be located in this position if the work has projections that prevent the wheel from reaching the center of the chuck. It may occupy a position intermediate between its normal working position and the position that it occupies when the work is being removed or loaded, that is, extending over the outer ring of the chuck surface, leaving the center free so that projections on the work will clear the wheel. In the following description of work-holding devices,

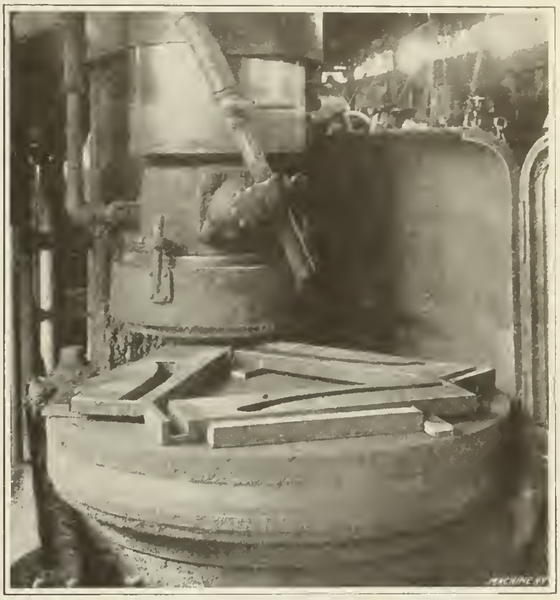

Fig. 3. Method of supporting and holding Cast-iron Guides on Magnetic Chuck made by Blanchard Machine Co., Cambridge, Mass.

it will be noticed that this feature is taken advantage of in several cases.

Magnetic Fixture for Holding Bolt Stop Springs for Rifles

As has been previously mentioned, flat work is held directly by means of the magnetic chuck. When the work has a projection similar to that shown at *A* in Fig. 2, it is necessary to provide some other means of support. This is easily accomplished, as shown, by using cold-rolled steel rings; one of these *b* is located under the tails of the pieces, and the

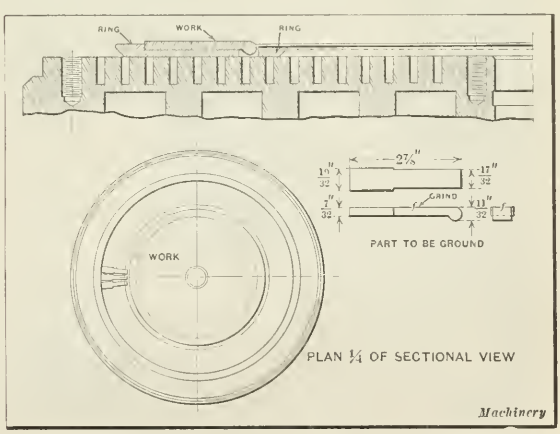

Fig. 4. Arrangement of Steel Rings for holding Parts on Magnetic Chuck

[1] For information previously published in MACHINERY relating to magnetic chucks, see "Holding Work on the Magnetic Chuck for Milling," September, 1915; "Holding Copper on a Magnetic Chuck," August, 1914; and "The Inside of the Magnetic Chuck," April and May, 1914.

[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

other, *c*, surrounds the pieces and thus prevents them from being moved toward the outer edge of the chuck when being ground. It will be seen that the magnetic force passes through the ring *b* and grips the thin part of the work, also holding the work directly at that point where it bears on the chuck. In addition, the outer end is attracted to ring *c*. This fixture is arranged to hold 150 rough forgings, which are ground on one side at the rate of 600 per hour.

Fixture for Holding Cast-iron Guides

Another similar example of a work-holding fixture employing the separate strip principle is shown in Fig. 3. In this case the parts being machined are cast-iron guides, three of which are held on the chuck at one time. The guide, it will be noticed, is of such a shape that its entire bottom surface does not contact with the chuck; consequently, cold-rolled steel strips are placed underneath the part to form additional contact. Other strips placed at the outer edges of the guides prevent the rotating wheel from sweeping them off the chuck. Here it also will be noticed that the chuck holds the parts directly and through the medium of the cold-rolled steel strips.

Work-holding Devices for Holding Small Irregular Parts

A fixture somewhat similar to that illustrated in Fig. 2 is shown in Fig. 4. In this case the parts to be operated on are comparatively small and of such shape that they cannot be

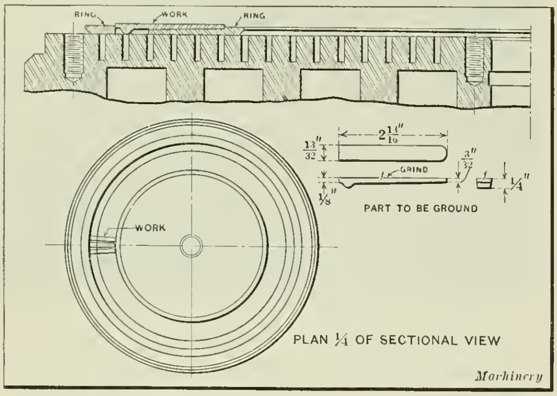

Fig. 5. Method of holding a Magazine Follower on a Blanchard Magnetic Chuck

held directly against the face of the chuck. A ring, therefore, of similar shape to the part being held is located on the chuck

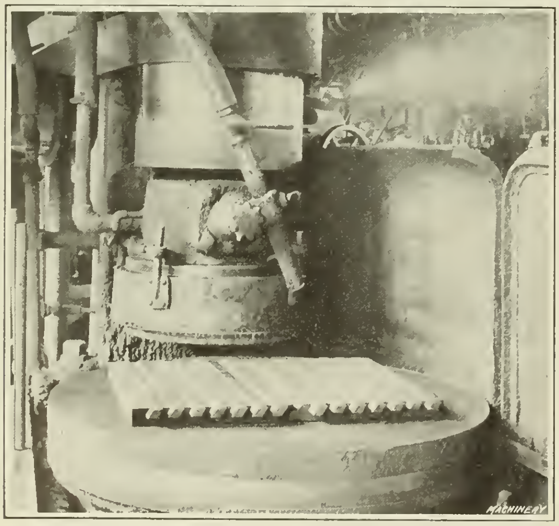

Fig. 6. Special Fixture for holding Gibs on Blanchard Magnetic Chuck

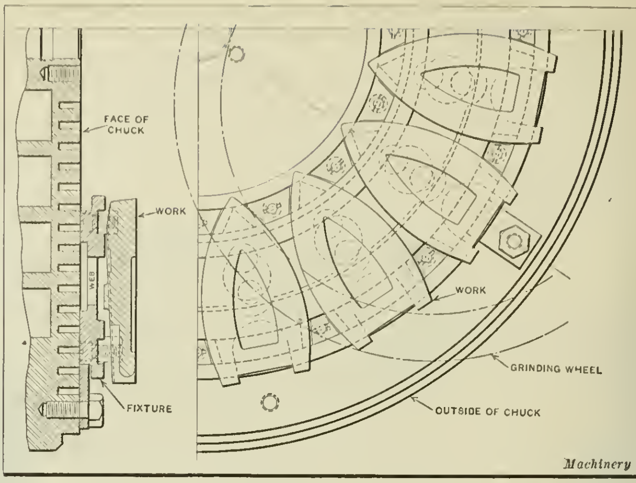

Fig. 7. Special Fixture for holding Electric Flat-iron Clamps on Blanchard Magnetic Chuck

and on this the pieces rest. This ring has a projecting boss against which the pieces fit, and another ring located inside the work prevents the parts from being shifted out of line with each other. In the example shown in Fig. 4 the work rests entirely on the plate, the magnetism passing up from the chuck through this thin steel plate, holding the work firmly in place.

Fig. 5 shows a fixture for holding a part similar to that shown in Fig. 4, this being a magazine follower for a military rifle, which is ground on one side only. The fixture provides for holding 120 pieces at one time in the rough-forged condition, and the production is 300 per hour. In this case also two

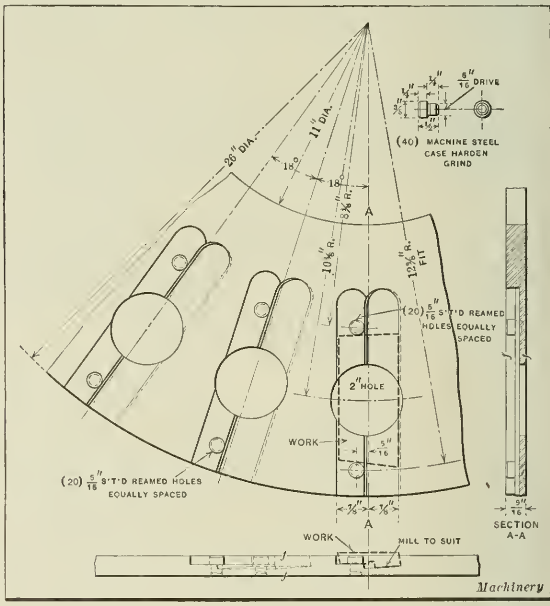

Fig. 8. Magnetic Fixture for holding Cutters

rings are employed, the inner one being formed to suit the work, the circular projection resting on the table; the other ring surrounds the parts on the outer end and prevents them from being swept off the chuck. In the various fixtures shown in Figs. 2, 4 and 5, the retaining rings and blocking plates are made separate to increase the facility with which the rings can be handled while cleaning the chuck. In operating machines with this type of fixture, it is the practice not only to remove the work when it is ground, but also to remove the rings and plates from the chuck each time to facilitate cleaning.

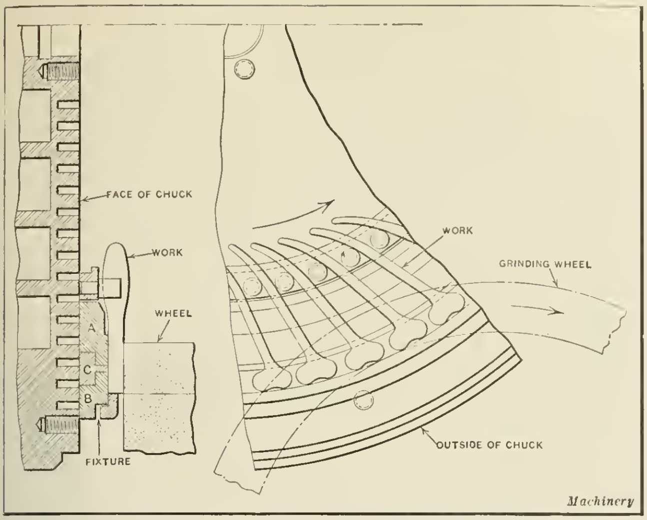

Fig. 9. Magnetic Fixture for holding Handles for Cut Nippers

Fixture for Holding Taper Gibs

An interesting type of magnetic fixture is shown in Fig. 6. The parts being ground are taper gibs for a lathe carriage. These are first ground on two parallel sides to exact thickness; then they are dropped into the milled slots in the cast-iron plate shown, the latter being held on the magnetic chuck of the machine. The bottoms of the slots in this plate have a taper which holds the work at the proper angle to give the taper required on the gib. It is interesting to note that no planing or other machining operations are done on these gibs before they are brought to the grinding machine. The rough castings are put on the grinding machine and approximately ⅛ inch of stock is removed from each side, both at the first and second operations. There is nothing to hold the pieces in the slots except friction and the slight magnetic pull that comes through the plate. This pull, however, is greater than might be expected, owing to the fact that the thickness of the plate at the bottom of the slot is not over ½ inch and the magnetic force is of sufficient strength to prevent the gibs from being moved back and forth in the slot. The gibs are 16 inches long, and the production is from seven to eight per hour, ground on all four surfaces.

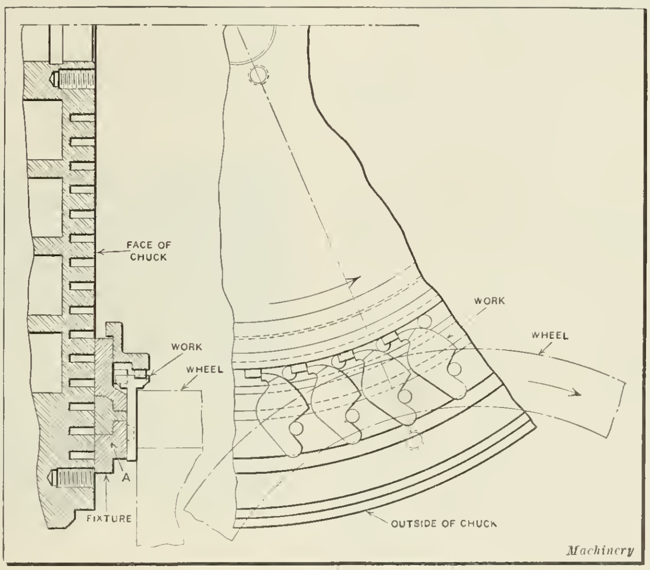

Fig. 10. Similar Fixture to that shown in Fig. 9 for holding Jaws for Cut Nippers

Magnetic Fixture for Holding Electric Flat-iron Clamps

A magnetic fixture for holding electric flat-iron clamps is shown in Fig. 7. As will be seen, this consists essentially of an inner and outer ring of fairly heavy section, which carry hardened steel blocks that locate and support the work. It will also be noticed that the two ring portions of the fixture are connected by a thin web which has further been lightened by drilling a series of holes in it, the idea being to prevent diversion of the magnetism through the entire fixture and confine it to those points where it will most effectively hold the work. This fixture is so designed that it carries sixteen pieces, and the production is 100 electric flat-iron clamps per hour, grinding one side only and removing 1/16 inch of stock.

Magnetic Fixture for Holding Irregular Shaped Steel Cutters

Fig. 8 shows a magnetic fixture for holding steel cutters that have an irregular under surface. Reference to this illustration will show that the plate has holes cut about midway of the length of the piece being held; these are to reduce the plate area and concentrate the magnetism at the points where it will hold the work securely. The fixture is made from boiler plate and is ground on both sides. The work is located by means of stop-pins at both ends.

Magnetic Work-holding Fixture for Cut Nipper Handles

In the type of work-holding fixture shown in Fig. 9 the area of grip on the work is comparatively limited, and hence special means have to be provided to concentrate the magnetism at the points where it will most effectively hold the work. The grinding wheel, of course, sweeps over the flat ends only, and in so doing has a tendency to draw the pieces out of the fixture. In order to overcome this action and also prevent the pieces from shifting sideways, a special fixture is necessary. The fixture body comprises two steel rings *A* and *B*, which are separated by a brass ring *C*. The effect is, therefore, to strongly magnetize these two steel rings, and as they are separated by a non-magnetic substance, the current has to pass through the work from one to the other, thus providing a secure means of holding. The inner ends of the work are separated by studs, as shown, which are held in a third steel ring on the chuck. The capacity of this chuck is 50 nipper handles, and the production is 125 per hour, grinding both sides and removing 1/32 inch of stock from the rough forging on each side.

Fig. 10 shows a somewhat similar fixture for holding the nipper jaws. Here, as before, three rings are provided, the two steel rings being separated by a brass ring; in this way the magnetism is localized in the flat surface of the nipper jaws so as to hold them securely. The inner ends of the jaws are prevented from shifting by means of

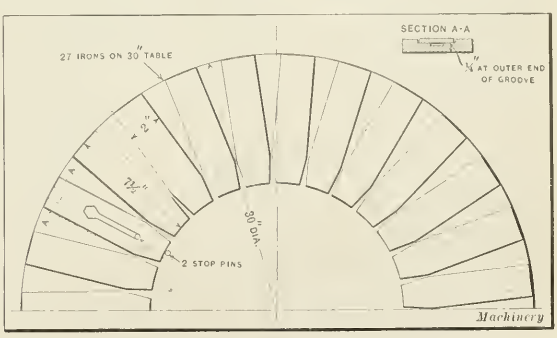

Fig. 11. Magnetic Fixture for holding Plane Irons

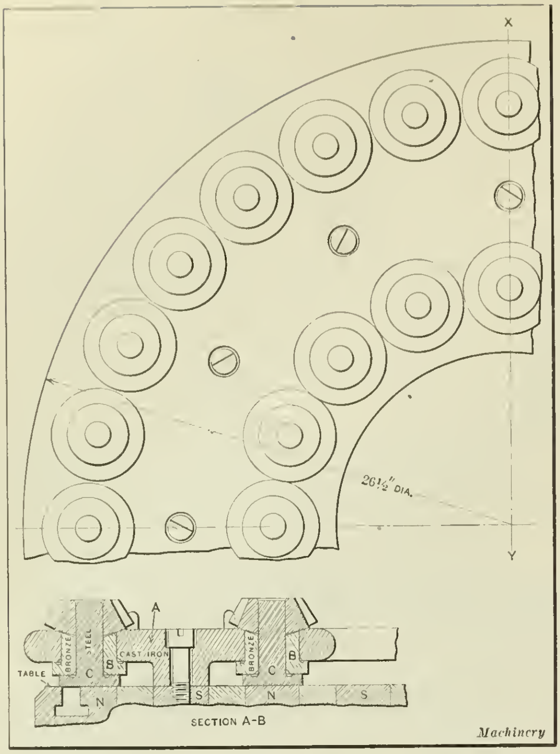

Fig. 12. Magnetic Fixture for holding Bevel Pinions when grinding Top Face

plugs as shown, and there are additional plugs in the block *A* that act as guides for the pieces and prevent them from contacting with each other. The capacity of this chuck is 45 jaws, and the production is 125 per hour, grinding both sides from the rough forging and removing 1/32 inch of stock from each side.

Magnetic Fixture for Holding Plane Irons

A simple but effective type of fixture for holding blades for carpenters' planes is shown in Fig. 11. In this case the work-holding fixture has slots milled in it converging toward the center, in which the plane irons are laid. These slots are recessed at the front edge to form a screwdriver slot for removing the work from the fixture after the magnetic current has been turned off. The slots in the fixture, of course, are machined to the required taper on the blade and the width of the slot is such that the blade can be easily slipped in and is kept from moving endwise by two stop-pins. The capacity of this fixture is twenty-seven irons on a 30-inch chuck.

Magnetic Fixture for Holding Bevel Pinions

An interesting type of fixture for holding bevel pinions for automobile differential gear mechanisms is shown in Fig. 12. This fixture is more elaborate than any thus far illustrated, and consists of a holder *A*, which completely surrounds the chuck and is bored to receive the bronze bushings *B*. This holder is so arranged that two rows of work can be held. The bronze bushings bear down on steel plugs *C*, the latter having a shoulder, as illustrated, and resting on the chuck face. The upper ends of these studs are machined to the size of the hole in the work so that the latter fits over them. The upper ends of the bronze bushings *B* are also machined to suit the shape of the rear face of the pinions. This chuck is so constructed that the studs are in contact with one pole of the chuck while the supporting plate *A* is in contact with the other, the stud and plate being separated by a non-magnetic material as shown. The effect of this arrangement is to hold the pinions securely in place on the studs and also on the supporting plate. By way of explanation, it may be stated that this illustration shows the fixture applied to an older type of Blanchard magnetic chuck, but the same arrangement, of course, can be used on the later type of chuck.

Fixture for Holding Work Square on Blanchard Surface Grinder

The Blanchard vertical surface grinder can be used with satisfactory results for grinding strips or other work having one or more sides square with a previously finished surface. A simple fixture for handling this work is shown in Fig. 13. A number of strips of steel are placed on the chuck in the manner illustrated, and then the work is located between these strips so that, in addition to being prevented from shifting, it is held square with the surface of the table. The magnetic current holds the entire mass of pieces firmly to the face of the chuck. It is not essential that the work bear evenly on its lower surface against the chuck, as the strips against which it is held prevent it from tipping. This particular fixture was used for grinding die parts, and the parallels were made from cold-rolled steel, pack-hardened and then carefully ground.

Magnetic Fixture for Holding Connecting-rods

An arrangement that can be used for holding connecting-rods when grinding the bearing faces is shown in Fig. 14. The small ends of the rods are thicker than the large ends, and the chuck is entirely cut away in the center, as illustrated, to concentrate the magnetic current at the large end of the rod and so that the projecting bosses on the smaller end will clear. It is evident, of course, that the wheel in this fixture only comes part way in over the chuck—just enough to cover the bearing surface being ground. There are two means of holding these pieces to the chuck; they can be held by brass plugs attached to the chuck face and fitting in the hole in the large end of the rod, or they can be located by loose pieces of flat steel, which are laid on the chuck face between the pieces of work. The latter method is sometimes preferred, as it makes it much easier to clean the face of the chuck, the bronze plugs, of course, being permanently attached.

Magnetic Fixture for Holding Steering Gears

A simple but effective fixture for holding steering gears when grinding the top face at right angles to the shank is shown in Fig. 15. This is made of cast iron and is located on the chuck by means of straps as illustrated. The work is

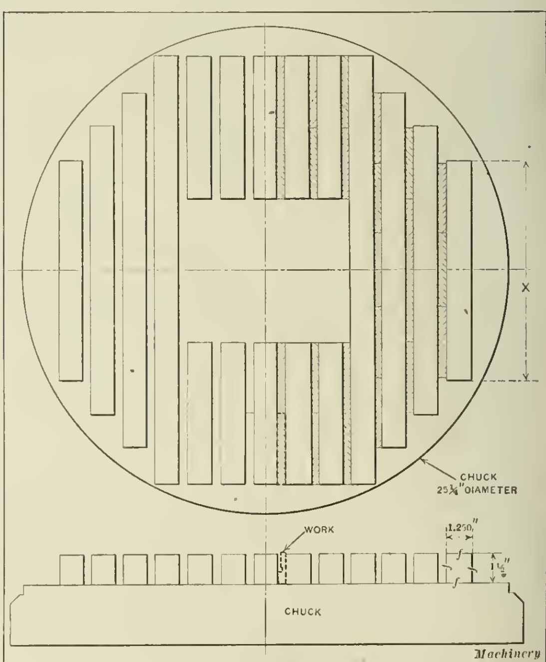

Fig. 13. Method of holding Work on Magnetic Chuck when it is desired to square One Surface with Another

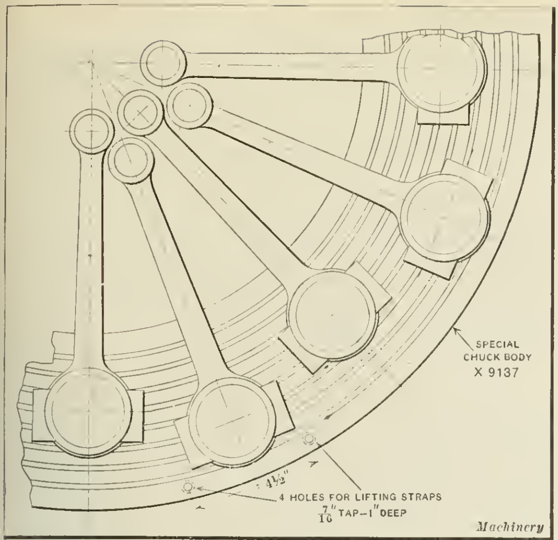

Fig. 14. Arrangement used in holding Connecting-rods for grinding Sides of Bearings

simply dropped into the holes in the fixture, the latter being made to fit the shank of the worm-wheel. The fixture can be held either by magnetism or by its own weight, the straps shown preventing it from shifting. This fixture holds twenty-one worm-wheels with shafts 1 1/8 inch in diameter by 5 1/2 inches long. The surface to be ground is 2 inches outside diameter, and 0.030 to 0.050 inch of material is removed. The production is 1000 pieces in ten hours, and they are ground to an accuracy of 0.001 inch.

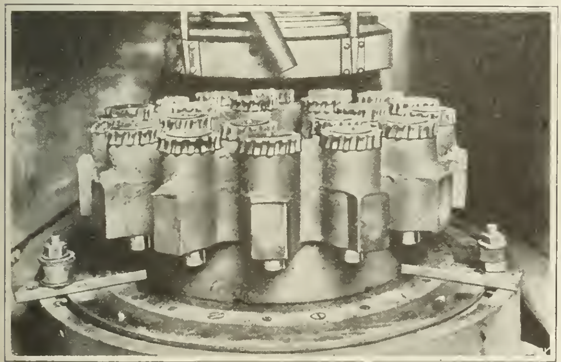

Fig. 15. Special Fixture for holding Steering-gear Worm-wheels

Fixtures for Holding Push-rods

Figs. 16 and 17 show two types of fixtures for holding valve push-rods when grinding the ends. As a rule, three or four duplicate fixtures are provided, so that a boy can load one while the other is on the machine. In this way the machine can be kept in practically continuous operation, except for the short time necessary to remove and replace the fixture.

Referring to Fig. 16, it will be noticed that the push-rod here shown is ground on the large end only. The fixture consists of a ring *B*, having V-slots on both inside and outside surfaces in which the push-rods are held by means of clamping blocks. As it is necessary to locate the rods from the small end, another stepped ring *A* is used at the bench for convenience in loading ring *B*. For the grinding operation, the lower ends of the rods rest directly on the chuck of the grinder, being maintained in a vertical position by ring *B*, to which they are clamped, while three stop-blocks on the chuck (not shown in the illustration) serve to center ring *B*. The capacity of the fixture is 104 rods. When such a fixture is to be used continuously, all locating and wearing surfaces should be of hardened steel; otherwise accuracy cannot be maintained.

The fixture shown in Fig. 17 differs from that shown in Fig. 16 in that it is arranged to grind both ends of the push-rod. This fixture has previously been described in MACHINERY,[1] and is reproduced here to illustrate how a push-rod can be held so that both ends can be ground. The capacity is 104 push-rods, and the production 700 per hour, grinding both ends and removing approximately 1/64 inch from each end. Three fixtures are used, two being on the loading bench while one is in the machine.

One of the chief advantages of the Blanchard vertical surface grinder is its unlimited capacity for holding a variety of shapes of work and grinding them to the required degree of accuracy. It is evident, of course, that with a carefully designed fixture, taking ordinary precautions in keeping the chuck clean, it is possible to hold a large number of pieces to within very close manufacturing tolerances; owing to the

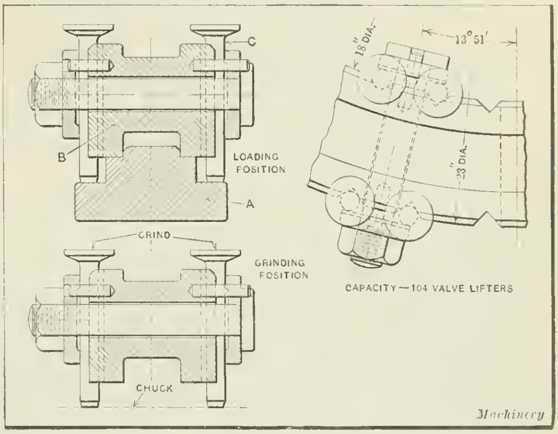

Fig. 16. Clamping Fixture used on Blanchard Vertical Surface Grinder for holding Valve Push-rods

fact also that a large number of pieces can be ground at one setting, the manufacturing costs are greatly reduced.

* * *

It is stated in *Industritidningen Norden* (Stockholm, Sweden) that since the beginning of the war not less than 20,000 war invalids have been systematically trained in Germany as oxy-acetylene welders. It has been found that welding is one of the occupations which is especially suitable for men who have been maimed in the war. The rapidity with which Germany has applied itself to the task of training those who have been injured in the war, so that they may be useful in after life, and the development that has been made in the manufacture of artificial arms and hands for the injured is remarkable.

[1] See MACHINERY, September, 1915, page 39.

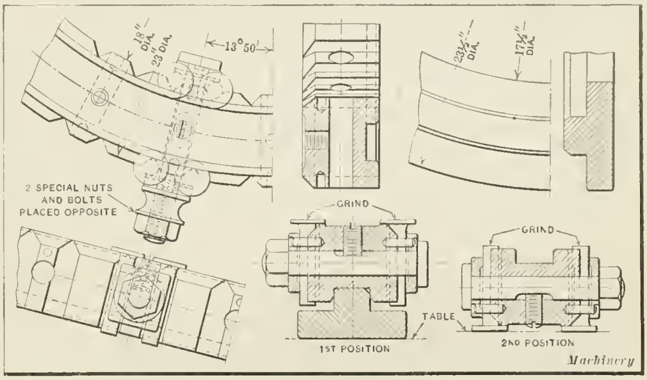

Fig. 17. Push-rod Fixture Similar in Design to that shown in Fig. 16, but so constructed as to enable it to be used for grinding Both Ends of Push-rods

FLUTES IN A HOB[1]

RELATION OF FLUTES IN A HOB TO RESULTS OBTAINED—THEORETICAL CONDITIONS NEVER OBTAINED IN PRACTICE

BY JOHN EDGAR[2]

When designing a hob, after the specification of worm or gear has been considered, probably the question of how many flutes to cut is the most difficult to treat in a general way. This has usually been treated as an arbitrary quantity, so that there is a great variation in the number of flutes cut in hobs of practically the same specifications in other respects. Although this question has been discussed before, a more thorough study will reveal something of interest to those who use hobs or have at any time the proposition of designing a hob suitable for some particular job. Some of the theories presented are not altogether suitable to the practical work of the shop because of the limitations that hem the shopman in on every side and seem to contradict theory in its application to everyday work. When considered from a purely theoretical standpoint, it is thought necessary to have an infinite number of gashes in the hob; this is exactly opposite to the practical point of view, as the life of the hob depends on its having as few gashes as will give the nearest approach to the theoretical tooth shape and still allow of the maximum number of sharpenings.

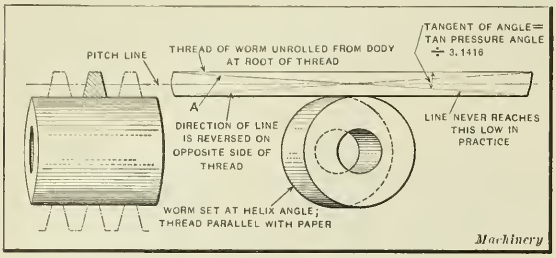

Fig. 1. Theoretical Bearing on Worm Thread

If a worm that has been run in action with the mating worm-gear is examined, it will be found that the bearing on the side of the threads of the worm does not cover the whole surface of the thread, but will show a spiral course, and if this thread is unrolled from the worm it will appear as at *A*, Fig. 1. This bearing, which in practice has a width greater in the middle of the worm than near the ends of the thread, is in theory a line and is made up of a series of points. The positions of these points gradually change from top to bottom, or from bottom to top, as the worm rotates; and in a single-thread worm, each point on the thread corresponds to a single point on each tooth of the gear. These points on each tooth of the gear are in exactly similar positions, and each point on the thread of the worm comes into contact with the corresponding point on each tooth of the gear, no matter what the number of teeth may be. That part of the thread that lies outside of this line of contact has, in theory, no reason for being, other than as a support, and if removed, would not interrupt the continuous rolling action of the worm and gear.

The foregoing proposition will be more easily understood if we consider a worm-gear of infinitely small width of face, which would result in purely point contact in the axial plane of the worm. If an axial section of the worm and gear is taken and the points of contact in this plane are connected by a line parallel to the plane, as in Fig. 2, the pressure line of the teeth will be obtained; and if the thread is of involute section, the pressure line will be straight. All contact between the teeth occurs on this line and is limited to that part of the line that lies between *A* and *B*. Just as the line in Fig. 1 is built up of points of contact, by rotating the worm and following the course of these points of contact as they appear in the axial plane it will be seen that the pressure line is built up of these points of contact and that they follow along this line and coincide with the corresponding point on the tooth of the gear. It can then easily be imagined that each point of contact is a diamond-pointed tool that has a reciprocating motion perpendicular to the axial plane and working at such a speed that the strokes are at close enough intervals to shape the teeth of the gear as it rotates in the proper relation to the movement of the tool-slide in the axial plane along the pressure line *AB*. This is a type of generating mechanism that, to the writer's knowledge, has not been used in practice but is theoretically correct in principle.

In Fig. 2, points *A* and *B* are the limits of contact. The distance from *A* to *B* projected on the pitch line limits the length of thread in contact. (In a hob this is the limit of generating action; in practice this limit is not approached.) C and C_1 are points of contact on opposite sides of the teeth. Lines drawn through the points and intersecting the pitch line at the pitch point *P* are known as pressure lines.

If the diamond point is replaced by a broad pointed tool, the face of which is perpendicular to the line of progress, it will be observed at once that the infinitely great number of strokes that the tool was required to make in the former case is now unnecessary, as the increased width of the tool allows of a greater interval between the strokes and the point of contact may become a line of considerable length. The outline of the gear tooth then becomes, not a curve made up of an infinite number of points, but a definite number of tangents to a curve. If the strokes of the tool are so controlled, these tangents will be of equal length from root to tip of the tooth; this would be accomplished by a constant feeding motion of the slide along the line *AB*. Now if the tool edge is made long enough to reach from top to bottom of the imaginary worm thread and is fed parallel to the axis of the worm by infinitely small increments, as the worm-gear is rotated in proper ratio, it will be found that the gear tooth can be formed as easily as before, but the cutting point of the tool will shift along the edge from the root to the tip, or *vice versa*, being always at the intersection of the pressure line and the cutting edge. If the thread in Fig. 1 is divided into equal parts and a cutting edge is placed at each division, a condition will be obtained that will answer as well as the latter supposition. These cutting edges

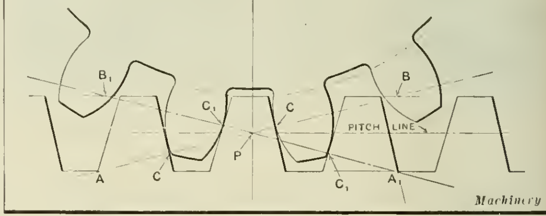

Fig. 2. Diagram showing Pressure Line, or Line of Contacts

are necessarily limited in location to the plane of the side of the thread. This condition is obviously what is found in the hob, the cutting edge being formed by the flute. This edge is relieved by forcing the thread tool in toward the axis of the hob as the latter revolves, giving an eccentric relief that allows the teeth formed by the gash to be sharpened without affecting their shape or size.

The problem before us involves the spacing of the cutting edges so as to obtain the most practical condition, which will balance the shape of the gear tooth to be produced against the life of the hob. It has always been the writer's contention that the most practical hob was one that had very few gashes, or flutes, since the distortions in hardening counteract any gain that might possibly be had by a greater number of flutes, as the distortion is directly proportional to the number of teeth subjected to it; also, that the finer teeth, being more slender, are subject to this distortion to a greater degree than those

[1] For other information on this subject, see "How Many Gashes Should a Hob Have?", in the January, 1909, number of MACHINERY.
[2] Address: 509 N. Church St., Rockford, Ill.

of the stouter proportions found in hobs with fewer flutes. Then, again, there are conditions of operation that counteract any gain there might be in having an abnormal number of flutes. Even hobs that have the teeth ground to remove any distortion of hardening and manufacture are subject to conditions of use that go far toward nullifying the prospect of fine finish with the greater number of flutes.

Minimum Number of Flutes in Hob

To find what may be deemed a minimum number of flutes, the significance of the tangents that are directly proportional to the number of flutes will be analyzed. This condition of direct proportion is often defeated in cases where the distortion of hardening is excessive or in case of careless sharpening. When the tooth of the gear appears with tangents of quite noticeable irregularity, this condition cannot, of course, be taken into consideration.

The rolling action of the worm-gear on the worm is analogous to that of the spur gear and rack, the rack being represented by the axial section of the worm and the spur gear by a worm-gear of very narrow face. The successive positions of the rack teeth may be represented by rotating the worm until each radial plane is brought into coincidence with the axial plane and registered. This has been done in Fig. 3, where each radial plane represents also one flute in a hob of the same pitch and proportions as would be used to hob the gear. It will be found that the pitch of the worm is divided into as many equal parts, or divisions, as there are radial planes, so that the number of positions assumed by the rack in each revolution of the worm is equal to the number of radial planes. It will also be found that the distance between each division is the pitch divided by the number of radial planes, or flutes, of worm or hob, respectively. Since the gear rolls on the pitch line of the worm, the pitch circle may be divided into spaces equal to the divisions on the pitch line of the worm. Each division will then represent an angular advance of the gear corresponding to the lateral movement of the thread section of the worm on the axial plane, and an equal advance by the imaginary rack.

In Fig. 4, these equal divisions have been spaced off, the space from one radial plane to another on the worm being equal to the lead of the hob divided by the number of flutes. This diagram shows that, in this case, twenty-two teeth generate the involute part of the tooth curve, there being twelve flutes in the hob. If the rack is rolled on the gear, it is obvious that the pressure line will always be perpendicular to a line drawn through the point of tangency of this line on the base circle, which is drawn tangent to the pressure line, with the axis of the gear as a center. Drawing a line to represent the pressure line at each position of the rack, when rolled on the gear, gives the series of tangents shown in Fig. 4. These tangents divide the tooth curve into unequal divisions, the distance between which gradually increases as the divisions near the point of the tooth. The distance varies almost in proportion to the distance from the point of tangency on the base circle; that is, it increases as the curve flattens out. Obviously, the point that governs the number of these tangents is the width of the tangent at the pitch point, as there the teeth roll on each other, and any condition that will answer there will be likely to answer at any other point on the tooth.

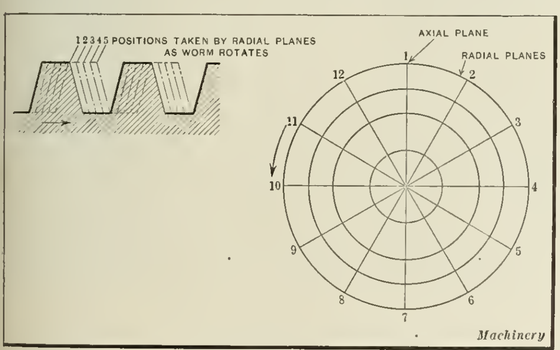

Fig. 3. Radial Section on Axial Plane and Successive Positions of Rack advancing in Direction of Arrow registered at Regular Intervals

From a lay-out similar to Fig. 4, it will be found that a width of tangent of 0.0625 inch in a tooth of one diametral pitch on a gear of twelve teeth will not be excessive or noticeable. The width of tangent at the pitch point on all gears cut with a hob of the same number of flutes will be equal. If the radius of the curve is taken as equal to the length of the pressure line between the curve and the point of tangency (and it will closely approximate this for so short a length as is being considered), it is possible to arrive at a close approximation of the depth of this tangent, as it differs from the curve it replaces, and so convince ourselves that the substitution is well within the limits of good practice. In the case of the twelve-tooth gear and a pressure angle of 14½ degrees, the radius of the curve may be said to equal the pitch radius of the gear multiplied by the sine of the pressure angle, or in this case, 1.5024 inch.

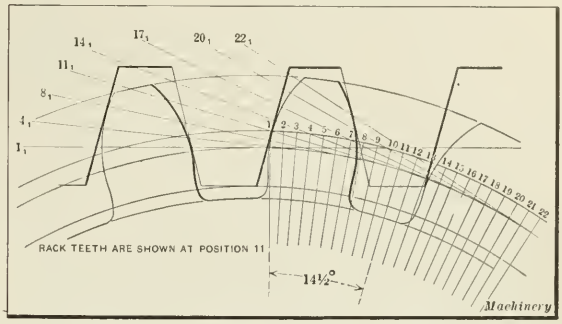

Fig. 4. Relation of Pressure Line to Tooth Curve

The depth of the "flat" is found by the modified formula for the rise of an arc:

$$H = F^2 \div 4R$$

where H = depth;
F = width of flat or tangent;
R = radius of tangent circle.

The depth in this particular case is 0.000333 inch. This seems to be a passably close approximation to the curve, as this depth could not be the cause of any great difference in the rolling of the gears. The depth of the tangent at the pitch point varies inversely as the number of teeth in the gear, so the question arises: What number of flutes will produce this result? In a 14½-degree involute, the spacing of the pitch line will be approximately four times that on the curve at the pitch point, or the spacing on the pitch circle will be $4 \times 0.0625 =$ 0.25 inch, approximately, since the pitch circle is divided equally into as many spaces per inch as the pitch line of the imaginary rack. As these spaces result from dividing the lead of the worm equally into as many spaces as there are cutting edges per convolution of thread, by reversing the operation the number of radial divisions in the hob is found to be $3.1416 \div 0.25 = 12.56$, or, say, 12, as an even number. This number would be as suitable for any pitch, for in the finer pitches the depth and width of the tangent decreases in direct proportion to the diametral pitch of the hob. The use of a smaller number of teeth in the hob, say ten, is permissible, as the error is only slightly greater than with twelve teeth, and in finer pitches would not be noticeably greater. In a general way, twelve teeth may be considered a good standard for spur and spiral gear hobs with a little leaning toward a smaller number of flutes.

Multiple-thread Hobs

In worm-gear hobs, conditions that limit the number of teeth or flutes are often met, so that the foregoing recommendation cannot be put into practice. For instance, the diameter and pitch of the worm may be such that a much smaller number of flutes will be found necessary to obtain the required strength of tooth. Many worm hobs with five or six flutes are found that seem to answer the requirements fully, while

others would give better results if the number of flutes were greater. Checking back in the manner just explained, figures would be found that one would doubt as being practical, the tangent being so wide, but when it is realized that the results obtained are giving satisfaction a person feels justified in recommending a small number of flutes. Such conditions as these should not be allowed in the case of spur-gear hobs, as that would be carrying the matter too far; but the writer knows of many cases where multiple-thread hobs with twelve flutes are used with good results. Such a hob has but six working flutes per thread. Multiple-thread hobs are being used extensively in finishing spur gears. To get as good results as with a single-thread hob of the same pitch, other conditions being equal, they should have the number of flutes that one would give a single-thread hob times the number of threads; thus, a double-thread hob should have twelve flutes per thread, or twenty-four flutes in all.

In using multiple-thread hobs for spur- and helical-gear finishing, the hob must be so proportioned that there are enough flutes per thread to give a good substitute for the theoretical tooth shape. This is obviously possible in only the smaller pitches; coarse pitches should not be handled this way. There are conditions of manufacture and use that enter into the proposition of getting good results from multiple-thread hobs that are not encountered in the case of single-thread hobs.

In the case of the single-thread hobs, there is no relation between the number of flutes and the number of teeth cut. Each tooth is produced by exactly the same action and by the same teeth of the hob, so that each tooth must be an exact duplicate of its mate. This is not the case in gears cut by multiple-thread hobs. Here the number of teeth is divided into groups, there being a group for every thread in the hob when the number of teeth in the gear is divisible by the number of threads. If the number of teeth in the gear is prime to the number of threads, the teeth in the gear are acted on by all the teeth in the hob, which produces the effect of a hob with twice the number of flutes as in the former case. This has produced the theory that the flutes in multiple-thread hobs should have a number prime to the number of threads. This theory is, of course, based on perfect conditions, but these conditions are so rarely met in practice that nothing would be gained by having such hobs. Were it possible to obtain a hob that did not vary in any degree in the spacing of the threads nor in the teeth as they come into the generating position, the teeth in the hob, having a number of flutes prime to the number of teeth in the gear, would not track, but would split the tangents into narrower tangents, thus producing a better approximation of the true involute. But since these conditions are never obtained in ordinary practice, it is desirable to employ the simpler methods of manufacture involved in making a hob with a divisible number of flutes, it being possible to obtain better results in this way than otherwise.

A mention of some of the difficulties encountered in making a hob with the number of flutes prime to the number of threads will show the wisdom of avoiding that condition whenever possible. Most multiple-thread hobs have a thread of considerable angle, and so are fluted spirally, making it more difficult to index the thread than were the flutes milled axially. The odd number of flutes to the number of threads complicates the indexing, as the relation of tool to flute is thrown out when the hob is indexed to bring the next thread to the forming position. This makes it necessary to reset the tool or perform another differential indexing operation to bring the tool back into proper relation with the flute in the hob. This multiplicity of operations cannot be performed without a long chance of error in the spacing of the thread. The error thus introduced may be sufficient to counteract any advantage gained by the prime relation of the flutes to the threads, as it results in a thick thread that will eradicate the work of the other thread when it passes through the tooth already formed by that thread. When the number of threads in the hob is divisible into the number of teeth cut, the result is thick and thin teeth. When the number of flutes is even to the number of threads, the indexing of the hob in forming the threads is a simple one-operation matter, and absolute accuracy is more nearly assured.

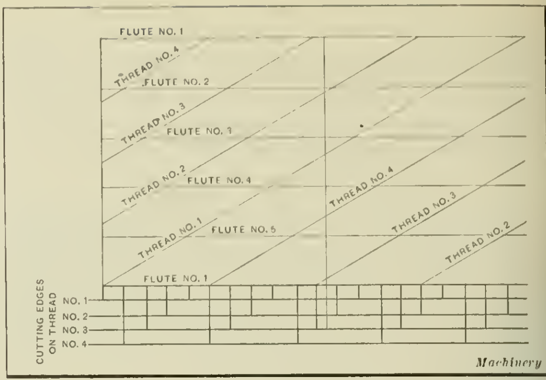

Fig. 6. Development of Cutting Edges of Five-fluted, Four-threaded Hob

It is when the use of the hob is considered that conditions counteracting any gain that could result from the prime relation of the threads and flutes are met, for even with a hob that is absolutely perfect in both design and manufacture, the conditions surrounding its use are never so nearly ideal. Even if the hob is in perfect condition and has been carefully sharpened, the proposition of placing it on the hobbing machine so as to run perfectly true is not so easily accomplished, and a very small amount of runout will counteract the slight gain that might otherwise be realized with the hob of prime relation. A very slight runout results in a condition similar to that obtained with a hob having a thick thread and gives a gear with thick and thin teeth, when the number of teeth is even; and a rough surface on spiral and helical gears, if the number of teeth is prime. Where the number of flutes can be made reasonably numerous, so that the tangents, when investigated as just described, are not of excessive width, the "prime relation" in the hob is to be avoided.

Conditions Making a Prime Number of Teeth in Hob Advisable

There are cases where it may be advisable to consider the use of the prime relation hob, such as where the lead is great and there are more than two or three threads. For example, suppose that the maximum number of flutes obtainable is five, because of the small diameter of the worm and the steep lead; that there are four threads; that the thread section is standard, that is, the working depth is 0.636 × the pitch; and that there are seventeen teeth in the gear.

In Fig. 5, the tooth shape of this gear is shown. Here *ABC* is the flat produced by one thread on a four-thread, five-flute hob in a gear of seventeen teeth, and shows the shape of tooth produced at one revolution of the worm-gear with the hob cutting the full depth for one revolution of the work. The equal spaces 1_1-5_1, 1_2-5_2, etc., corresponding to the cutting planes of the hob are laid off on the pitch line and the tangents to the tooth curve relative to one thread are shown. This condition

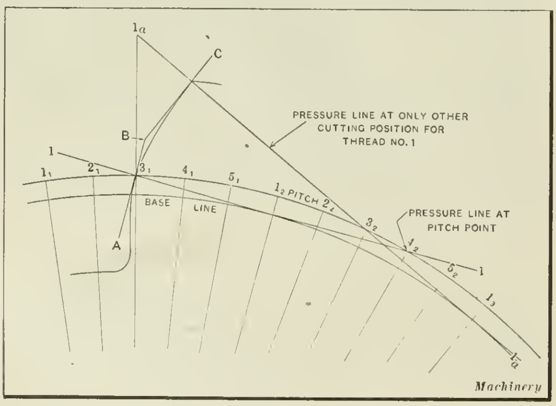

Fig. 5. Extreme Case of Insufficient Flutes

shows that if the teeth in the gear are a multiple of the number of threads, the junction of the two flats produced by the only cutting edges—there being but two in this case—will leave the hump as at *B*. Therefore, a hob of such extreme proportions would be a failure, and the only remedy would be to have more teeth or use some of the hobbing systems where the hob is moved along on its axis in proper relation to the rotation of the gear so as to produce a better approximation to the theoretical curve.

In the case of the gear having a number of teeth that is prime to the number of threads, the threads alternately pass through the spaces between the teeth, and by reason of the flutes of the hob being prime to the number of threads, the teeth of the hob do not track. Each tooth strikes the tooth curve at a different angle, and the tangents produced, therefore, blend into one another and a close approximation to the true involute curve is obtained. This only applies to those gears that have a number of teeth which is odd to the number of threads in the worm. If the number of teeth in the gear is not a multiple of the number of threads, but is even when the threads are even, the number of tangents obtained on the tooth curve is only a fraction of that obtained when the teeth are odd to the number of threads, or *vice versa*. In the present example, if the number of teeth should happen to be even, but not a multiple of the number of threads, the number of tangents will be only half the number obtained when the teeth are odd. A number of combinations can be obtained, depending on the number of threads in the worm and the number of flutes in the hob.

A diagram like that shown in Fig. 6 will reveal many interesting facts if studied in connection with the design of the hob for such extreme cases as those being considered. It not only shows the number of cutting edges there are in the hob, but also whether or not they track. The diagram is constructed by laying out the pitch of the threads on the horizontal lines and the pitch of the flutes on the vertical and then drawing the threads at the proper angle from the points laid out on the horizontal. The points of intersection of these lines will be the location of the cutting edges. The cutting edges in rows 1, 2, 3 and 4 act on the first, second, third and fourth teeth of the gear, respectively, when the number of teeth is a multiple of the number of threads. Cutting edges in rows 1 and 3 and 2 and 4 act alternately on every other tooth when the number of teeth is even but not a multiple of the number of threads. Cutting edges in rows 1, 2, 3 and 4 act on all the teeth of the gear when the number is odd.

In conclusion, it may be said that for spur and helical gears, when the hob is used on standard hobbing machines, the hob should be designed with ten to twelve flutes. In cases where the conditions are special and require holding a given diameter, the number of flutes should be determined by the methods just explained, the tangent being held within limits of 0.075 to 0.050 divided by the diametral pitch of the gear. In cases of multiple-thread hobs, the prime relation should be avoided, the threads being equally divisible into the number of flutes. When, however, the prime relation has to be employed, the following rule should be observed: If the number of threads is even, the number of teeth in the gear and of flutes in the hob should be odd; if the number of threads is odd, the number of teeth and flutes may be odd or even, but not multiples.

Many hobs are now in use that would be much better producers, so far as quality of product is concerned, had the prime relation been avoided. They were designed (or shall we say laid out?) according to rule, without proper insight into the limits of practical conditions surrounding their manufacture. Many purchasers of hobs would do well to take the manufacturer into their confidence in the design of their hobs and not insist on stated specifications, which are only a drawback to efficient hobs that can be made accurately and give perfect satisfaction in every way if these restrictions that make it difficult to give good service are avoided. All the flutes that can be crowded into a hob will not give good gears unless intelligent use and proper upkeep enter into the proposition.

COMPOSITION AND CHARACTERISTICS OF EXPLOSIVES

BY A. SCHLEIMER [1]

Perhaps no one class of articles at the present time is attracting as much attention as explosives, but the only one familiar to most of us is the old black gunpowder. This has been in use since the middle of the thirteenth century, and while the origin is not known, it is generally attributed to the Chinese. Its composition today is practically the same as it was then, the difference being only a matter of proportion. As made today, the powder is 75 per cent potash nitrate, 10 per cent sulphur, and 15 per cent charcoal.

Practically all the higher explosives are based on "nitro," which is a chemical combination of glycerine and nitric acid, wherein the three hydroxyls of the glycerine are replaced by nitrogen oxide or some other organic substance with which the nitric acid can combine in a similar manner. The first step in the manufacture of nitroglycerine is making the mixed acid. This is a mixture of nitric and sulphuric acids with a small percentage of water, in definite proportions. The acids are mixed in a large vat by means of compressed air, and cooled. The glycerine is warmed sufficiently to overcome its viscosity, and carefully added. The temperature at this stage of the process is a most important factor, and is controlled by a coil in the liquid. When the reaction is complete, the nitroglycerine is run off and washed thoroughly with water and alkali in order to free it from all traces of free acid. This forms what is known as trinitro-glycerine, which is the true chemical name, as distinguished from other combinations of nitric acid and glycerine, of which there are a number; this, however, is by far the most important one. The sulphuric acid in this instance has no chemical significance whatever, its action being purely catalytic. After the nitroglycerine has been removed, concentrated acid is added to the mixed acid, which is used over again. The "spent" mixed acid contains considerable nitroglycerine, which is recovered by diluting with water, heating, and agitating, which causes the nitroglycerine to separate.

Nitroglycerine is a heavy, thick, syrupy liquid. It has a specific gravity of 1.6, and its melting point is 13 degrees C. It has an intensely sweet taste, but is very poisonous, even in small quantities, when taken internally. The dose, when given internally, is only from 1/200 to 1/50 drop. Nitroglycerine is very sensitive to shock and friction, for which reason it is dangerous when frozen, as it must be thawed out before it can be used. It is only within the last few years that a diluent has been found that will lower its freezing point without impairing its explosive power.

Dynamite

Dynamite is simply nitroglycerine to which an absorbent has been added in sufficient quantity to form a solid mass, such as diatomaceous earth, clay, ashes or carbon. It is important that the adulterant have the correct absorbing qualities, for an excess of nitro will naturally exude, while if the absorbent is in excess, it is likely to crumble. Either condition is likely to give serious trouble at some unexpected moment. Both nitroglycerine and dynamite are particularly dangerous, owing to their instability. One can never tell just what they are going to do. The slightest shock will frequently be sufficient to explode them; consequently, the greatest care is necessary in their handling and transportation. On the other hand, there are many cases on record where the sudden application of great shock has had no effect. In one case a truck loaded with dynamite broke down and the load rolled down a short, steep hill, after falling off the truck. In another case a large ammunition plant, several years ago, was practically demolished. The explosions, as the buildings were destroyed, were so great that they were plainly heard fifty miles distant, and hundreds of windows were shattered in nearby towns. Yet the nitro house, which at the time of the explosion contained four tons of nitroglycerine, was not destroyed.

In making dynamite, the absorbent is first mixed by hand

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and then passed through a sieve; the care necessary can readily be understood when it is realized that a spark will set it off. This makes the use of machinery for mixing very dangerous; for, while it is easy to make machinery that will do the required work as long as it remains mechanically exact, the dropping out of a screw or the chipping of one of the blades or other parts while in operation is likely to cause a spark, which means disaster and loss.

Dynamite can easily be exploded by a blow. A small quantity can be ignited and burned with impunity, but larger quantities, if ignited, will be exploded by the heat generated. When frozen, dynamite is exceedingly dangerous and likely to explode by force of fracture. When brought into contact with water, the nitroglycerine readily separates from the absorbent, and for this reason precaution is always taken to keep it dry. To overcome this, the absorbent is sometimes replaced by collodion, forming the so-called blasting gelatine, or gelatine dynamite. This class of explosives has the advantage of being more stable for transportation purposes. On the other hand, it is more dangerous to make, as it must, of necessity, be mixed by machinery. Wood is used in the machinery wherever possible, and iron and steel are replaced by softer metals, lead, brass and zinc, which are not so likely to spark when struck. The mixing tanks are fitted with connections for hot water, in order to raise the temperature to the proper degree, as well as for cold water, to be used should the temperature rise too near the danger point, which it has a tendency to do. While in the "doughy" condition, the mass is run through a continuous screw machine similar to the ordinary household meat chopper, which turns it out the required size, after which it is dried and cut.

There are quite a number of different nitrocelluloses. The one used for the manufacture of high explosives is the trinitro, which is not the same as the dinitro used for making commercial collodion. The dinitro, while not so highly explosive as the trinitro, is sufficiently dangerous to warrant no undue unfamiliarity. Starch, which is so closely allied to cellulose chemically, is also used to a great extent for making blasting powder, by treatment similar to that used for nitroglycerine and guncotton. When wet, guncotton is quite harmless, though when mixed with some that is dry, it can be exploded by means of the dried. Blotting paper, tissue, wood-pulp, rag and other paper have all been discarded in the manufacture of guncotton for high explosives, and only cotton cloth is used in the form of rags or waste. The structural changes taking place in cellulose do not, however, affect its solubility, and for this reason any form of cellulose may be used for the manufacture of such products as collodion, celluloid, etc.

In the factory, the cotton waste is first hand-picked to remove the greater part of the mechanical impurities, such as pieces of wood, metal, rubber or whatever it may contain. It is then run through a teasing machine, which opens the knots, lumps, etc., and separates the fibers to permit of easy and rapid absorption of the acid. It is afterward run through a drying machine, which removes all but about 1 per cent of moisture, and this is taken care of by the sulphuric acid. The cotton is then nitrated in earthen pans, being added to the acid slowly and carefully, a small quantity at a time, so that the acid may permeate it thoroughly. After it has all been added, weights are placed on the cotton to keep it below the surface until the action is complete. The time required for nitration depends on the temperature, the strength of the acid and the dryness of the cotton. The greater part of the waste acid is run into a storage tank, where it is revivified by the addition of concentrated acid and used over again.

A thorough washing of the cotton is necessary after the acid treatment, as it must be absolutely free from any trace of acid. In some cases an alkali wash is used to counteract the acid, and then the cotton is washed to free it from the alkali. This is not advisable, however, as the cotton is likely to suffer from the chemical action of the alkali, which causes hydrolysis to a greater or less degree. The nature of the water used must also be taken into consideration.

After the final washing and drying, the cotton is placed in a machine, where it is treated to loosen and tear the fibers apart, and in this way whatever impurities remain are removed. For certain kinds of work, however, the cotton is formed into cylinders or slabs, while still damp, and then dried, which facilitates handling, as the cotton is less dangerous when moist.

Picric Acid

Picric acid, which for years has been used for coloring purposes, is one of the later explosives. Chemically, it is a relative of nitroglycerine, being a trinitro-phenol, whereas nitroglycerine is a trinitro-glycerine. It is a powerful explosive with a very high melting point; so high, in fact, that it must be adulterated to bring its melting point down in order to make it of practical value. Picric acid is one of the most dangerous explosives to handle or manufacture. It readily attacks most metals or their oxides, combining with them to form metallic picrates, which are as "ticklish" and uncertain as the well-known fulminates. For this reason it is not allowed to come in contact with metals, and shells in which it is used must be waxed or shellacked so that it will not contact with the metal. For this reason picric acid is used for priming more than for any other purpose. It has a tendency, furthermore, to dissociate most salts with which it comes into contact. Even the fumes arising from it in process of manufacture are deadly, and the skins of those working in it are stained a deep yellow, which is permanent. Phenol, from which picric acid is made, is the chemical name for what is commonly known as carbolic acid.

Trinitro-toluene

Trinitro-toluene is one of the most recent achievements of the military laboratories, and is probably the most commonly used high explosive today. As its name indicates, it is a combination of trinitryl and toluol. It is much less dangerous to manufacture or handle than either picric acid or nitroglycerine, as its fumes are not injurious nor is it sensitive to shock. Heat and moisture have little or no effect upon it, and it refuses to combine with the metals or their oxides. It seems rather incongruous that this substance, which is probably responsible for the greatest destruction of human life in the history of the world, is also the source of the sweetest substance known. From toluene is obtained saccharine, which is approximately five hundred times sweeter than sugar. In use, the nitro-toluene is melted and poured into the steel or iron shell, where it solidifies, and is exploded by a time or percussion fuse. The investigation and study of explosives is fascinating, and there is a wealth of information open to those who are interested.

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PLATINUM DEPOSITS OF THE WORLD

The metals of the platinum group—platinum, palladium, iridium, rhodium, ruthenium and osmium—are necessary in many industries closely connected with the war. But the known supply is limited; possibly 5,000,000 ounces have been produced in the world to date, about 95 per cent of which was obtained in Russia. It is estimated that 500,000 ounces are used in contact plants for the manufacture of sulphuric acid; 1,000,000 ounces, in chemical and physical laboratories; 250,000 ounces, in electrical devices; and 1,000,000 ounces, each in jewelry and dentistry. The United States uses 165,000 ounces of platinum a year; about 45,000 ounces are used in the manufacture of sulphuric acid and about 80,000 ounces in jewelry. Of this amount, 65,000 ounces are refined in the United States and 100,000 ounces are imported. With the exception of a little platinum and allied metals obtained by refiners of copper and nickel mattes and gold bullion, all the platinum in the world has been won from placer deposits. Platinum is not known in all countries in the world, but it seems hardly possible that all the deposits of this valuable metal are known. In fact, platiniferous deposits in southern Spain have been discovered quite recently. Colombia, South America, is the second largest producer of platinum. The metal is also found in Brazil, Borneo and Australia. In North America, platinum exists in the gravels of a number of streams in the western mountains, both in Canada and the United States.—*U. S. Commerce Reports.*

USE OF OIL AS FUEL

ECONOMY—STORAGE AND FEEDING SYSTEMS—TYPES OF BURNERS

BY J. V. HUNTER [1]

A FEW months ago a visit was made to a large manufacturing plant, where the visitor is welcomed and gladly shown through the place, as those in charge feel that they have an establishment of which they can be justly proud. Like most really successful factories, it has specialized in one line of product, and it shows plainly that it is a one-man institution. The forge shop astonished the writer; it was the third that he had visited within a few months where no furnace equipment had been provided for the rapid heating of large and small metal parts by means of fuel oil. Large quantities of small steel parts were being slowly heated in ordinary blacksmith coal fires. Two small built-up brick-walled coke furnaces did a little toward speeding up the work by furnishing quantities of unevenly heated metal parts, when they were not cold from fresh fuel charges. Nor were there any gas furnaces, although this plant had its own producer plant outfit for furnishing producer gas to heat a series of enameling ovens. However, few plants have service that will justify the expenditure required for a producer-gas installation merely for heating a few furnaces, so it will seldom be found as a general adjunct to a blacksmith-shop. It does seem, however, that many factory managers have been slighting the efficiency of their forge-shop departments by failing to provide means for heating steel parts rapidly, so as to keep the workmen steadily employed.

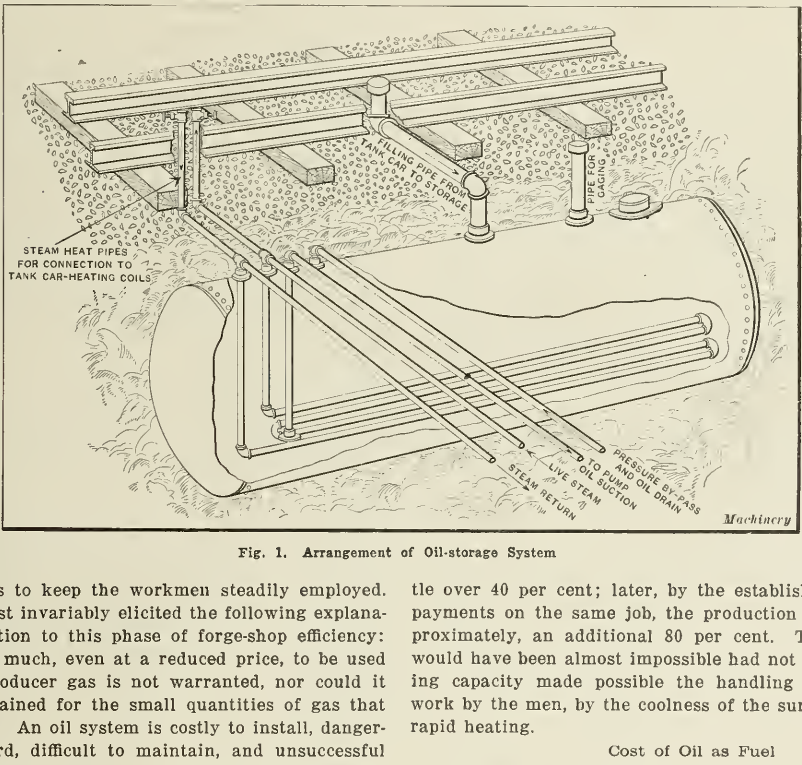

Fig. 1. Arrangement of Oil-storage System

Inquiry has almost invariably elicited the following explanation of the inattention to this phase of forge-shop efficiency: "City gas costs too much, even at a reduced price, to be used as a fuel, while producer gas is not warranted, nor could it be profitably maintained for the small quantities of gas that would be consumed. An oil system is costly to install, dangerous as a fire hazard, difficult to maintain, and unsuccessful unless installed and maintained by one who thoroughly understands its intricacies. The representations of the different oil furnace salesmen do not sound reasonable and the furnaces that they sell are very costly."

Yet if reasonable care and sensible directions are followed, all these objections can be reduced to a minimum. The cost of installation will not be great as compared with the savings that will accrue. The fire-risk will be no greater than may be expected from the sparks and live embers from a coal or coke fire. The cost of maintenance will be practically nil; a few cents a day for power, and a like amount for occasionally oiling the pump and starting and stopping the motor of the pump. Moreover, with a little study of the few simple rules or systems involved in the design of oil-heating furnaces, anyone may design and at small cost build furnaces exactly suited to the types of work that he desires to heat. Many good furnaces have been built of scrap sheet steel, angles, and bars that were lying around in the scrap yard. Many shops design or build their own furnaces and burners at from one-third to one-fourth the cost at which these could be bought. Good furnaces are the most valuable production stimulators in any forge shop. The oil furnace will add practically 50 per cent to the production that can be obtained from the customary coke or hard-coal furnace; and often at an additional reduction in the labor burden, as the coal fires require much of a helper's time for replenishing the fuel. After each charging, an appreciable time is lost waiting for the bed of coals to burn through and bring the work up to its proper heat. With an oil furnace of proper design, the work can be charged and withdrawn at a uniform rate, and an even heat maintained on all pieces.

One job of heavy hammer forging, in a western shop doing gas-tractor work, was heated on the bed of coals of a large hard-coal furnace. Because of the size of the furnace and the quantity of work to be handled, one helper was kept busy charging the coal and turning over the pieces to get as even a heat as possible (which was not very even at the best). After the installation of an oil burner, the time lost between heats was entirely avoided, and as the hammerman's helper laid in a cold piece each time that he withdrew a hot one, the furnace tender was eliminated. This change, on a day-work system, increased the production by a little over 40 per cent; later, by the establishment of premium payments on the same job, the production was increased, approximately, an additional 80 per cent. The latter increase would have been almost impossible had not the increased heating capacity made possible the handling of so much more work by the men, by the coolness of the surroundings and the rapid heating.

Cost of Oil as Fuel

Depending on the locality, the price of fuel oil in tank-car shipments will vary from a little over two cents to somewhat over four cents a gallon. Those who buy in smaller quantities, depending on the local oil supply houses for their wants, will have to pay a considerably higher price. Consequently, as a 10,000-gallon storage tank will cost about $125 in this locality, and perhaps no more elsewhere, it will pay nearly any user to equip his plant for quantity purchases.

The cost of the oil fuel depends greatly on the locality of the consumer with respect to the oil fields from which the supply will be derived. The known oil fields of this country are now so well developed and so widely scattered that the freight haul cost does not become excessive in any locality. Those who have access to the western, or Texas and Kansas, oils have an additional advantage, because these oils have little or no value for the production of lubricating oils and the other valuable petroleum derivatives, and consequently, in their crude state, are of much less value than the other oils.

Unlike coal or coke fuels, which vary widely, the oils from

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each field are almost uniform with respect to their heat values per pound. Some grades are of greater specific gravities than others, and as the price of oil is based on a "per gallon" system of measurement, a heavier oil will furnish a greater number of heat units per gallon. But a light oil can be more easily and efficiently burned than a heavier one, which offsets its lesser heat value per gallon. The range in heat values of American oils are given in Table 1. The eastern states are largely supplied with oil carried in tank steamers to their most accessible ports from the Texas fields, this being by far the most economical oil. The central states draw from the great Illinois, Indiana, and Ohio fields; the Middle West, from the Kansas region; and the Pacific states, from the asphaltic oil fields of California. When the Mexican fields were producing in large quantities, their output was largely used in Europe.

The smallest tank cars usually shipped with fuel oil contain from 6000 to 7000 gallons. Smaller cars can occasionally be obtained, but the number of these cars is very small, so as a shipper might be forced to wait some months before obtaining one, it would be unsafe to depend on such unreliable shipments. Allowing approximately 3000 gallons excess capacity to carry over any periods of delayed delivery of the oil car, it is customary to install about a 10,000-gallon tank for storage purposes.

Oil Storage Systems

Tank cars can be most readily drained by gravity, and the majority are drained in this way. An oil tank situated in a convenient position for filling from an oil tank car is shown in Fig. 1. The tank shown is of steel, but reinforced concrete has given very satisfactory service; when concrete is used the capacity of the tank can be considerably increased at little additional cost. There is at least one concrete tank in the extreme northwest, built mostly underground, that has been subject to great climatic changes without developing the slightest leakage. Needless to say, both for convenience in unloading and to meet the fire underwriters' requirements, the tank should be entirely underground. When located above ground, it should be situated at least 150 feet from the nearest building.

Tank cars are emptied through a connection, in the center and bottom of the tank. The pipe connections for emptying should be placed either between two ties in the center of the track or very close outside. An arrangement that will necessitate the laying of several lengths of pipe every time that a car must be emptied is most inefficient. The piping should be so arranged that one standard length of pipe, with an elbow for slight adjustment, will always reach the proper spot; if necessary, the car can be shifted slightly with a pinch-bar. Another plan is to use for the connection a six-foot piece of flexible oil-proof hose.

Fig. 1 shows an arrangement in which the flexible hose connection is used. All that is necessary, when making the attachment, is to remove the cap placed on the end of the upright pipe to prevent the entrance of dirt. When, during cold weather, it is necessary to heat the oil to facilitate its flow, the connections can readily be made to the steam mains provided, as shown in the illustration. Ordinary rubber steam hose should be used for this purpose. It is advisable to have this hose at least fifteen or eighteen feet long, as, unfortunately, all tank cars do not have their steam connections uniformly located; and to use pipe would necessitate cutting and fitting it for each car.

Fig. 2 shows a double underground tank installation; only

TABLE 1. HEAT VALUES OF AMERICAN OILS

Oil Field	Average Density of Crude Oil	Heat Value per Pound
Pennsylvania, heavy	0.886	20,736
California	0.933	18,880
Lima, Ohio, fuel grade.....	0.943	18,900
Texas, fuel-oil distillate....	0.880	18,850
Mexican	0.878	18,000

Machinery

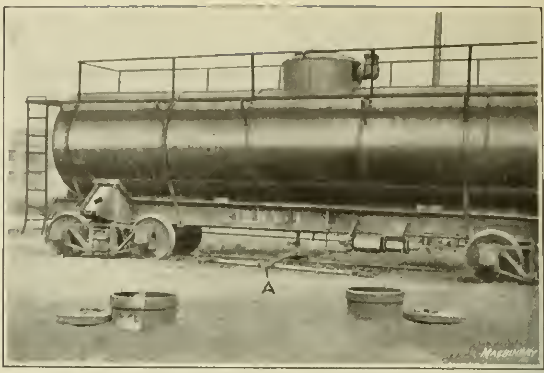


Fig. 2. Arrangement of Double Underground Tank

the manholes for inspection purposes show above ground. Ordinarily, it is unnecessary to provide such manholes; when used, their covers should be kept padlocked. With these tanks, a pipe connection *A* of standard length is provided for draining the tank car that stands on the siding. The quantity of oil in the tanks may be determined by lowering a pole through one of the manholes. In Fig. 1 the manhole opening is entirely below ground. To provide for measuring the oil in this tank, a two-inch pipe is run to a capped end above ground; this is large enough for the insertion of a rod or bar. Sometimes a tee is inserted in the filling pipe and the end of the pipe run from this is capped to prevent the entrance of dirt.

Usually, the writer has figured the capacity of the tank for each inch of height. Then taking a clean wooden rod about one inch square, he has marked upon it at each inch of its length, with quarter-inch steel numbers, the capacity of the tank at that point. A coat or two of shellac is then given to prevent the oil from soaking into the wood and obscuring the lettering. Daily or weekly readings of the tank will give the consumption of fuel, if this data is desired for cost or other records.

The winter climate in the majority of the states is sufficiently cold to reduce the consistency of most fuel oils to a very heavy grease that will not flow without warming. For this reason several loops of 1-inch steam heating pipe should be placed in the bottom of the tank and then connected to the boiler or any steam supply. A return pipe and outlet should be provided for the condensed steam. When possible, the steam pipe to the tank should be placed in the same ditch as the suction feed line from the tank to the oil pump. This will assist the flow of oil during the winter and prevent the clogging of the pipe should the frost penetrate the ground to that depth. Tees should be provided in both the live and the return steam lines, and from these branches should be run to valves above the ground beside or inside the track. The heating coils of all tank cars are provided with a steam trap at their outlet for draining out the water, so a return pipe is not absolutely necessary.

When a tank is placed in a freshly filled ditch, it should be filled with the oil soon after it is imbedded, so that there will be no chance of its floating before the ground becomes thoroughly packed about it to hold it down. The writer once sank a tank in a pit in what was a clay, fairly water-tight soil. As the filling-in of the pit was hastily done late in the evening, the filling of the tank was postponed until the next day. But that night there was a heavy storm and enough water ran into the loose soil of the pit to completely fill it, with the result that in the morning the newly buried air-tight tank was entirely above the surface of the ground and washed as clean as though it had never been below.

Tanks are not always placed below ground; occasionally conditions render a situation above the surface desirable. Such a tank is shown in Fig. 3; this is situated near a large forge shop. Behind the tank is a tank car which is being discharged into the receiving tank. In the small brick pump house to the right of the tank is a motor-driven pump that keeps a constant pressure upon the oil system of the factory. The use of this form of tank adds another factor to the in-

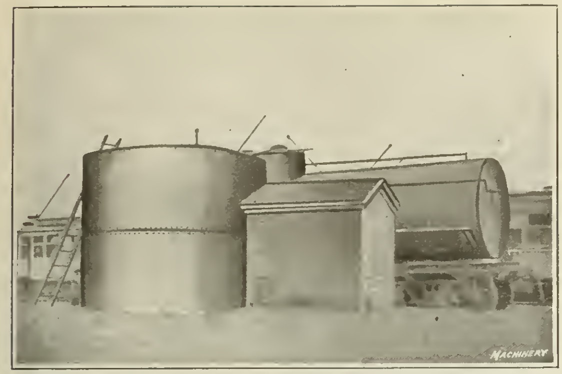


Fig. 3. Above-ground Storage Tank and Pump House

stallation. Since compressed air is necessary to discharge the car into the storage tank, an additional pipe line is required to carry the compressed air from the factory supply to the position where the car will be discharged, and time must be consumed in making one additional connection on each car.

The fullness of the description does not indicate a complicated or expensive system. Making all allowances for contingencies, the installation of a simple system, as described, and the piping (which is usually done by a shop's own crew) should not cost more than $250. If one cent a gallon is saved on the cost of buying the oil locally in small quantities, the saving on the first three or four cars of oil received will pay for the whole thing. Besides, it will save worry as to the non-delivery of the supplies needed daily in the shop.

Advantages of Oil-burning Casehardening Furnaces

Few factory managers realize that for actual heat value received for a given investment there is really little difference between the cost of fuel oil and that of high-grade coal or coke. There is too much tendency to look at a price of from two to four cents per gallon, and count the pennies seen there. A gallon of oil at an average density of 0.9 will contain approximately 7½ pounds of a fuel that runs, in heat value, close to 20,000 B.T.U. per pound; this will be equal to the heat given by an ordinary scoopful of coal, which will not run over fifteen pounds.

A year ago a large northwestern manufacturer was running his casehardening furnaces with hard coal as a fuel. Although he had the advantage of lake and rail freight rates on his carload purchases, the coal cost him $6.50 a ton on his siding, before he expended any labor unloading it. Fuel oil could be obtained from the Kansas fields at four cents a gallon delivered. In addition to one hour's labor each day for filling the casehardening pots, it took from four to six hours to tend the fire, wheel in coal, and remove the ashes, at a wage of 22½ cents an hour. The manager thought that oil at four cents a gallon was too expensive a fuel, but these figures convinced him:

Hard coal: Price, $6.50 a ton of 2000 pounds; heat value, 12,500 B.T.U. per pound; 38,460 B.T.U. received for one cent.

Fuel oil: Price, 4 cents a gallon of 7.49 pounds; heat value, 19,000 B.T.U. per pound; 35,570 B.T.U. received for one cent.

The heat value received in coal is 7.5 per cent more than that received from the oil. The hard coal required per heat is 400 pounds, which costs $1.30. The oil required for the same heat value is 34.9 gallons, which costs $1.39. The blacksmith's helper from a nearby forge adjusted the oil flame as it was necessary, so for an additional fuel expense of nine cents a day it was possible to save from 90 cents to $1.35 a day in labor expense. The oil consumed by that furnace was never actually measured, but knowing the high burning efficiency of the oil flame and the very poor and wasteful conditions of that old hard-coal furnace, the writer feels safe in stating that the furnace, when burning oil, operated on a B.T.U. input of about 50 per cent of what was necessary with the coal; so there must have been another saving in the fuel bill. There was another very satisfactory result of the oil-heated annealing furnace. The period each day of the anneal was approximately nine hours. As the oil flame brought the casehardening pots up to the correct soaking temperature much more rapidly than did the coal-fired furnace, usually doing so in less than two hours, as compared with five or six for the coal furnace, the penetration of the case was more than double the depth formerly obtained; a most desirable advantage.

This same manufacturer originally purchased his fuel oil in small lots locally and had installed a four-barrel tank, which, after each filling, was closed and the oil forced to the burners by compressed air. The success of each oil furnace led him to install additions, but finally he put in a large storage tank and a pumping outfit to keep a constant pressure on his pipe lines, abandoning entirely the original lay-out as inefficient.

Gravity Feed Systems

The ordinary types of oil feed lines for furnace equipments can be divided into the following general classes: gravity feed, pressure feed, and continuous-pumping feed. The first class, the gravity feed line, is the simplest installation, but it is applicable only for the very smallest installations, and cannot be used for larger ones without considerable variation from the lay-out shown in Fig. 4; it can be adopted by almost any small plant at little expense if the appropriation for that purpose is limited.

As shown, a 10,000-gallon storage tank is buried in the ground outside the building line. If the oil is to be bought in small quantities, the size of the storage tank can be reduced. Through a suction line extending to the bottom of the tank, the oil is drawn by a hand-operated suction pump. Any ordinary force pump is suitable for this purpose provided it has sufficient strength to force the oil against a head of about twelve pounds pressure; such a pump will range in price from $8 to $12. The pump forces the oil through a filter into a temporary storage tank somewhere near the roof. The filter is a fine-mesh screen, and is a most necessary adjunct to the system, especially where the oil is of low grade and full of dirt or small hard particles of tar, which would be likely to clog the small openings of the burners. The filter is readily cleaned of all the sediment that may collect by separating the pipe at the union and then separating the two halves of the filter.

The fifteen-gallon reservoir will contain enough oil to operate any ordinary two-burner furnace for at least half a day, and a few minutes work at the pump before starting the fires after the noon hour will fill the tank for the afternoon's run. A thirty- or a fifty-gallon tank can be used, but should the fuel consumption exceed these amounts, one of the more extensive systems would be more satisfactory. The pipe line extends from the bottom of the tank to the furnaces, but it is arranged in such a way that there is a return connection through a valve which will drain all the oil, both in the tank and in the pipe system, back into the main outside storage tank. This is a requirement of the fire underwriters' inspection service, in order that the oil in the tank may be drained out of the building each night to reduce the fire risk. The small pet-cock at the top of the tank is usually left open to exhaust the air from the tank, when it is being filled, and to admit air to prevent back pressure when the oil is draining away into the lines during the day. Should the pump have good suction power, the foot-valve at the bottom of the pipe in the tank is unnecessary and can be replaced by a ⅛-inch mesh strainer to prevent the admission of any large particles to the valves of the pump. Although the writer has seen only one of these systems, and that was in a single brass melting furnace in a small foundry, there are a number of them scattered around the country, and many have been successfully used.

Pressure Feed Systems

The general features of the pressure feed system shown in Fig. 5 are somewhat similar to those of the system just described. Yet it differs in the capacity of the plant, in the adoption of power for pumping, and in the use of air pressure

to provide a constant pressure upon the oil in the system. The capacity of this plant is very much greater than the first, and it may be increased to any extent by keeping the pump operating a certain length of time each day, while the oil is flowing out of the tank, to replace that consumed. This condition is also true of the gravity system, for if a laborer is kept pumping long enough each day, he can keep even a fifteen-gallon tank of fuel ready to meet any reasonable demands.

In the pressure feed system it is only necessary to have a pump of sufficient strength to charge the tank against the air pressure on it. It can be any old boiler-feed pump, which may often be bought second-hand, because, even though it is no longer sufficiently reliable or powerful for boiler service, it will be able to force thick oil without leaking over too much in the drip pan. The pump shown in Fig. 7 was recovered from some old steamboat scrap, yet it is giving most effective service in its new job.

One objection to oil as fuel that has been cited by many who have had little experience in its control is a "popping" or "puffing" flame that may be encountered, which seems to be due to the oil not flowing steadily. The cause of this trouble may almost invariably be traced back to an unsatisfactory condition of the pumping outfit which in some way introduces water or, more often, air into the oil stream; consequently when these air or water bubbles reach the burner they temporarily shut off the flame. As the air passes through an opening much more rapidly than the oil, the velocity of flow of the oil is momentarily increased in the pipe so that a heavy spurt of oil is forced into the furnace, giving a large puff of flame. This is an annoying condition, as it gives an unsteady flame and produces an unnecessary amount of smoke in the shop. This trouble can always be remedied by insuring a perfectly air-tight pipe line on the suction side of the pump, as it is through leaky fittings that the air usually enters. A tight packing about the rod of the piston of a double-acting pump will insure the non-admission of air at this point. This trouble is felt more when the pump discharges directly into the main pipe line to the furnaces. Where the oil first enters a temporary storage tank, as in Fig. 5, a pet-cock placed at the top of the tank permits the escape of any air that accumulates there; it also acts as a guide to indicate when the tank is full.

Some of the lower grades of oil from the western fields contain considerable water, and occasionally this is augmented by the seepage of condensed steam from a leaking steam coil in the tank car. This water always separates from the oil after a short time and settles to the bottom of the tank; naturally the suction line of any pump drawing from the bottom of the tank will pick up a large part of this water. In the system shown in Fig. 5, the water settles to the bottom of the reservoir soon after filling; if very much is allowed to accumulate there, it will reach the level of the feed line and flow out in it, causing trouble at the burners. To prevent this happening, a pet-cock should be placed at the bottom of the tank so that all accumulations can be occasionally drained off.

The oil filter is on the delivery line from the pump to the reservoir, so that it may be cleaned any time during the day without interfering with the flow of the fuel to the furnaces. Another safety device in this system is the "automatic safety cut-off for excess flow." This acts to stop the flow in case a fuel pipe line should break. If there were no such provision, the oil might flood the neighborhood of a furnace and ignite, causing considerable damage. When such an accident occurs there is a sudden rush of oil, greatly in excess of normal, through the new opening. As soon as the reduction in pressure is felt by the delicately balanced plunger in the automatic cut-off, a trip on a spring-operated valve is worked, and almost as soon as the accident has happened all pressure has been cut off from the oil, the leakage stopped, and the danger has passed.

As is shown in Fig. 5, the pressure necessary to cause the oil to flow through the system is obtained by admitting compressed air. However, most air systems are operated at a pressure of about 100 pounds, which is too high for the most successful burning of the fuel. Consequently an air-pressure reducing valve is introduced in the air pipe line and a pressure of twenty-five pounds is maintained on the tank. As reducing valves sometimes get out of order, a safety pop-valve can be placed on the top of the tank.

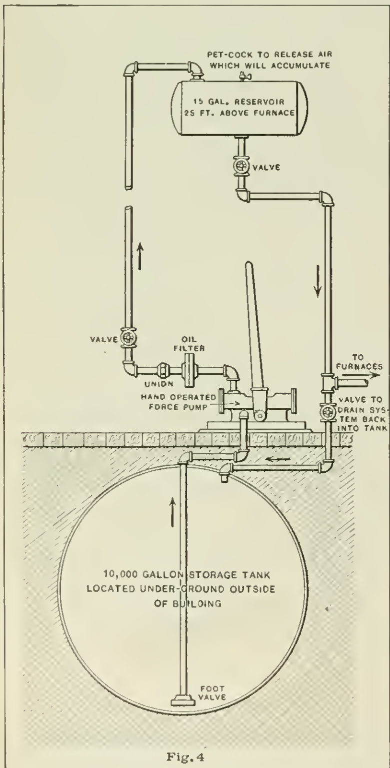


Fig. 4. Oil Gravity Feed System

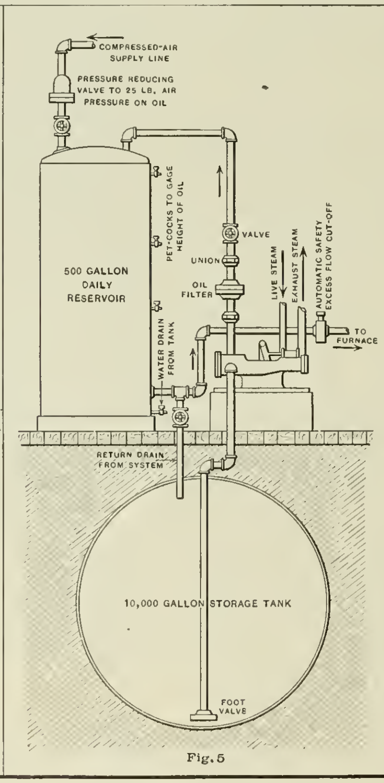


Fig. 5. Oil Pressure Feed System

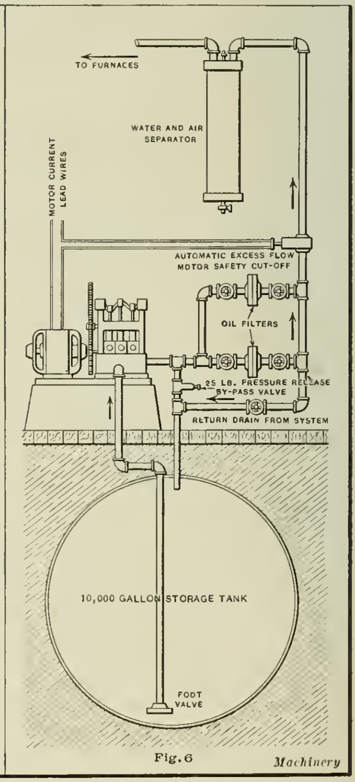


Fig. 6. Oil Continuous-pumping Feed System

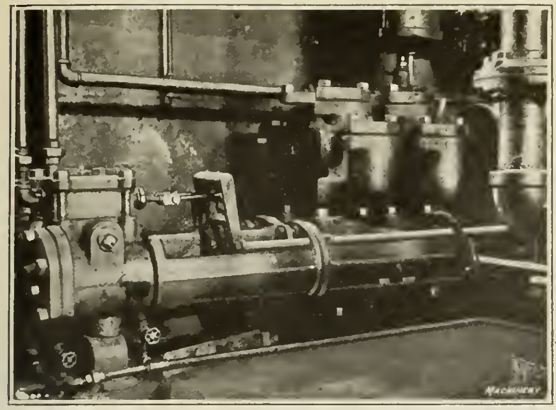


Fig. 7. Old Steamboat Pump used in Pressure Feed System

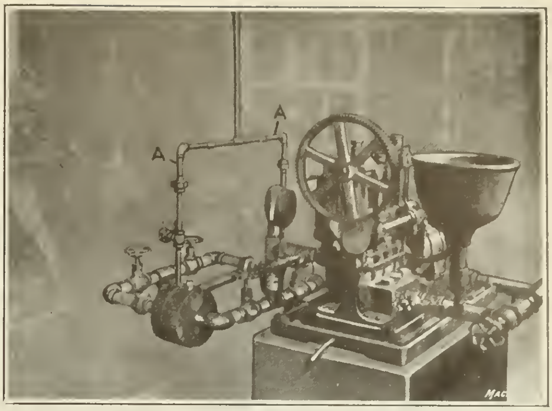


Fig. 8. Pump for Continuous System; also Filter Arrangement

A large electric railway repair shop that occasionally runs a night crew has installed a standard electrically driven compressor for air-brake service on a separate air line close to the tank. As the oil furnaces use only low-pressure fan-blown air for combustion, it is undesirable to run the large air compressor to provide air for the oil-storage tank. So, at night, the regular air-supply line is shut off to avoid filling the whole system, and the little compressor is cut into service. All electric compressors of this type are provided with an automatic cut-out that stops or starts them when the pressure rises or falls within certain prescribed limits. This automatic switch has been set for limits between twenty and thirty pounds pressure, and with very little effort holds the pressure between these points. This air compressor and the automatic switch mounted on the wall above it are shown in Fig. 9.

Continuous-pumping Feed Systems

The most recent development in the oil-supply system is the use of a continuously operating pump, which furnishes a constant supply of fuel to the system and by-passes the unused part to the storage tank. This system involves no large reservoir with its supply under pressure, in a position constituting a fire hazard, and may be considered safer on that account. The system is shown in outline in Fig. 6, and a pump, with its filters, is shown in Fig. 8.

The pump shown in Figs. 6 and 8 is a small direct motor-driven pump of three cylinders, but a steam-driven pump may be used. A steam-driven unit will be more expensive to maintain, but many plants use it because they have a small boiler feed pump that can be adapted for the purpose. No ordinary plant will need a pump of greater capacity than 120 gallons an hour; this will be large for most places, but a smaller pump will cost no less nor take appreciably less power. The power consumption of a motor to drive this size pump is remarkably small; the motors range in size from one-fourth to one-half horsepower. A complete motor-driven pump can be obtained for about $125. A gear-driven outfit is especially desirable; a pump driven by a belt is not as reliable, because the oil will inevitably get smeared about and cause the belt to slip.

On the delivery line from the pump is located a pressure-release by-pass valve which is set for the pressure at which it is desired to operate the system. This valve opens to a line that returns direct to the main storage tank. Some pipemen, when installing the equipment, object to running the long extra return line to the tank and want to send all the by-passed oil back into the suction line. This arrangement, however, is very objectionable because the pump will always draw in a little air, and if the furnaces are using little oil, the greater part of this air will be by-passed back into the suction line. As a result, the air will accumulate in the pipe line, and much more will pass into the line to the burners than would otherwise, giving an unnecessary amount of trouble with "puffing" flames.

One duplication in the continuous feed system that is unnecessary in the previous types is the double oil filter. In the other systems the oil filters can be cleaned any time after the tank has been filled, but with the continuous feed system the filter is in continuous operation. To avoid any possibility of a temporary shut-down should the filter become clogged when cleaning very dirty oil, a duplicate filter is provided, which is cheaply arranged. Then if one ceases to work, it is merely necessary to open the other, and close the valves to the first one, which may be cleaned at the attendant's convenience.

The automatic excess-flow safety cut-off for this system serves the same purpose as the one already described. The only difference is that this valve is connected with an electric switch installed in one of the leads to the motor. In case of accident, this automatic switch immediately disconnects the motor line and stops all pumping of oil. To separate any air and water that may pass into the line, a separator can be cheaply constructed of pipe fittings. This will afford a small chamber of slow flow in which the water can settle out of the oil and the air can rise to the top to be released when necessary.

The writer can recall but one serious shut-down in installations of this type. The tank was situated about fifty feet from the building, underground and close to the railroad track. When a large shipment of bar iron was unloaded, about ten tons were piled across two logs in this intervening space. One of these logs ran squarely across the suction pipe line, which was only two feet underground. Then when the dirt was softened by rain the log settled under the load until most of the weight was placed on the pipe, which naturally pulled apart at the nearest elbow. As soon as the trouble was located, a temporary connection was made above ground to the tank, which furnished oil until repairs could be made.

Necessity of Filters in Feed Lines

Many machine tools and systems established in manufacturing plants have failed to be of the greatest possible value to the owners because the men in direct charge of them have not understood them sufficiently to develop them to the utmost efficiency. The adoption of oil for the heating of work in forge-shop practice has suffered through neglect and misunderstanding of its advantages in the same manner. In some shops, oil heating has never been carried beyond the preliminary stages because some irregularity in its operation has caused it to be considered unreliable, when the real cause of the irregularity was either faulty installation or ignorant or inexperienced handling.

One western gas-engine manufacturer, who found it necessary to install an oil furnace for casehardening, built a furnace that a so-called expert told him was admirably suited to his class of work. The interior arrangement of the furnace was all that was to be desired, but it took all of one man's time to keep the oil adjusted and the burners clean. The reason for this was that the only oil available contained particles of asphalt, or other gummy substances, which clogged the small oil openings in the burners. No one had ever explained to him that installing a fine-mesh wire strainer in

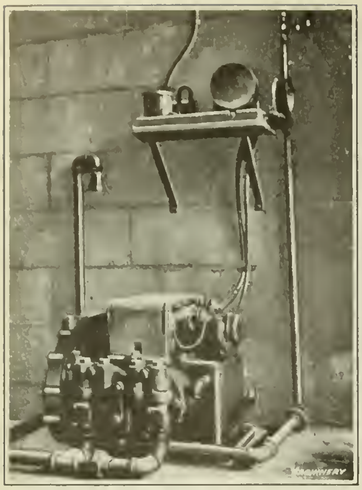


Fig. 9. Electric Air Compressor with Automatic Switch

the pipe lines would quickly remedy this difficulty. Hence, it was years before he could be convinced of the desirability of using oil-heating in some of the other processes in his shop.

The difficulty with clogged burners could have been remedied by the introduction of a filter in the first part of the pipe line from the pump or storage tank, and preferably close to it. A fine-wire mesh filter admirably suited to this purpose is shown at A, Fig. 10. It consists of two gray iron castings, machined on only one surface so that they may be bolted together to provide a non-leaking joint, with a pipe inlet or outlet tapped into each side for the oil flow. Another pair of pipe connections is provided when it is desired to clean the filter by passing steam through it instead of taking the filter apart. This steam connection is shown at A, Fig. 8. A screen of 1/32-inch mesh brass wire is loosely clamped between the two sides. This, in turn, is supported by a 1/4-inch steel plate punched fairly full of 1/2-inch holes. The object of this plate is to take up the pressure over the entire area and support the screen should the latter become so clogged that, failing to pass any oil, the full pressure would fall upon it.

In a simple installation, without the steam-cleaning connections, the filter is removed when clogged, and the sediment is blown off with compressed air or the screen is washed in kerosene. In the first installation in which the writer used steam for cleaning, the steam pipes for heating the tank passed so near to the filter that it was no trick at all to try the experiment. This plan worked exceedingly well, because the heat thus applied softened the gummy sediment so that it was quickly blown off and passed through the waste pipe.

Air and Water Separators

Another difficulty in the operation of oil burners, as has been mentioned, is due to the introduction of small quantities of water or air into the pipe lines. These cause the oil to burn poorly and unsteadily with a smoky, puffing flame that will not heat properly. This trouble can be overcome by the apparatus shown at B, Fig. 10. This is made of two caps and one piece of six- or eight-inch pipe, the larger the better. The oil passing in through the pipe at the left, which extends well into the reservoir, forces the oil to rise slowly at a decreased velocity through the larger pipe. This gives any water that the oil may contain ample opportunity to separate and settle to the bottom of the container. At the same time, the little bubbles of air will rise to the top of the container, where space is provided above the end of the outlet pipe to the oil line. Both the air and the water that have been entrapped can be removed at regular intervals through the drain cocks provided at the top and the bottom of the so-called trap.

Efficient Oil-burning Pressures

Opinions among oil-system experts vary greatly regarding the proper pressure for the most efficient burning of this fuel; that is, the pressure which should be carried on the pipe lines to the burners. The range is from five to twenty-five pounds; very few, however, go below ten pounds, while occasionally some go as high as fifty. These high pressures are used when a line has been overloaded and it is necessary to increase the pressure in order to increase the flow. A range of working pressures between twenty and twenty-five pounds can be recommended as the best adapted for all conditions. These pressures give the best burner-nozzle spray and at the same time keep the pressure low enough, from a safety standpoint. With low pressures, the burner-nozzle adjustment must be kept more widely open to admit sufficient oil; and at the same time there is likely to be a thick, sluggish stream of oil that will not break up readily in the air blast, and consequently will give a smoky, inefficient flame. Low pressures also decrease the volume of oil that will flow through a given size of pipe and thus necessitate the installation of larger sizes. From the standpoint of economy, factory owners demand the cheapest installation and the most efficient fuel-burning system. Large sizes of pipe lines will not decrease the cost of installation; yet when using heavy grades of liquid fuel it is necessary to provide much larger lines than would be necessary for an equal flow of water, because the oil flows so sluggishly through the pipes in cold weather. Table 2 gives an approximate idea of the sizes of piping that can be recommended for varying consumptions of oil; it is based on the number of burners that draw their supply from a line.

When one considers that the approximate consumption of an ordinary burner will not exceed four gallons an hour, it may seem excessive to install such large pipe for so small a service, but in the winter the consistency of crude oil may become that of stiff vaseline, so that considerable space will be required for the oil to flow in if any is to be delivered to the burners. In one system containing three burners, a one-inch pipe was laid about 600 feet out of doors, two feet underground, in a line to supply the foundry, and a great part of the way it followed close to the steam-heating mains. But on very cold days it was necessary to raise the pressure at the pump to sixty pounds in order to deliver sufficient fuel to the burners.

Some sort of valve or cock should be provided at the end of the run-offs of the pipe lines to the different departments, so that each can be shut off without interfering or disarranging the service to other departments. Some of the mutual insurance companies also require that a valve be placed on all fuel-oil lines just at the point where they enter a building, so that, in case of accident, the supply of oil can be shut off.

Types of Oil Burners

If all the kinds of burners that have been made for fuel oil were listed, it is probable that their number would run well into the thousands. The writer does not think he has visited two plants that used identically the same oil burner in the same manner. Each man seems to have changed the burner in some way, and each is sure that his type is really the one that should be adopted for all work. Moreover, nearly every description of an oil furnace that appears in the technical press includes a description of an improved oil burner, thus adding its quota to the previous designs. Recently, an acquaintance spoke of some investigations he had conducted to obtain the most suitable oil burner for glass-factory work, and said that he had obtained sample burners from all over the country which he had tried. Yet he did not select any of these for his purpose. He designed one that he thinks, for just this service, is better than any other. Therefore one must hesitate to give a description of the different types of oil burners that will be satisfactory for factory use; for what someone else thinks is the one "best" type may be entirely overlooked. However, the number of models that will suffice for most purposes is less than ten; and the only reason for

TABLE 2. SIZES OF PIPES FOR OIL DISTRIBUTING SYSTEMS

Approximate Rate of Consumption, Number of Burners	Pipe Sizes in Inches, for Varying Distances to Point of Consumption			
	100 feet	200 feet	400 feet	800 feet
1	½	¾	1	1
2	¾	1	1	1¼
4	1	1¼	1½	1½
6	1¼	1½	1½	2
8	1½	1½	2	2

Machinery

more than two or three is that there are several systems of supplying the air for the spraying and burning of the oil, and each of these requires a different type of burner.

To burn fuel oil completely in a furnace without giving off a heavy and offensive smoke, it is necessary for the oil to enter the furnace in a fine spray, and be surrounded at its entrance point with the air necessary for its complete combustion. At the place where this spraying is accomplished is the device known as the burner. Owing to the viscosity of fuel oil, it cannot be projected through any known nozzle by its own pressure and turned into a spray like water emerging from the common lawn sprinkler. Consequently, some agent must assist the spraying action. Ordinarily, this is done by the air, under greater or less pressure, that is provided for the combustion of the oil, although high-pressure steam has been used for this purpose, the air for combustion being furnished in some other manner.

Almost everyone is familiar with the manner in which ordinary illuminating gas, issuing from the end of a plain pipe, will burn with a low-temperature smoky flame; and how the application of the Bunsen, or blast of air, principle will produce with the same amount of gas, a fierce flame of much higher temperature. This same principle applies to the burning of fuel oil, for oil burning without auxiliary aid seems to produce little heat and much smoke. The air for this combustion may be supplied by one of three methods, namely: "low pressure," in which the pressure ranges from four to fourteen ounces; "high pressure," with a range of from ten to eighty pounds; and a combination of the two, in which high pressure air is supplied, in small quantities, immediately to the jet of oil to insure a more complete degree of atomization of the spray.

Of these methods, the first is the most economical for the first cost of installation, because a blower fan can be bought and installed for a fraction of the cost of a high-pressure compressor outfit. Those that claim they have the compressed air already installed in their plant must remember that, with an expanding business, the time will come when all the high-pressure air will be required for other purposes that cannot be filled by blower-driven air. Moreover, the cost of compressing air to sixty or eighty pounds is in direct proportion to the cost of blowing it at one pound; and while a little more of the latter is required to obtain the same efficient degree of combustion, the power consumption will be much less.

So far as the efficiency of the oil burning is concerned, either of the other methods is better as a general rule. This is due generally to a better atomizing of the oil, which tends to produce more complete combustion at a higher temperature. While this is the general rule, it does not by any means appear to apply to all cases, for when a good low-pressure system is correctly installed and carefully maintained (so that the oil nozzles do not become burned out or clogged with heavy, oily dirt) it seems possible to obtain quite as efficient combustion of the oil from this system.

When buying or installing a blower for use in a low-pressure system the first essential is that the blower will deliver air at sufficient pressure to keep all the burners supplied at the right pressure. Too many blowers are run at so low a speed that the air gives little assistance toward spraying the oil, so from one day's end to the next the owner spends his time condemning the inefficiency of his oil burners, while nine times out of ten it is a condition due solely to too low air pressure. Positive-pressure blowers are more reliable to meet this condition, since they deliver a constant volume for each rotation of the impellers, and if they have been speeded fast enough to have their safety valve just on the verge of blowing off under full load, they can be relied upon to deliver their air under almost constant-pressure conditions. But these positive blowers are very noisy, and only a foreman who has attempted to make his orders understood by the workmen in a shop where one of them is running will known how difficult this is when the blower is running constantly. Consequently, if this type of blower is to be used, and, as explained, it is in some ways more desirable, it should be installed in some outbuilding away from the shop; or if it must be in the shop, it should be enclosed by a sound-proof hollow-tile wall.

Blower fans are sometimes built with special housings that are much larger than the standard sizes. These, when run at a lower speed of rotation, will still have a high centrifugal speed at the outer circumference of the fan blades and, consequently, at these speeds will deliver the air at as high a blast pressure as that obtained from much higher speeds using the standard types of blower fans. However, there is little to be gained by buying these special fans. The buyer should be careful to consult the manufacturer of the blower fan that he is getting and ascertain the speed at which it must be run in order to insure the delivery of air at not less than ten ounces of pressure, for the average lead that he expects to carry. In fixing the pressure at ten ounces, the writer does so knowing that oil burners will give excellent service at this pressure; and will even do good work, on the average, at pressures below this point. However, there will always be drains on the air system that were not foreseen, so it will probably be seldom that the fan will deliver any more than is actually needed from it. When a blower is to be driven by an individual motor, the direct-connected type should always be chosen, for then the many troubles of belts run at the high speeds of fans will easily be avoided.

It is hard to estimate the amount of blower air that will be required by each burner, since there is always some loss from the amount theoretically required, but it has been determined that 306 cubic feet of free air is required to burn one pound of crude petroleum. It is better, though, to allow at least 350 cubic feet of air for each pound of oil that will be burned. So that estimating the average large size burner to have a consumption of forty-five pounds (approximately six gallons) of oil an hour, the blower should deliver approximately 15,750 cubic feet of air an hour for each burner that will be in use.

For conveying the blower air to the individual burners, pipes smaller than three inches may be used, but it is inadvisable to do so. Experience has shown that small pipes restrict the delivery of the necessary amounts of air and reduce the pressure, if due to the friction developing in the pipes. The main pipe at the blower should be the same diameter as the blower outlet and may be decreased in proportion to the number of side outlets that are taken off as it progresses through the shop. For pressures up to several pounds, pipe of standard galvanized sheet steel, about No. 20 gage, has ample strength. The joints of this pipe should be soldered to insure against extensive leakage.

A control valve should precede each burner on its individual air supply line, so that the amount of air entering the burner may be adjusted to the amount of oil being burned and the size of flame. These valves are very simple; two small flanged iron castings are bolted together with a small space between in which a ⅛-inch plate can slide to act as a gate.

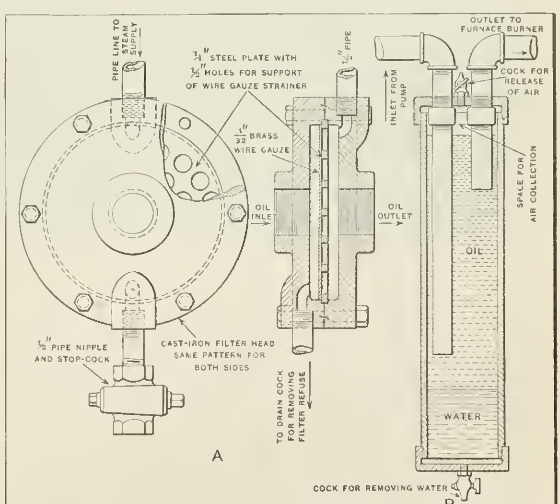


Fig. 10. (A) Filter. (B) Air and Water Separator

High-pressure air burners also require valves, which should be placed close to the oil-control valve, so that in starting the fire it will be possible to control one with either hand until the correct adjustment is obtained.

In Fig. 11 is shown the simplest type of low-pressure oil burner; it is one that has been used by nearly everyone that has built his own furnaces and by some furnace manufacturers as well. Its simplicity of adjustment and the ease with which it may be cleaned are its most desirable points. The air casing is a simple goose-neck casting, within which a ¼-inch pipe is centrally placed. This pipe, which extends almost to the outlet, passes through a small side outlet in the casting. This is tapped for a small clamping set-screw for the adjustment of the oil outlet, since for some conditions it must be advanced or withdrawn. The pipe tee on the outside end of the oil-pipe nozzle is one of the most important features, since after the flame is shut off the heat of the furnace often causes the heavy oil to congeal and close the oil outlet. Consequently, when it is impossible to get any oil in the furnace in the morning, it is simply necessary to close the oil valve, remove the plug, and run a small cleaning rod through the nozzle.

A variation of this type of burner has a small steel cone that slips freely over the oil nozzle and is tapered so that it will fit the taper of the inside of the air nozzle. By means of a small rod that extends out through the air casing, this cone can be pushed forward or withdrawn. In this way, it regulates the amount of air flowing at the nozzle and makes possible a desirable adjustment for a long or short flame.

Another form of burner for low-pressure air is shown in Fig. 12; this can be made entirely from standard pipe fittings. This burner was designed by a foreman in a large railway forge shop, and was used extensively for this class of furnace work. As will be noted, part of the air blast is by-passed through a side pipe loop, which returns through the center of the main blast. The oil is fed into this side air pipe some little way back from the outlet. It was thought that the air would spray the oil as it came out of its feed pipe and would carry this spray to the point where it met the main blast, which would further aid in forming a mist of the oil. But experience with high-pressure burners of somewhat similar principle has shown that it is more probable that the first blast drives the oil, in an even skin coat, along the inside surface of this pipe to the nozzle, where it sprays off in a minutely thin layer from the entire circumference and is caught at this point and atomized by the second blast of air. Consequently, if this nozzle were not close to the larger outlet, it would again drive the oil into another thin skin coat on the inside of the larger pipe. But if the burner is well designed and the inside nozzle is close to the outlet of the larger, there should be no reason for not obtaining a finely subdivided spray. This burner needs very careful regulating for all changes in the degrees of heat required. In order to force sufficient air through the inside nozzle at all times, a small butterfly valve is placed in the outside air pipe, as shown in dotted lines at X. By adequately adjusting this the necessary amount of air can be forced to flow through the inner air pipe.

After the burners that utilize low-pressure air exclusively comes the class that employs a combination of both high- and low-pressure air. A typical burner of this class is shown in Fig. 13. High-pressure air gives much better results in the atomizing of oil than can be obtained with low-pressure air. This is due possibly to the fact that the former, in escaping from the nozzle, expands at a very rapid rate, and when doing so the currents of air carry the oil spray outward with them. As will be noted, the oil in this burner is fed through a small centrally located pipe that has a slightly pointed nozzle. A needle-valve adjustment is provided at this point for further regulation of the oil supply, which for safety and to prevent any oil leakage when the burner is not in operation must be provided with another oil-control valve back farther from the burner. Another purpose of the needle valve in the burner nozzle is that it may be conveniently withdrawn for cleaning in case the burner clogs.

The high-pressure air is fed through a slightly larger pipe surrounding the oil pipe, and likewise terminates in a pointed nozzle, which extends approximately an eighth of an inch in advance of the oil pipe. This air pipe need have but little clearance over the oil pipe, for the amount of high-pressure air that is required will be small in comparison with the amount of low-pressure air required for combustion. The low-pressure air conveyed in the large pipe surrounds the other two, and may extend from a quarter to a half inch in advance, depending on the size of the burner. Both air lines must be controlled by suitable valves, so that the air supply may be regulated when starting the fire or when altering the size of the flame. When starting this type of burner, that is, when firing up a cold furnace, less trouble will be experienced if the oil and the low-pressure air are turned on first; then as soon as a flame is obtained the high-pressure air may be turned on very slowly. By this method a fire may be started readily, whereas if the high-pressure air is on at the beginning trouble will be experienced by the flame blowing out and giving forth the dense white fumes of unconsumed oil.

In Fig. 14 is shown one of the most satisfactory high-pressure air burners the writer has seen. It is particularly adapted for such furnaces as rivet heaters or tool dressers because of its short, intensely hot flame. But it is just as useful when in such service as ladle heaters in the foundry and in service that presents no permanent incandescent wall for the ignition of the oil vapor, because the oil is atomized to such a fine mist that it ignites itself almost as readily as a gas flame would do. This is a small and particularly compact burner, for as usually made it measures about four inches in length. The oil- and air-pipe nozzles enter at one end of the thin outer cylindrical shell. The oil nozzle extends a short

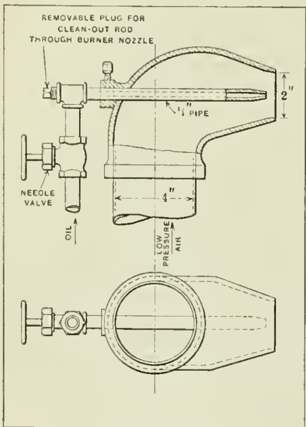


Fig. 11. Simplest Type of Low-pressure Oil Burner

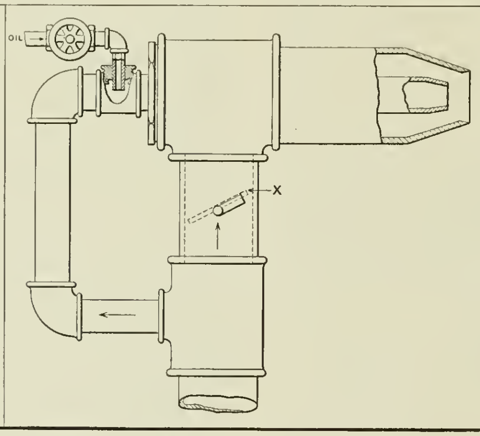


Fig. 12. Low-pressure Oil Burner made of Standard Pipe Fittings

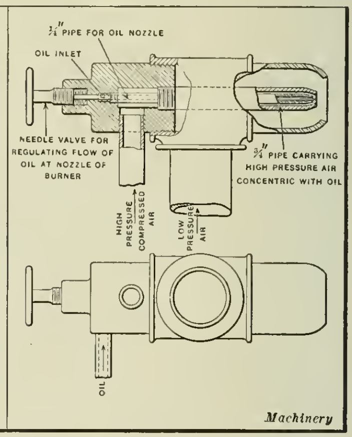


Fig. 13. Combination High-pressure and Low-pressure Burner

distance in front of the air nozzle and is turned upward in such a way that the air, in leaving its nozzle, sweeps across the end of the oil nozzle and picks up the fuel in its blast. From this point it would appear that the action of the interior of the burner is somewhat similar to the action described in the burner shown in Fig. 12; that is, that the oil drives for-

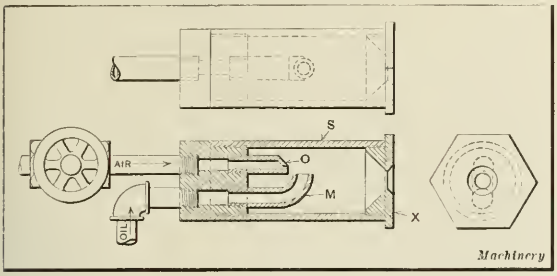


Fig. 14. High-pressure Burner

ward in a thin sheet along the inside wall, converging toward the sharp edge of the outside nozzle, and from this point mists away in a finely atomized condition.

The oil nozzle should never be designed to put the oil in a thin sheet to be picked up by the air blast; it will not work. It might be thought, judging from the needle valve outlet of the burner shown in Fig. 13, that by extending this principle in some way, such as prolonging the needle, a thin sheet of oil could be obtained that would be more readily sprayed by the blast of air. This might be possible with water, or even with gasoline if it were clean or could be fed with sufficient force to keep the opening clean, but oil carries so many thick particles that small burner openings will be clogged in almost an instant, and burners designed on this principle have proved failures.

* * *

WHEEL DRESSING AND TRUING

BY HOWARD W. DUNBAR [1]

Frequently, one hears grinding-machine operators refer to the use of a diamond, or a wheel dresser, on a wheel as a truing operation; at other times, this is referred to as a dressing operation. There appears to be some confusion in the minds of operators as to the distinction between these operations; therefore, an effort will be made here to make the meanings of these terms clear.

Dressing a Wheel

The wheel face is dressed after it has been worked to a point where it no longer acts as it should; that is, the wheel may have become loaded, the particles dulled, or the face of the wheel smoothed up so that it does not cut freely. A dressing operation frees the worn-out and useless grains in the face of the wheel and presents new particles of abrasive in the grinding operation, making what the operator calls a "sharp" wheel. Sometimes this is called "roughing up" the wheel, and is usually done only when rough-grinding, as such a condition in the wheel face cuts off material very rapidly. The wheel does not of necessity have a perfect face; it may be slightly out of round, it may not be exactly parallel, or it may not be exactly concentric, but for rough-grinding, when removing a lot of material, it serves its purpose.

After considerable investigation, the Norton Grinding Co. has found a means for accomplishing this result without using a diamond, and is now recommending the "Huntington" dresser, which is especially designed for use with Norton grinding machines. This dresser is held in the diamond tool-holder in the same manner as the diamond, and is passed in front of the wheel for the purpose of dressing it. There are many reasons why a dresser is recommended for this purpose, but the principal one is the scarcity, expense and unreliability of diamonds at this time. It must not be understood, however, that diamonds cannot be used for dressing purposes, because they can be used and will produce the same results, but always at the expense of the diamond. On the other hand, dressers cannot be used for the fine finishing operation, which can only be done by using a diamond for correcting the wheel face. It is difficult to draw the line between the use of the dresser and the diamond, as it will depend on the results desired. As operators acquire more and more skill, the dresser, by careful use, will find a wider and wider field.

[1]Address: Norton Grinding Co., Worcester, Mass.

Truing a Wheel

Truing a wheel has for its object the correction of the wheel face and the perfecting of the wheel so that it will grind perfectly round and smooth work. This can be accomplished with satisfaction and economy only by the use of the diamond. When truing, the face of the wheel is made straight or parallel with the work to be ground. It is made concentric with its mounting, so that the extreme point of every particle in the face is exactly the same distance from the center of the wheel. The truing operation is also done for the purpose of producing the particular kind of face desired for the work in hand. The ability to do this is a part of the grinder's skill. It is something that is difficult to teach, but is an accomplishment that comes naturally to a skillful operator. A great many times in producing the desired result in ground work, it is necessary to dull the face of the wheel instead of sharpening it, which is contrary to the belief of the inexperienced.

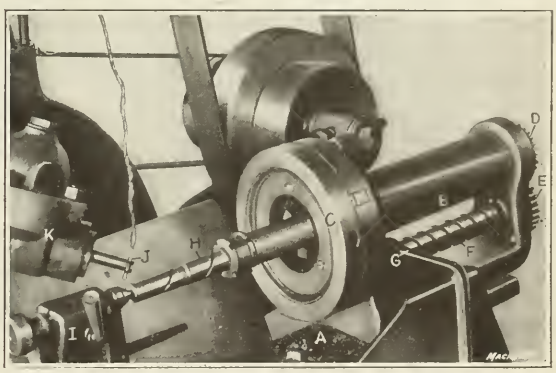
No ground work can be any more perfect than the wheel that produced it, so the importance of the diamond for truing is easily seen. The highly reflecting, bright surfaces sometimes noticed on ground work could not be produced without the diamond; 0.00025-inch limits would be unheard of in grinding, and flat or round work would be impossible except by tedious lapping operations.

* * *

MILLING OIL GROOVES

BY ROBERT MORRIS

The illustration shows how some special shafts were oil-grooved in a Whitney milling machine. The fixture *A* is provided with a large hollow spindle *B*, on the end of which is mounted a scroll chuck *C* taken from a Whitton centering machine. At the rear end of the spindle is a gear *D* which meshes with a gear *E* keyed to the lead-screw *F*, which engages a nut in the end of bracket *G*. Bracket *G* is secured to the knee of the milling machine. The work *H* is held in the chuck *C* and the outer end is supported by the tail-center *I*; it is also secured to the fixture *A*. As the table of the machine is fed to



Cutting Oil Grooves on Whitney Milling Machine

the left, it carries the fixture and the work with it, and the stationary nut in the bracket *G* forces the steep pitch lead-screw *F* to rotate. The rotary motion of the lead-screw is transmitted through the gears to the spindle and work. The grooving cutter *J* is mounted in and driven by the universal head *K*. The work done with this arrangement was entirely satisfactory.

* * *

The newly discovered beds of molybdenum ore in southern Peru are said to be the largest known molybdenum deposits in the world.

MAKING DIE-PRESSED CLUTCH CASTINGS

There are many small parts of machines and instruments, and numerous metal products that may be produced advantageously by a method known as die-pressed casting. A variety of metals can be worked in this way, although the most satisfactory results are obtained with brass and other alloys that can be made to flow without applying such high pressures that the dies are destroyed rapidly. In an article entitled "The Production of Die-pressed Castings," which was published in the January, 1916, number of MACHINERY, general information was given concerning the construction of the dies and methods used in work of this kind. It is the purpose of the present article to describe the design and method of making a set of dies for the production of the small brass clutch shown at *A* in Fig. 1. In this illustration are also shown pivot *B*, on which this clutch is assembled, die *C* and swaging punch *D*.

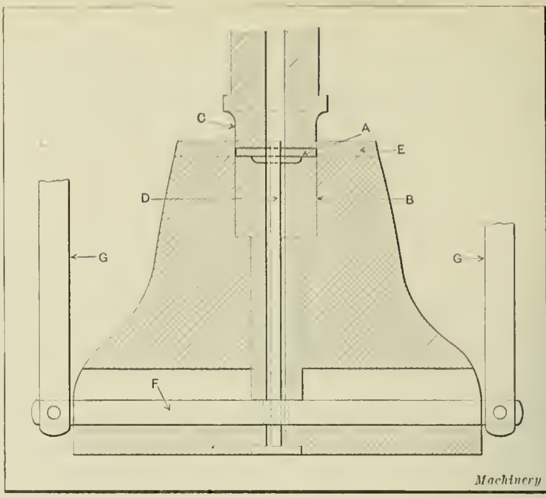


Fig. 3. Punch and Die used for making Die-pressed Clutch Casting shown at A

The assembled punch and die for making the clutches are shown in Fig. 3, in which one of the die-pressed clutches is shown in place at *A* in the closed die. It will be noticed that die *B* is supported by a cast-iron shoe. The brass blanks from which the clutches are pressed are turned up on a Brown & Sharpe automatic screw machine, the blanks being flat disks with a hole in the center of a diameter equal to that of a circle which could be circumscribed around the pentagonal shaped hole at the center of the clutch. Punch *C* has a flat face, and there is a hole in it just large enough to provide a sliding fit for pentagonal swaging punch *D*, which is pressed into the bottom of the cast-iron die-holder. In operation, the brass blank is dropped into the die and properly located by the pentagonal punch *D* that slips through the round central hole. When the press is tripped, the application of pressure by punch *C* causes the metal to flow down into the die cavity, which results in forming the clutch teeth; and, in addition, the metal flows inward around swaging punch *D*, so that the circular hole in the blank is changed to the required pentagonal shape. The metal also flows outward to fill out the hole in steel collar *E*, which provides for securing a nice finish on the edge of the work.

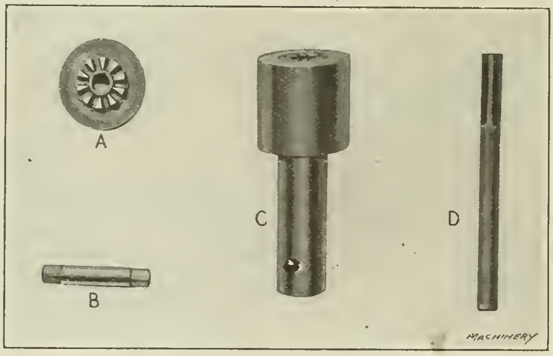


Fig. 1. Clutch A, Pivot B, Die C in which Clutch A is pressed, and Swaging Punch D for forming Pentagonal Hole

After the press has completed its downward stroke and the ram starts to rise, cross-bar *F* comes into contact with the bottom of die *B*, as shown. This result is obtained by having cross-bar *F* connected to vertical rods *G*, which are coupled to the ram of the press, and after the engagement of bar *F* with the die—which takes place when the ram is close to the top of its upward stroke—continued movement results in lifting die *B* a short distance out of the holder. This provides for stripping work *A* off swaging punch *D* and lifting the top of the die clear of the holder, so that the operator may reach in and pick the finished die-pressed casting off the top of the die. It will be apparent that the edge of the work is exposed so that the operator is enabled to get a good grip with his thumb and index finger; and as the sides of the die cavity are given a draft of about 0.001 inch, no difficulty is experienced in removing the work. It may appear that this method of picking the pieces off the die by hand would make the cost of production exceedingly high, but on this particular class of work the output obtained with this die equipment is said to be far in excess of what would be obtained in producing the parts by any other method. Attention is called to the fact that a hole is drilled through cross-bar *F* to provide clearance for swaging punch *D*.

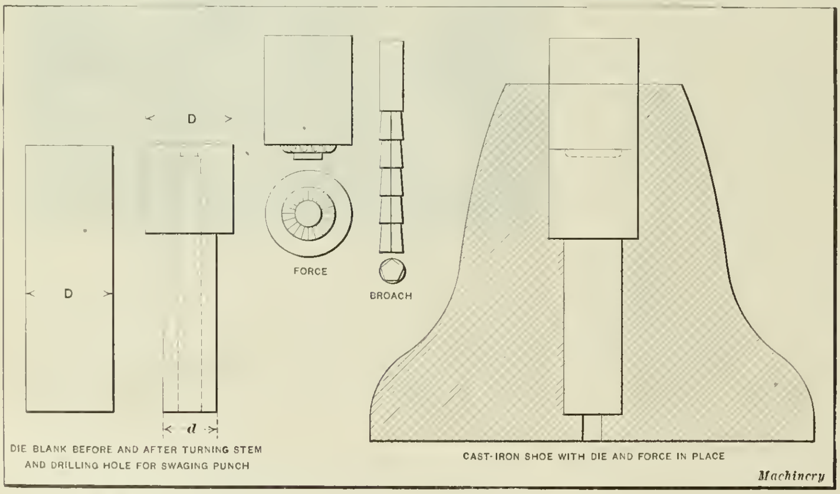


Fig. 2. Die Blank, Force for making Die Cavity, Broach for Pentagonal Hole in Die, and Holder in which Die Cavity is formed by Force

In starting to make this die, the first step was to take a piece of Ketos steel and turn a blank, Fig. 2, to a diameter *D* plus the necessary allowance for finish; after this had been done, the stem of the die was turned down to a diameter *d*. For sinking the impression in the die, a male force was made with projections corresponding to the clutch teeth, and these were tapered 0.001 inch on the sides to provide sufficient draft for the die-pressed castings to be easily removed. In addition, this force was provided with a pilot for countersinking an impression at the center of the die. The next step was to make a cast-iron die-

holder suitable for supporting the die blank in a vertical position, the hole being deep enough to allow the force to be dropped in on top of the die blank in the manner shown. The die blank was heated to a cherry red and immediately placed in the holder, which had already been set up under a drop-hammer; and being careful to avoid loss of time, the force was put in place and struck a blow of the required weight to drive it into the heated die blank.

After progressing to this point, the die blank was set up in the chuck of a bench lathe, using an indicator to locate the work from the swaged counterbore in the die, after which an axial hole was drilled, the diameter of which was that of the inscribed circle of the pentagonal hole at the center of clutch A, Fig. 1. The next step was to rough- and finish-turn the forward end of the die blank to diameter D, Fig. 2, after which the work was reversed end for end in the chuck for rough- and finish-turning the stem to diameter d. It will be apparent to all experienced mechanics that the reason for delaying the finish-turning operation until this time is to correct the distortion of the work caused when the force was driven into the heated die blank. With the die blank still held in the lathe chuck with the small end out, a somewhat larger axial hole was drilled almost to the forward end.

It was then necessary to broach the pentagonal hole at the top of the die, which was done with a small five-stepped broach made especially for the purpose. This broach was made from 1/8-inch drill rod, and so it did not possess a great deal of strength; consequently, it was decided to perform the broaching operation by tapping the broach through with a light hammer, which was found to give satisfactory results. Both die B and punch C, Fig. 3, are made of Ketos steel, and little need be said in regard to making the punch, as it is simply a matter of turning up a blank on the lathe and drilling the clearance hole for swaging punch D. This swaging punch was made of steel, with a head upset at the end to provide for mounting it in the die-holder. After the head had been made and turned to size, the punch was hardened and ground to the desired pentagonal form. E. K. H.

* * *

FORD MOTOR CO.'S PROFIT-SHARING PLAN

More than three years have passed since the inauguration of the profit-sharing plan of the Ford Motor Co., at Detroit, under which a minimum wage of $5 a day is paid to employes who comply with certain conditions stipulated by the plan. The results of the profit-sharing scheme have been satisfactory to the company and to the men alike. At the end of the past year, there were, in all, 55,752 employes of the Ford Motor Co. at the home factory and branch factories and offices. Of these, about 42,400 were employed at the Detroit factory. When the profit-sharing plan was inaugurated three years ago, there were 13,500 men on the Detroit factory pay-roll. In the year 1913, 50,448 men left the employ of the company before the adoption of the profit-sharing plan. Last year, only 7512 men left, and of these, 66 per cent had not been with the company for the six months necessary to become profit sharers; hence, the profit-sharing system has largely increased the stability of the working force. Two years ago, the accumulated savings and the property owned by Ford employes amounted to about $18,000,000. At the end of the present year, this sum had increased to about $27,250,000. The company employs nine men in the legal department, which devotes a large share of its time to the interests of the employes. Legal counsel is given free, including advice regarding real estate purchases and investments, to between 150 and 200 employes daily. The medical department employs ten doctors, with twenty-six assistants, giving treatment, surgical and medical, to about 1500 cases a day.

The third year under the profit-sharing plan has been a year of remarkable achievement for the Ford Motor Co. The annual business for the year ending July 31, 1916, was $261,000,000. The standard of 500,000 cars set for production was passed, and during the past winter, the factory has been turning out parts for 3000 cars a day, which are shipped to the various assembling plants, only about forty cars a day being assembled at the factory.

HOURS, FATIGUE, AND HEALTH IN BRITISH MUNITION FACTORIES

According to a recent bulletin issued by the United States Department of Labor, the British Health of Munitions Workers Committee has found that Sunday labor is not profitable and that continuous work is a mistake and does not lead to increased output; that a system of shifts, although impracticable in some cases, is to be preferred to overtime, since the latter taxes the strength of workers too severely, results in loss of time because of exhaustion and sickness, and curtails unduly the period of rest; that night work should be discouraged; that output cannot be maintained at the highest level for any considerable period if the conditions are such as to lead to excessive fatigue and to deterioration in the health of the worker. The committee recommends that the hours should not exceed fifty-six per week for men engaged in very heavy labor, or sixty for men engaged in moderately heavy labor, while sixty-four should be a maximum.

In its report on sickness and injury, the committee says, "To conserve energy and efficiency is, other things being equal, the way to improve output," and recommends the medical examination of all workers before employment. It also suggests that factories should have proper sanitary facilities, safeguarded machinery, arrangements for adequate medical and nurse schemes, etc., and emphasizes the value of first-aid. The committee calls particular attention to the importance of adequate lighting and ventilation, which are absolutely essential for the maintenance of health and comfort, and hence efficiency, of the workers and recommends special measures to prevent undue strain upon eyesight and to reduce the liability of accident to a minimum. Attention is called to the added danger of industrial accidents as follows: "Moreover, at the present time, the introduction of new labor, and of employes unaccustomed to the processes concerned, particularly in conjunction with the need for speed and pressure, overtime and night work, with the consequent fatigue, must inevitably lead to greater risk of accident."

This conclusion corresponds exactly with American experience, as stated in a Safety Bulletin issued by the Utica Mutual Compensation Insurance Corporation, which contained the following:

> The war has caused, indirectly, an enormous increase in the number, severity and cost of industrial accidents, especially during the year 1916. The principal reasons for this large increase of industrial accidents are as follows: the employment of incompetent, unskilled and inefficient labor; the increased pressure for larger output; and the disregard and non-enforcement of safety rules and regulations. During the past few months, the accident rate has been somewhat reduced, because employes have become more accustomed to their work. However, many industrial workers will now enlist to fight for our country, and the services of many skilled workmen will be placed at the disposal of the War Department. To fill their places, employes who are unfamiliar with the work will have to be hired, and women will fill the places of many men called for service. With these changed conditions, there will be even greater necessity for safety measures to prevent accidents.

* * *

The average price of copper for 1916 was slightly over 27 cents a pound, as compared with 17.4 cents in 1915, according to the United States Geological Survey. The year's production, however, surpassed all records. Arizona produced 675,000,000 pounds, as compared with 432,000,000 pounds in 1915; this exceeds the total output of the United States as late as 1902. Montana produced 350,000,000 pounds, about 268,000,000 pounds in 1915 and 314,900,000 pounds in 1912. Michigan's output was about 269,000,000 pounds, and 238,900,000 in 1915. Utah shows an increase of 60,000,000 pounds over the record production of 175,000,000 pounds in 1915. The output from Alaska is estimated at over 120,000,000 pounds; it was 70,600,000 pounds in 1915. Nevada's production reached 100,000,000 pounds, the previous largest output being 85,200,000 pounds in 1913; the output for 1915 was 67,700,000 pounds. The production of New Mexico was 90,000,000 pounds, as compared with 62,800,000 pounds for 1915. California's production exceeded 60,000,000 pounds; in 1915 the production was 37,600,000 pounds. Tennessee's production of 15,000,000 fell slightly below its 1915 production of 18,000,000 pounds.

Machining 9.2-inch High-Explosive Howitzer Shells

by Chester L. Lucas and Victor Brook

THE following illustrations show the manufacture of 9.2-inch high-explosive howitzer shells as carried on by the A. P. Smith Mfg. Co., East Orange, N. J., who successfully completed a large order recently. The operations include not only the machining of the shell proper, but also the machining of the base plug which ultimately becomes an integral part of the completed shell. Starting with the rough forging, the shell goes through the following operations: drilling and facing nose, cutting forging to length, rough-turning straight section, rough-turning nose, rough- and finish reaming, boring and threading nose, finish-turning, cutting band groove, preliminary inspection, copper banding, boring, reaming and turning base end, washing and drying, hand-tapping nose, varnishing and baking, putting in base plug, band turning, weight cutting, polishing, stamping, final inspection and boxing for shipment. In addition to this, the chief operations in the making of the base plug are illustrated. The base plug is eventually screwed into the base end of the shell and the joint made secure by the use of Petman cement, which is placed on the thread of the plug before insertion.

The approximate cost of the different items making up a complete 9.2-inch shell is as follows: shell body, including forging and material, $57; copper band, $5; bursting charge (36 pounds of T. N. T), $21; fuse, $3; propelling charge (60 pounds), $36; percussion tube, $30; freight, $15; making a total of $167 for the shell as delivered through the muzzle of a field howitzer. The howitzer is a short gun, firing a heavy shell at high angles of elevation.

The material for this article consists of representative pictures from a moving picture recently made and produced by MACHINERY entitled "Machining 9.2-inch High-explosive Howitzer Shells." This moving picture is entirely new and marks an advance in industrial educational moving picture films. It was made especially for mechanical men under the direction of mechanical experts. Because of its rare mechanical interest and the timeliness of the subject, MACHINERY considers it a patriotic privilege to offer to show this film gratis before mechanical audiences, and representatives of such bodies are invited to correspond with the Editor of MACHINERY regarding the matter.

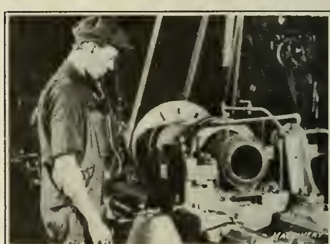
The Completed Shell

Shell and Base Plug Forgings

Drilling and facing Nose

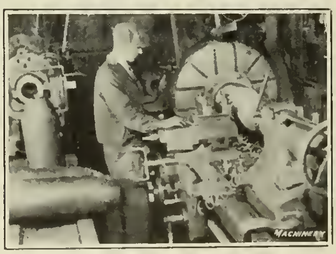
Drilling Nose

Facing Nose



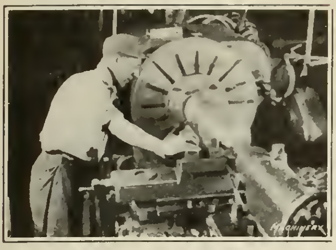
Cutting Forging—

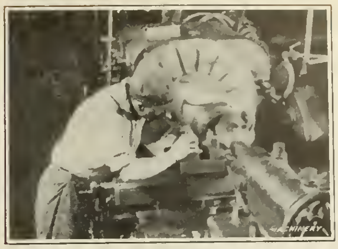
—to Length



Rough-turning Straight Section

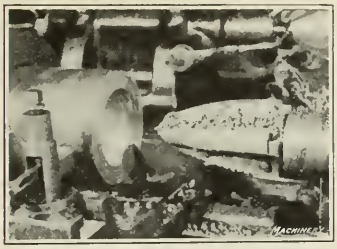
Speed and Feed set at Maximum

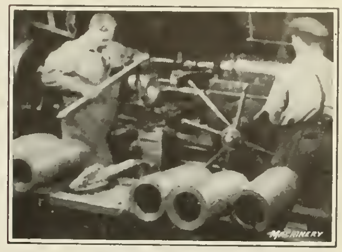

Rough-turning Nose


Gaging Nose

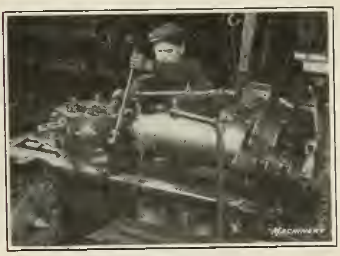

Proceeding at Maximum Speed

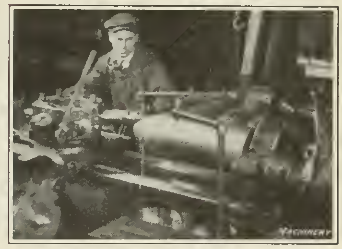

Rough- and Finish-reaming

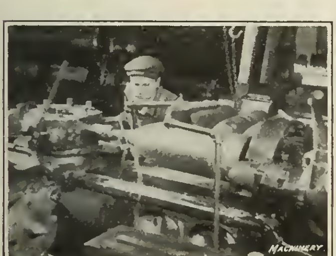

Roughing Reamer, showing Chips


Inspector must O. K. before proceeding


Keeping up the Contour of Reamers

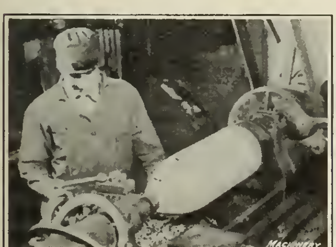

Boring and threading Nose


Bringing Boring Tool into Action


Threading with Collapsing Tap


Inspection of Nose

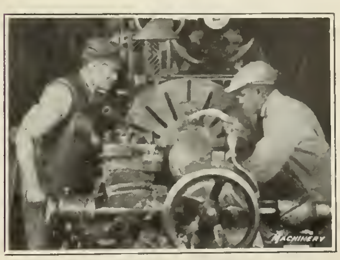

Finish-turning all over


Cam and Follower maintain Shell Contour


Careful inspection after Previous Operation


Cutting Band Groove


Depth of Groove is accurately gaged


Cutting Band Groove requires Two Men


Special Attachment forms Waves

Getting ready for Next Shell

Complete Preliminary Inspection of Shell

Copper-banding Shell

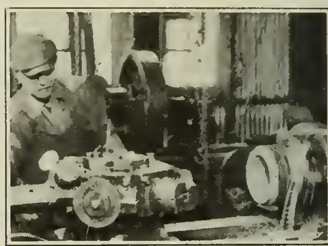
White Hot Band being put into Place

Guiding carefully into Dies on Hammer

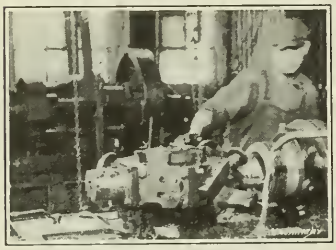
Three Blows well placed are Sufficient

Operation Completed—Ready for Another Shell

Boring, Reaming and Threading Base



Indexing Reamer into Position



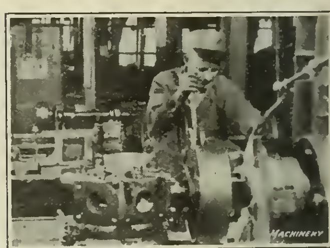
Reversing Spindle to cut Left-hand Thread

Cleaning out Shell for Inspection

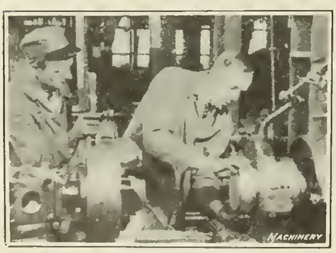
Inspector's Approval Necessary before proceeding

Making Base Plug

Turning and facing Base Plug



Threading Base Plug



Inspecting before removing from Machine

Fitting Base Plug

Applying Prussian Blue to assure fit

Washing and Drying

Shells are given Two Immersions

Hand-tapping Nose

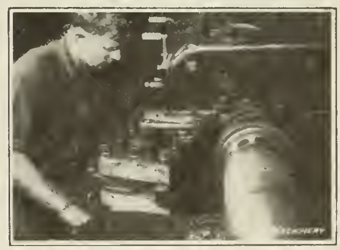
Varnishing and Baking

Shell revolves while Varnish is sprayed

A Truck Load ready to bake

Putting in Base Plug

Band-turning



Band Contour governed by Tool in Rear

Inspector's Careful Check is necessary

Weight Cutting

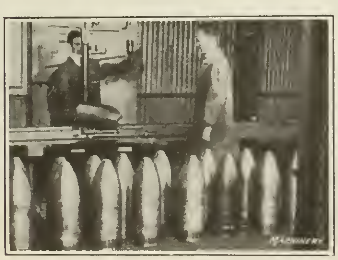
Weight may vary between 250 and 253¾ Pounds

Polishing to remove Rust or Discolorations

Stamping

Final Governmental Inspection

This is a Most Complete Inspection



Among Other Things, the Weight is checked

Boxing for Shipping

INDUSTRIAL APPLICATIONS OF NICHROME

A NICKEL-CHROMIUM ALLOY HAVING CONSIDERABLE STRENGTH AT HIGH TEMPERATURES AND OTHER REMARKABLE PROPERTIES

BY FRANKLIN D. JONES[1]

Fig. 1. Collection of Nichrome Castings, including Carburizing Boxes and Tubes, Dipping Baskets, etc.

WHILE it is possible to obtain a metal or alloy having almost any required physical property at ordinary temperatures, the effect of a decided increase in temperature is often highly injurious. The result may be a reduction of strength, a change of form, or oxidation of the exposed surface. If cast iron, cast steel or structural steel is heated above 400 or 500 degrees F., there will be a reduction of strength which will represent a large percentage of the total strength if the temperature is increased sufficiently. Wrought iron begins to lose its strength at temperatures of about 550 to 600 degrees F., and the strength of copper and bronze is reduced if the temperature exceeds approximately 200 degrees F. In some cases, the strength at an ordinary temperature (say, 70 degrees F.) increases within certain limits, and then higher temperatures cause a rapid reduction of strength. For instance, according to one series of experiments, wrought iron at 570 degrees F. was about 16 per cent stronger than at 70 degrees F., but at a temperature of 1475 degrees F. about 85 per cent of the normal strength at 70 degrees F. was lost. Structural steel gained about 32 per cent at 400 degrees F., but lost 72 per cent at 1000 degrees F. The strength of cast iron remained about constant until the temperature exceeded 500 degrees F., and at 1100 degrees F. it had only 58 per cent of the normal strength. While the figures given are subject to some variation because of differences in the composition of the materials of the same class, they indicate one of the injurious effects produced when the materials mentioned are subjected to relatively high temperatures.

Cast iron that is heated and cooled repeatedly undergoes another well-known change, in that it gradually increases in size. This change of size is known as "growth," and it has been the cause of much trouble, especially in connection with cast-iron annealing furnaces, retorts, grates and other equipment or parts that are alternately heated to relatively high temperatures and cooled. Experiments on a test bar 1 inch square and 14 13/16 inches long showed an expansion of nearly 41 per cent as a result of heating and cooling the bar twenty-seven times, the heating period being one hour and the maximum temperature 1470 degrees F. After these tests, the bar measured 1⅛ inch by 1⅛ inch in section and 16½ inches long. In addition to the growth of cast iron, there is also an increase of weight equivalent to approximately 7 or 8 per cent, due to the absorption of gases.

The injurious effect of oxidation previously mentioned is of especial importance in the case of steel and wrought iron. As is generally known, oxidation occurs when the materials are subjected to dampness or prolonged immersion in water, and it is also the effect of heating, since either moisture or an increase in temperature causes the oxygen of the atmosphere to unite more readily with the iron or steel. The result in the case of moisture is corrosion, whereas oxidation of the heated metal causes a scale to be formed on the surface. This scaling mars a smooth or finished surface, and it may also reduce the size of the part, especially if it must be heated repeatedly, as in the case of annealing and casehardening boxes, etc.

The injurious effects referred to may be avoided in many cases by the use of a nickel-chromium alloy known as "nichrome." This alloy has been used for some time in the manufacture of resistance coils for electrical heating apparatus and rheostats, and the physical properties which adapt it particularly for use in electrical work have proved of practical value in various ways. Nichrome is not injured by oxidation of the exposed surface at high temperatures, and it is very strong even when heated red hot, which makes it possible to use this alloy for many purposes for which other materials could not be employed. When nichrome is subjected to an oxidizing atmosphere of high temperature, a slight film of oxide forms on the surface. This film is strong and durable, and resists the action of alka-

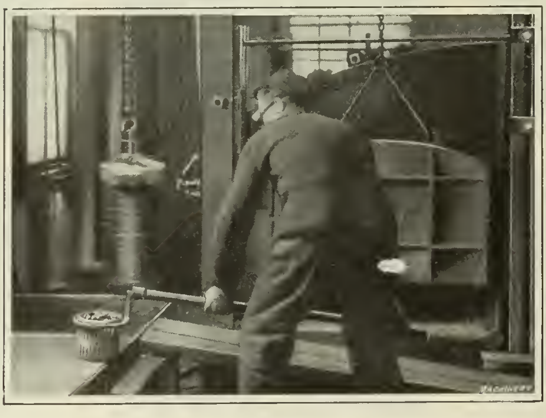


Fig. 2. Use of Nichrome Dipping Basket in Connection with Cyanide Bath

[1]Associate Editor of MACHINERY.

lies and of such acids as sulphuric and hydrochloric acid. The oxide is non-flaking and affords additional protection against corrosion or further oxidation. Another noteworthy characteristic of nichrome, especially as compared with cast iron, is that there is no growth or appreciable change of form as the result of alternate heating and cooling.

Nichrome melts at a temperature of about 2800 degrees F. The strength of a nichrome casting, when cold, varies from 45,000 to 50,000 pounds per square inch. At a temperature of 1800 degrees F., nichrome has a tensile strength of about 30,000 pounds per square inch, and it is tough and will bend considerably before breaking, even when heated red or white hot. In order to demonstrate the remarkable strength of nichrome at high temperatures, a cast nichrome plate, approximately ¾ inch thick, was heated red hot and then struck repeatedly with 20-pound sledges upon the unsupported center of the plate. The result was stubborn resistance and gradual bending.

In general, nichrome is adapted for annealing and carburizing boxes, heating retorts of various kinds, conveyor chains subjected to high temperatures, valves and valve seats of internal combustion engines, molds, plungers and conveyors for use in the working of glass, wire baskets or receptacles of other form that must resist the action of acids, etc. Nichrome is the product of the Driver-Harris Co. of Harrison, N. J., and some of the specific applications of this alloy will be referred to in order to illustrate its possibilities as a substitute for other materials, especially where there is difficulty from oxidation, pitting of surfaces, corrosion, change of form, or lack of strength at high temperatures.

Fig. 1 shows a collection of cast nichrome boxes and circular pots for use in annealing or carburizing, and a few other nichrome parts. Up to the present time the use of nichrome for making annealing and carburizing boxes has proved to be one of its most important applications. Boxes made of this alloy are superior to those of steel, principally because they are much more durable. A steel box must be made quite thick to allow for the reduction of thickness caused by scaling or oxidation each time the box is heated. As there is no appreciable loss with a nichrome box, the walls may be made much thinner, thus increasing the conductivity of heat. The durability of steel boxes as compared with nichrome boxes is indicated by the fact that steel boxes of good grade may be used for about 200 or 250 hours, whereas nichrome boxes, under similar conditions, have been known to last about 6000 hours. While the latter are much more expensive, the difference in cost is more than offset by the superior qualities mentioned.

Fig. 2 illustrates the use of a cast nichrome dipping basket and holder, for immersing small steel parts in a cyanide bath having a temperature of 1700 degrees F. These nichrome baskets (now in use at the Ford plant) are not appreciably affected by the cyanide and do not shrink or lose weight. They are about one hundred times as durable as iron or steel wire baskets.

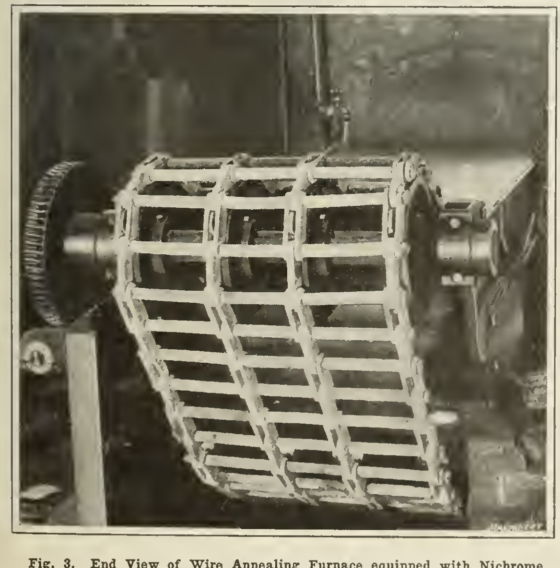


Fig. 3. End View of Wire Annealing Furnace equipped with Nichrome Conveyor Chain

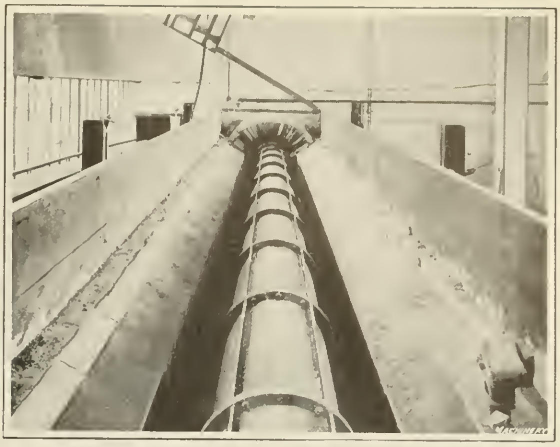


Fig. 4. Nichrome Heating Retort which is kept at a Temperature of about 2000 Degrees F.

Another interesting application of nichrome is shown in Fig. 3, which is the end view of a wire annealing furnace. This furnace has an endless nichrome chain to which the bundles of wire are attached, and as this chain moves along very slowly, the wire is carried through the annealing furnace, which is kept at a temperature of about 1600 degrees F. The ends of the furnace are water-sealed to exclude the atmosphere and prevent oxidation of the heated wire. This repeated heating and cooling would soon destroy a chain made of ordinary materials, but a nichrome chain has proved to be very durable. The heating retort shown in Fig. 4, which is subjected to high temperatures, is made of nichrome and is also equipped with a nichrome conveyor chain.

It has been demonstrated that the use of nichrome valves in internal combustion engines eliminates difficulties due to pitting or warping, so that regrinding to prevent leakage is rarely, if ever, necessary. Nichrome valves are of especial value as substitutes for the water-cooled exhaust valves that are used on some engines, especially of the larger sizes, to prevent injuring the valves as a result of excessive heating.

Molds made of nichrome are particularly useful in the manufacture of glass articles, such as bottles. The molds withstand the high temperatures and abrasion, and produce more highly polished glassware, because they can be subjected to higher temperatures than other materials, without difficulty from the molten glass adhering to the mold surfaces. These nichrome molds also resist the chemical action of the elements in the glass. As the molds are strong while hot, they can be made much lighter than cast-iron molds, and they are also more durable.

Crucibles for melting brass and other alloys may be made of nichrome, but its application for this purpose has not as yet been fully developed. While the heat conductivity of nichrome is low as compared with other alloys or metals, it is much higher than that of the graphite or magnesite used for making crucibles. The nichrome crucibles may also be made thinner than those made of the materials mentioned, so that the contents are brought to the melting point more rapidly. The nichrome does not affect the quality of the molten contents, and alternate heating and cooling does not damage the crucibles.

To what extent molds for castings may be made of nichrome has not as yet been fully determined, but experiments indicate that its peculiar properties may prove of great value in connection with this branch of work. Small cast-iron castings poured in nichrome molds have been soft enough to machine, smooth and of close-grained texture. Experiments are to be made in the use of nichrome molds for making shells, the idea being to produce shells very rapidly by casting them with such accuracy as to eliminate many machining processes.

INCREASING THE USEFULNESS OF ADJUSTABLE PARALLELS

BY HARRY P. SIMMONS[1]

The simple device shown in Fig. 1 has proved a great help in solving the problem of spacing and drilling small holes where close limits on center distances are required. Though it is intended for holes too small to be made by the locating button and boring method, for a large percentage of jig and fixture work holes drilled with this tool and then enlarged to size will easily come within the limits of accuracy required.

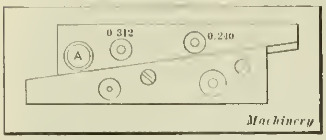


Fig. 1. Adjustable Parallels adapted for Use in drilling Four Sizes of Holes

This device is nothing more than an ordinary Starrett adjustable parallel, with hardened drill-rod bushings inserted in both halves. The bushings are lapped, after insertion, to fit closely drills ranging in size from No. 52 to No. 30. Since the ends of the bushings are flush on both sides, the parallel can be used either side up, and is just as useful for its original purpose as it is without the spacing-jig feature. When the parallel is opened or closed, the relative positions of the holes are naturally changed. With small plugs inserted in a pair of holes in opposite halves of the parallel, it is easy to get the desired center distance with micrometers or vernier calipers. By tightening the screws a solid jig is secured, which may be clamped to the work, and the drilling can be quickly done.

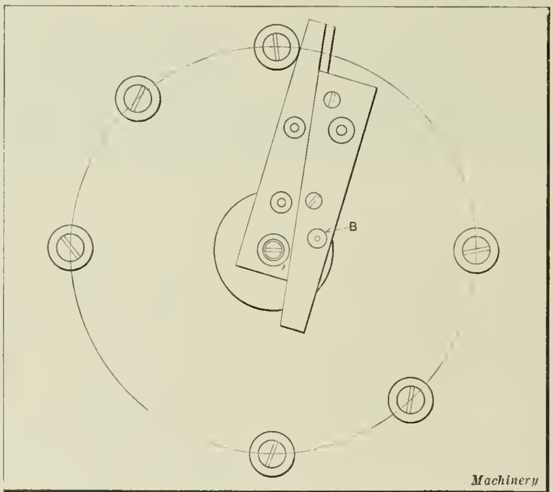


Fig. 2. Use of Parallels for boring Holes in Gear Blanks

In Fig. 1, a bushing *A* with a quarter-inch hole is shown inserted close to one end of the parallel. The bushing is slipped onto a locating button, which is fastened to the work to be drilled by the usual screw, or on a plug set solid in a flat plate, as in Fig. 2. In this case, several 0.063-inch holes were to be drilled on a small radius in gear blanks about 1¼ inch in diameter; the limit of variation was 0.001 inch. Locating buttons were set in a circle around a central plug 0.187 inch in diameter, which was the size of the hole in the gear blanks. It was easy to locate the buttons, getting the required angles between the holes by using the chords of the arcs of the angles between the holes. The parallel was adjusted so that bushing *B* checked the correct distance with the quarter-inch hole in the opposite half of the parallel. A thin bushing was, of course, slipped over the 0.187-inch center plug after the gear blank was in position. The holes were drilled by moving the end of the parallel from one button to the next. The first hole in the blank was drilled through into the plate and a close-fitting pin was inserted to hold the blank in position for the other holes.

Fig. 3 shows the ordinary surface plate with two strips located at right angles along the edges, such as is used by many toolmakers for locating holes in small work with a depth gage against a plug inserted in a small plate clamped to the work to be drilled. The parallel with the bushing will do this work easier and better. The center distance of the holes from the edge of the half of the parallel in which they are inserted should be marked on the parallel. This center distance will, of course, be constant. Then to get the varying distances to the opposite edge as required, it is merely necessary to subtract the constant center distance from the distance from edge to edge, as measured with the micrometer. The parallel should be held on the magnetic chuck of the surface grinder and have the edges nicely trued up before the constant center distances are marked on it.

[1]Address: 1109 Alberta Ave., Dayton, Ohio.

It is an easy matter to fix up a parallel in the manner described; and since they are made in several sizes, all being the same thickness, it is a good idea to have parallels of different sizes arranged with bushings for small drills. It is better to have different sizes of holes, but all should be small—not over No. 30. Any hole larger than this can easily be brought to size afterward. There is no particular location required in drilling the holes in the parallels for the bushings; but care should be taken to get them squarely through the halves, and have them clean and smooth to receive the bushings. The bushings can be inserted in the split half of the parallel with pressure enough to hold them firmly in position and yet not interfere with the sliding action. A second locking screw has been added to the parallels shown, to make sure that there will be no slipping after the proper position is secured with the micrometers.

When drilling small holes, it is well to remember that a small drill works on the same principle as a large one; just because the cutting edge of a small drill cannot be easily seen is no reason for putting it in the chuck and coming down hard on the lever of the drill press. The cutting edge should be examined with a glass and the drill sharpened with a hone. A good speed should be used. In enlarging the small holes to size, the same rule for care holds good. With a properly sharpened drill, correct speed and a fine feed, it is an easy matter to enlarge the holes to the size required, and still keep the center distance within close limits. The operator should always see that the drill is running true and is accurately centered over the work before permitting it to come in contact with the hole to be enlarged.

* * *

The National Advisory Committee for Aeronautics has defined a right-hand engine as one in which the shaft rotates in a clockwise direction when viewed from the output shaft, looking toward the output shaft end.

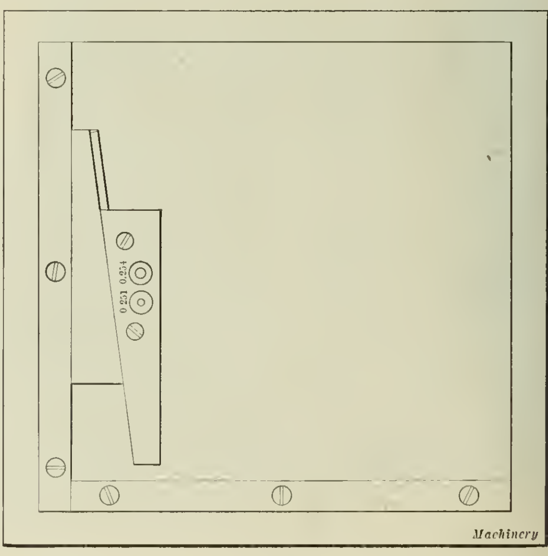


Fig. 3. Using Parallels with Surface Plate for locating Holes in Small Work

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

MAKING A ONE-PIECE BRASS DOOR KNOB

There are two ways of making a one-piece, pressed, brass door knob; the method here shown is that used by a firm in Waterbury, Conn. The blank *A*, Fig. 1, is a simple job of drawing, and the dies are so well known that no description is necessary. The next five blanks *B*, *C*, *D*, *E* and *F* are made with simple tapering dies, but using a punch with a female taper; they need no explanation except that an annealing operation is necessary between each press operation. The dies for the last two blanks *G* and *H* are of the type known as a fluid or water punch; one is shown in Fig. 2. This die is split along the line *AB* and is held in a holder with a heavy, strong wedge clamp *C*. The punch *D* is a plain, straight piece of tool steel, which is tempered, not because it is subject to wear, but to stiffen and strengthen it. This punch fits snugly in the hole in the stem of the blank.

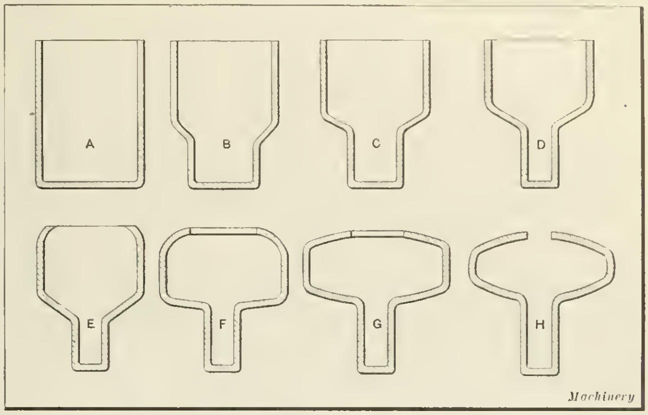


Fig. 3. Alternative Method of making Brass Door Knobs

After the blank *F*, Fig. 1, is placed in the split die, it is filled with water (some prefer oil) and the press is tripped. As the punch *D* enters the stem, it displaces the water, causing it to expand the blank to the shape shown at *G*, Fig. 1. It is possible to swell the blank to the shape shown at *H* in one stroke; but this operation is hard on the clamping fixtures of the dies, and if the metal from which the knob is made is not of the best, the work is likely to rupture. For these reasons blank *F* is pressed into the form *H* in two stages, between which the work is annealed. The operations in both these stages, of course, are the same.

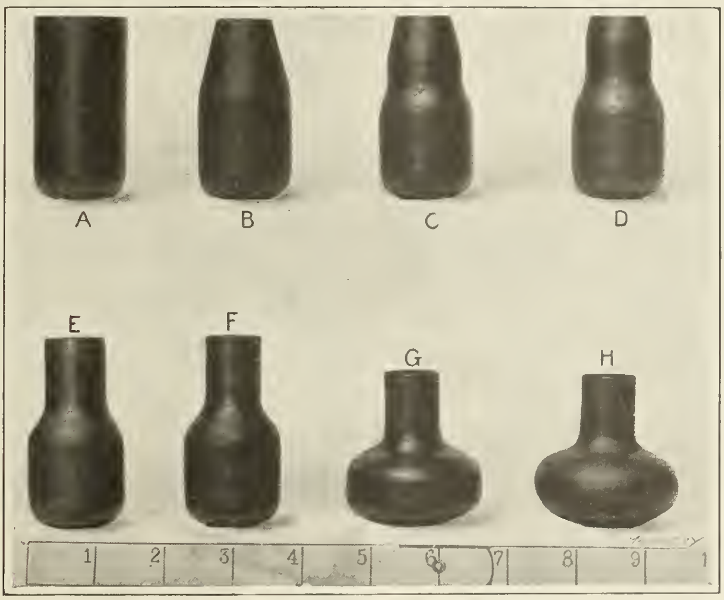


Fig. 1. Steps in making One-piece Brass Door Knob

As the punch descends in the work, some of the fluid is forced out; and as it is under heavy pressure and passes through a small opening, it is likely to be thrown some distance from the press. This trouble and the work of filling each blank are partly avoided by setting the die in a pan that is deep enough to keep the work and die submerged in the fluid. The fluid on the surface retards the upward flow of the water from the work, but does not entirely stop its being thrown about, so a thin brass guard *E*, Fig. 2, is fastened to the punch.

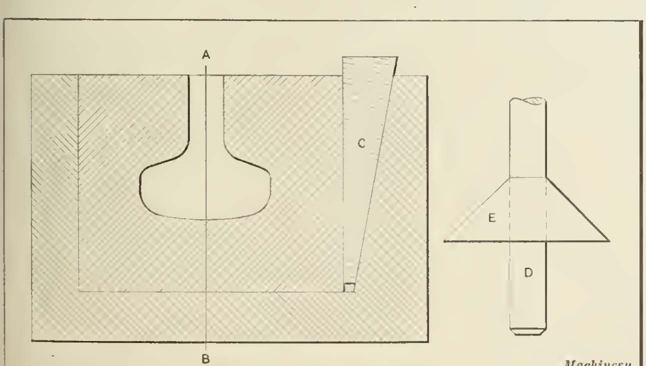


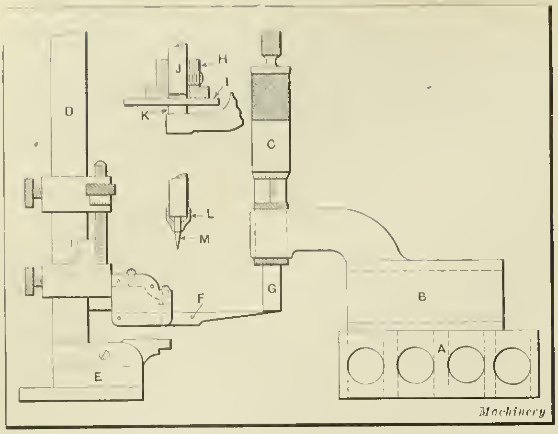
Fig. 2. Dies used for making Door Knobs

A second method of making one-piece, drawn door knobs is shown in Fig. 3. The procedure in this case is somewhat similar to that described, but the reduction in diameter is concentrated on the closed end of the blank until this part is reduced to the desired size for the shank of the knob. Afterward the open end is gradually closed in. It is possible to close the end almost entirely, but it is sometimes left open about 5/8 inch and then turned in the lathe to fit an embossed button, which is soldered or screwed in place.

ROBERT MORRIS

HANDY MICROMETER ACCESSORIES

When a hardened, ground and lapped steel block *A* is used in conjunction with a micrometer *C*, measurements up to 4 inches in height may be taken. This



Handy Micrometer Accessories

block is 1 by 2 by 3 inches, and is perforated as shown to reduce its weight. The micrometer base *B* is 2 inches wide. Parts *A* and *B* were made by a shopmate, who, while suffering from an attack of "farmingitis," sold them to the writer. This tool was so useful to the inspector of gun work at the Sloan & Chace plant that the company had one made especially for his use. The other features shown are of the writer's own design, except *D* which is a Starrett caliper gage. The base *E* of this gage is about 2 inches wide. By means of the detachable point *F*, it is easy to transfer heights from the micrometer spindle *G*; the least contact of the point *F* with the spindle *G* by side motion will move the latter. When used in conjunction with blocks, any height can be found with this gage.

The collar *H* is used for lapping micrometer parts into shape when worn; it is used in conjunction with a flat piece of metal *I*, which must be of uniform thickness. The hole in the collar *H* may be large enough to include the spindle *J* of any micrometer. The collar *H* is fastened to the spindle *J* and then the collar *H*, the piece of metal *I*, and the anvil *K* are brought into contact; the emery or carborundum is on one side only of piece *I*. When the anvil is lapped into shape, piece *I* is reversed and spindle *J* is brought down against it and lapped, anvil *K* acting as a guide.

Parts *L* and *M* require no explanation, being simply attachments to a micrometer for taking point measurements within the limits of a 1-inch "mike." A micrometer with a hole in the anvil would admit of two points at short range. The writer thinks it would be a good idea if some manufacturer would get out a micrometer with a 1- by 1/16-inch stem meeting an adjustable point in the anvil; or with reversible points in the spindle and anvil, each having a square and a pointed end.

Princes Bay, S. I., N. Y. A. H. CLEAVES

PROTECTIVE ELECTROPLATING

The superiority of zinc to other metals as an anti-rust coating for iron and steel is commonly accounted to be due to the fact that zinc is electro-positive to iron. With the exception of cadmium, which is too expensive for general use, all other metals that can be used for commercial protective plating (nickel, copper, brass, etc.) are electro-negative to iron whenever damp penetrates the surface, either by reason of the porosity of the coating or a hole being broken or worn in it. But the superiority of zinc might, on the other hand, be partly due to its being less porous than the other plating metals; to determine this point a series of experiments was recently carried out at the University of Wisconsin.

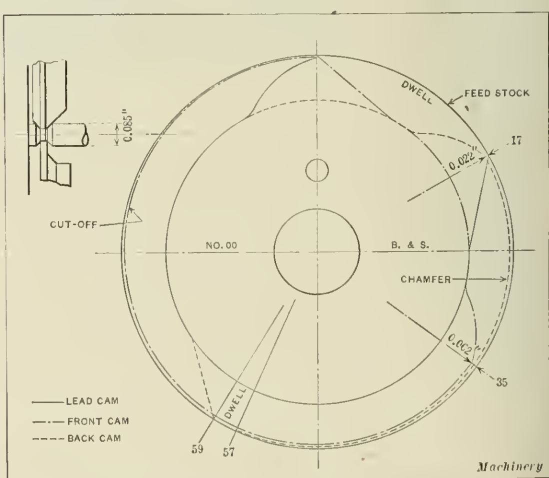
Since it is generally conceded that commercial plating with nickel, copper and brass does not protect iron from rust, it was decided to try much thicker deposits than those usually employed. Heavily plated samples were prepared and subjected to weathering tests. The most striking feature of these tests was the complete protection against rust, during four months of very wet weather, afforded by electro-galvanizing less than 0.0002 inch thick, while rusting occurred through 0.0027 inch deposits of copper, 0.0033 inch of brass, and 0.001 inch of nickel. With thin plating, rusting was serious and widely distributed; but on the thicker deposits, it was confined to a few widely scattered spots. The nickel plate on two samples 0.006 and 0.007 inch in thickness was not only free from rust but appeared as bright as when deposited. The effect of double-plating (a deposit of zinc followed by a deposit of copper or brass) was next investigated, and the samples showed slightly better protection than would be afforded by the same total thickness of brass or copper alone.

The prompt rusting of the iron beneath the thinner deposits of all the metals except zinc seemed to indicate either that such deposits are porous in structure or that there are small holes at certain points that leave the iron exposed. This question was next investigated, and it was concluded that the remarkable protection afforded by very thin deposits of zinc must be due entirely to galvanic action, for thin zinc deposits proved to be as full of holes as were the coatings of other metals. A study of the porosity of electroplating seems to show that deposits of brass 0.00015 inch thick and copper 0.00034 inch thick contain pin-holes. The only hope of a general use of copper and brass plate on iron exposed to the weather seems to lie in securing a uniform deposit free from pin-holes. In special cases it may be feasible to employ the extremely thick deposits of these metals that have been shown to be necessary to protect iron from the weather, but unless the plated article is fairly rigid, there is danger of their cracking and peeling; besides, the time and expense of producing them will prevent their general employment. These experiments confirm the view that the superiority of the electro-galvanizing over deposits of other metals for the protection of iron is due to absence of voltaic action. Deposits of nickel should exceed 0.0015 inch in thickness in order to protect iron out of doors, and copper or brass plate should be three times this thickness. For the protection by electroplating of iron that is to be exposed to the weather, zinc is the only metal that can be used economically.

Liverpool, England MARK MEREDITH

MAKING CHAMFERED PINS

In regard to the improved method of making chamfered pins, described in the January number of MACHINERY, the writer would say that it is unnecessary to come up the second time with the chamfering tool, as this means too great a degree of accuracy in milling the cams and a loss of time. The writer would suggest that the chamfering tool start cutting as soon as the stock is fed out and that the cutting-off tool start a little later, as is shown by the accompanying lay-out of cams. Then as the feed of the cutting-off tool is a little faster than that of the chamfering tool, the former will



Cam Arrangement for making Chamfered Pins

be cutting on the same diameter as the latter when it is through cutting. By this plan the pins will not break off, as the chamfering tool has the same cutting angle. The order of operations is as follows:

Operation	Number of Revolutions of Stock	Hundredths
Feed stock to stop, lead cam	20	17
Chamfer, back-slide cam 0.022 inch stroke, 0.00045 inch feed	50	42
Cut off, front-slide cam 0.062 inch stroke, 0.0008 inch feed	(78)	(65)
Time allowed for cutting off is 0.039 inch stroke at 0.0008 inch feed	49	41
Total	119	100

The spindle speed and surface feet of the stock is the same as in the other method but there is a gain of one second in time, which means quite an item on a quick job. As the time required is only three seconds, the production of 10,800 pins per day of nine hours against 8100 by the other method.

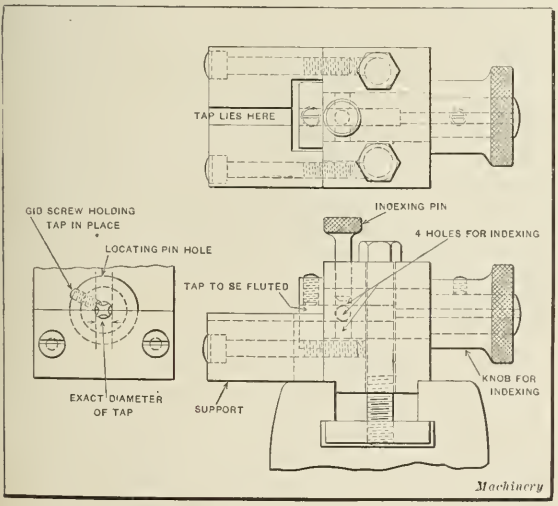
In either case, though, this is only the theoretical production. From this must be deducted the time required to put in each new bar of stock. For instance, a bar of stock is 120 inches long, the length of the piece is 1 inch with ± 0.005 inch limit, the thickness of the cutting tool is 3/64 inch, and 2 inches of each bar is wasted; it is possible, therefore, to average only 111 pieces per bar. As the time required to make one piece is three seconds, it requires 333 seconds to cut up each bar. Figuring on a nine-hour basis, the operator will not put in a new bar of stock in less than one minute, or sixty seconds; therefore, it will take at least 393 seconds to put in a bar of stock and cut it into the required number of pieces. Adding to this the time required for grinding and resetting the tools, the machine will produce approximately 8500 pins in nine hours, or about 22 per cent less than the theoretical production as given above.

Providence, R. I. HARRY G. BROWN

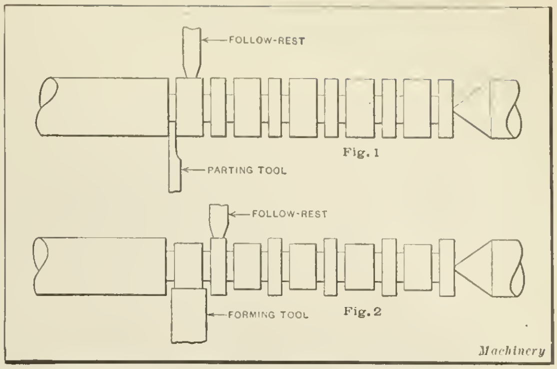
FLUTING ATTACHMENT FOR LATHE

The accompanying illustration shows an attachment for fluting taps in a lathe. The attachment was designed by the writer when it was necessary to flute a number of small taps and it was not convenient to put the work on a milling machine. The semicircular groove in the table is made exactly the diameter of the tap, so when four-fluted taps are being fluted two lands rest on the support. Various sizes of taps can be fluted if bushings are used. While it can be used for three-fluted taps, the attachment is better adapted for four-fluted taps.

Boston, Mass. JOHN A. SHAND



Attachment for fluting Taps in Lathe



Figs. 1 and 2. Advantageous Use of Follow-rest in turning Jig Bushings

USING THE STEADYREST AND FOLLOW-REST

Despite occasional magazine articles on their use, it is apparent to any machine shop man that the steadyrest and follow-rest are not used except when absolutely necessary. They seem to be considered undesirable members that must be kept out of sight as much as possible. The writer was first led to a wider use of the follow-rest by an order to make five or six dozen jig bushings, in two or three sizes. The shop was new and an effort was being made to run before much of the equipment had arrived. The lathe was fitted with a big chuck which had to be shimmed to hold stock smaller than 1¼ inch round, so it was a slow job to feed out and true a bar of stock in the usual way. The writer, therefore, put on the follow-rest and turned up 4 feet of stock to the diameter of the collar on the jig bushings; then, with a parting tool, a series of grooves was cut along the bar, as shown in Fig. 1. The grooves were a little smaller at the bottom than the finished size of the bushing body, which made a neck for the grinding wheel later. Next, with a broad forming tool, the stock was turned out between every other pair of grooves, as shown in Fig. 2. Then the steadyrest was bolted lightly at the left of the lathe carriage, leaving it loose enough so that it could be crowded along with the carriage. The parting tool was set to work to the left of the follow-rest, and the follow-rest jaws were used to steady a drill held in the tailstock in a drill chuck. The bushings were drilled, reamed and countersunk by interchanging tools in the tailstock, and then cut off all nicely necked in for the grinder. A considerable saving could have been made by using special forming tools or holders, but this would have been entirely offset by the cost of making the special devices. Only stock tools and holders were used.

Two steadyrests once got the writer out of a bad fix on a shaft repair. He had been detailed to clean up and put in salable shape a cold-saw machine. While sledging one of the last parts into place, the sledge missed and knocked a small threaded teat off the end of a long drive shaft. As the shaft was longer than any lathe in the shop, the break looked like a bad one. After some pretty hard thinking while taking the shaft out of its bearings, two steadyrests were put on a Hendey lathe, the tailstock removed, and the shaft swung in. Putting the good end on the live center, the shaft was leveled and lined up with a surface gage from the ways, the rest being adjusted farthest from the headstock. Then the jaws of the other rest were set against the shaft, the shaft was turned end for end, a drill chuck was put in place of the live center, and the broken end of the shaft was drilled and tapped, the feeding being accomplished by shoving the carriage against a dog on the shaft. A stud screwed and pinned into the end of the shaft finished the job.

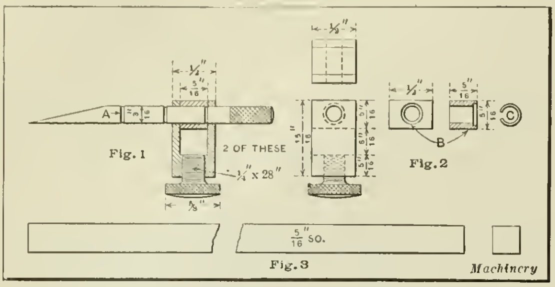
A polishing machine spindle nearly 3 inches in diameter, with a rotor for driving motor in place, was handled in a chuck and two steadyrests, over one-fifth of the shaft extending beyond the lathe. This job was turned end for end when partly done, and called for extreme care, because all work had to be done with reference to the rotor, which was not per-

mitted to run out. This spindle ran 1800 revolutions per minute and swung 20-inch rag wheels. Things had to be pretty nearly right to work well.

Poughkeepsie, N. Y. H. W. JOHNSON

A HANDY TRAMMEL

The trammel here described, which was made by the writer, will be found very handy. One of the trammel points is shown assembled in Fig. 1. The holder, which is ½ inch square, is made of cold-drawn steel. The parts are prevented



Figs. 1 to 3. Construction of Trammel

from falling out when the instrument is being adjusted by a spring *C*, Fig. 2, that fits into the recess *B* and in grooves *A*, Fig. 1, on the beam. Caliper points can also be made if desired. One advantage of this trammel is that as the beam is made of 5/16-inch, square, cold-drawn steel (Fig. 3), it can generally be obtained in any length desired without machining.

S. C.

ASSEMBLING GAS-ENGINE PISTON RINGS

It is sometimes quite a problem to compress and hold piston rings while the piston is being inserted in a gas-engine cylinder. The worst case the writer has met was in a horizontal opposed engine, the pistons of which had to be put in through the crank-case. There was no chamfer at the end of the cylinder bore and the crank-case walls were so close to the pistons that the fingers could not be used to compress the rings so they could enter. After some unsuccessful trials with other methods, the writer wrapped fine wire once around each ring, drawing it tight, so that the ring was compressed to the size of the cylinder. As the piston was pushed into the cylinder, the wire held the rings until they entered the bore, when the wire was cut off.

Poughkeepsie, N. Y. H. W. JOHNSON

MAKING A QUICK REPAIR

The question "How long will it take to make this repair"? is heard in the pattern-shop and in the machine shop every day. In order to make a repair in the shortest time possible, a steel casting is often made to take the place of a hand-forged piece or a piece shaped from a solid bar like a crankshaft. The writer has made quite a few patterns for cast-steel crankshafts to take the place of forged shafts, and these castings have in nearly every case proved quite satisfactory. In Fig. 1 is shown a triple crankshaft for which a new pattern was made, and a steel casting was produced in twelve hours

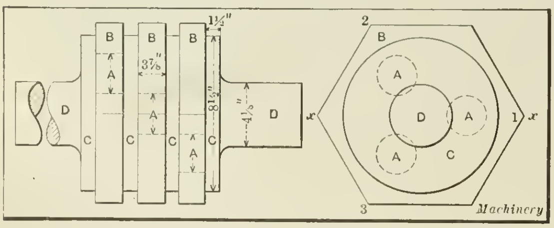


Fig. 1. Pattern of Triple Crankshaft

after the break. Boards for the four disks *C* and the three core-prints *B* were dressed on the planer to exact thickness and cut on the band saw to the correct sizes. These were then assembled and the shafts *D* built on. The pattern was split on the line x–x. A core-box to make the cores *B* was sawed to the exact size on the band saw. The writer had not seen the hexagon core, Fig. 2, used before. The core-box is easily and quickly made and the correct setting of the cores is a simple job. This work must be done accurately, care being taken to cut exactly to the lines marked. The only hand work done on this job was turning the shafts *D*.

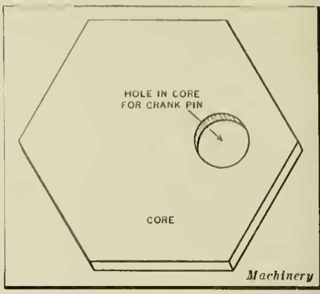


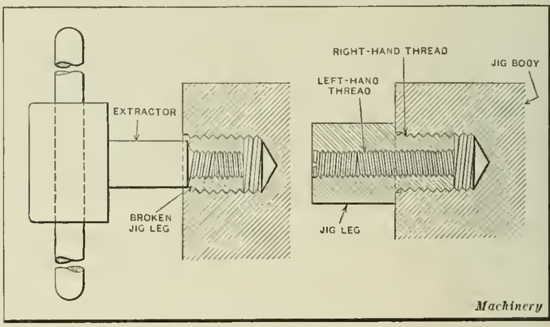
Fig. 2. Core for Triple Crankshaft

Kenosha, Wis. M. E. DUGOAN

EXTRACTING BROKEN JIG LEGS

Some time ago, considerable difficulty was encountered in extracting broken jig legs, and several expensive jigs were practically ruined by locally annealing the broken part of the leg in order to extract it. The jig legs were steel, made glass-hard, except the screw, which was kept as soft as possible; but it is a difficult matter to harden the jig-leg body without hardening the screw to some extent. This is chiefly where the trouble comes in. As the screw is more or less hard, the constant jarring of the legs on the machine table causes them to snap off.

The jig leg here shown was designed to overcome this difficulty. The leg had a 9/16-inch right-hand thread on the outside, and a 1/4-inch hole was drilled vertically through the center. This hole was tapped with a left-hand thread. When the jig legs were screwed into the body of the jig, a special 1/4-inch headless screw was screwed into the leg until it was



Jig Leg and Wrench for extracting it

flush with the bottom of the leg, to prevent chips and dirt from getting into the tapped hole. When a leg broke off, it usually broke near the hole in the jig. A wrench was then screwed into the broken part left in the jig, and when the shoulder of the wrench (which was made smaller in diameter than the leg) came in contact with the broken part, the latter commenced to unscrew. Thus broken jig legs were extracted quickly and easily.

New Haven, Conn. ERIC LEE

THREADING STEEL

The writer read with interest the article by F. E. Metzler in the February number of MACHINERY, on cutting threads. However, he would like to submit what he has been able to accomplish with the 90-degree advance. Although this method has been used mostly in cutting taper threads, it is just as effective on straight work and either internal or external threads.

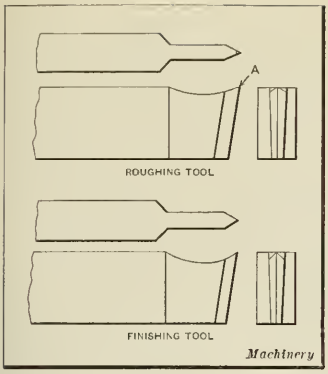


Fig. 1. Roughing and Finishing Threading Tools

The compound rest is set over approximately 30 degrees; the exact angle is immaterial, as the rest is only used to obtain a side movement when setting the finishing tool. The thread is roughed out with the roughing tool shown in Fig. 1. This tool is ground to a sharper angle than 60 degrees, the amount depending on the pitch of the thread to be cut; 50 degrees is correct for an 8-pitch thread in soft steel. The point is also snubbed off, as shown at *A*. With this tool a 7- or 8-pitch thread can be roughed out in two cuts. It will not work well if the second cut is too light; the cut must be heavy enough to keep the chip flowing over the point of the tool so that it will not clog and tear the sides of the thread. The roughing tool for internal work must be ground with as little clearance as possible, so that when the tool springs downward under the force of the cut it will find a bearing on the work and thus be supported. The tool is fed straight in on all cuts.

The thread is finished with the other tool shown in Fig. 1. This tool must have as much rake, or lip, as the nature of the steel will permit. Care must be taken when grinding the tool to the center gage. If the gage is held parallel with the bottom, or shank, of the tool, the thread will not be 60 degrees; nor will it be correct if the gage is held at the same angle as the rake. The tool will be very nearly correct if ground with the gage held about half way between the two. The cuts are taken with the tool fed straight in to the center of the roughed-out thread. The tool will not cut on the point as the first cut is taken, but will act more like a side tool, taking a

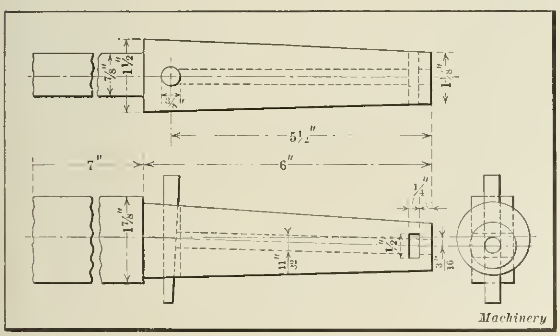


Fig. 2. Threading Bar

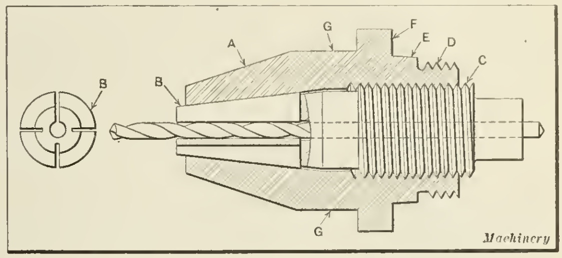
cut from both sides of the thread at the same time. The first cut should be so proportioned that the next one will clean out the bottom and take a light "skim" from both sides. The thread will now be finished, if the roughing cuts were of the proper depth. Three finishing cuts will be found more satisfactory on internal work because of the spring in the tool. If the lathe is stiff enough and the work is flooded with cutting compound, the finishing cuts on soft steel can be taken at a speed of 130 feet per minute. While this method will not do for precision work, it is satisfactory for ordinary commercial work and is very fast. The object is to feed straight in on all cuts, and finish both sides of the thread at once.

In Fig. 2 is shown a threading bar for ¼- by ½-inch tool steel that has the proper balance for good threading. A tool-steel pin inserted in the 11/32-inch hole in the end of the bar, acts in conjunction with the taper pin to hold the tool securely in place.

Los Angeles, Cal. L. J. Bechaud

DRILL CHUCK FOR QUANTITY MANUFACTURING

The accompanying illustration shows a chuck for quantity manufacturing. The body *A* is taper-reamed for the collet *B* and tapped for a screw having a squared end. It is threaded at *D* to suit the spindle of the machine. The thread should be loose enough in the spindle to allow the taper *E* and the shoulder *F* to true the chuck with the spindle. The chuck body is also flattened at *G* for a wrench. The collet *B* must be long enough to hold the drill by the fluted part. It is not feasible to hold a drill by the fluted part in the standard three-jaw



Drill Chuck for Quantity Manufacturing

chucks, as each jaw grips the drill at a point only, but this collet is long enough to grip the drill for at least the length of one helix, and it is held as securely as if held by the shank. As the chuck is threaded on the shank, instead of having a standard taper shank, it may be removed in a limited space. Accurate drilling can be done with the drill held in the manner described.

New Britain, Conn. F. E. Potter

USING THE SLIDE-RULE

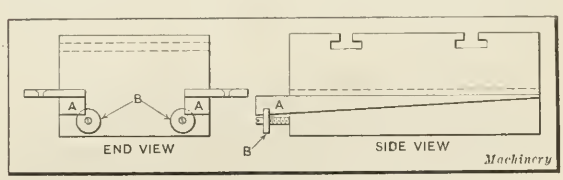
The method of using mixed numbers on the slide-rule that was given in the article "Uses of Slide-rule" in the March number of Machinery is correct, but it requires finding mentally the product of the whole number and the denominator of the fraction. This mental calculation can be avoided by setting the denominator of the fraction on the C scale over 1 on the D scale, and then proceeding as described in that article. Assuming that it is desired to find 2 3/16 on the rule, set 16 on the C scale over the left-hand 1 on the D scale, and then set the rider on the third division on the C scale (corresponding to 35) to the right of 2 on the D scale. It is well to note that this relation holds true regardless of the denomination of the fraction; for instance, if working with feet and inches, it is only necessary to set 12 on the C scale over 1 on the D scale and proceed as before.

Pasadena, Cal. H. L. Doolittle

REPAIRING A CUTTING-OFF TOOL-SLIDE

Although the cutting-off tool-slide of the Gridley multiple-spindle automatic has an adjustment for side play, there is none for wear up and down. The writer, however, has found the following method of repairing these slides very satisfactory: The gib slot in the slide is machined to a taper of one-quarter inch to the foot, and a piece *A* with a corresponding taper is fitted into the slot beneath the gib; this piece is held in place and adjusted by a screw *B*. This method of adjustment, together with the adjustment for side play, gives a rigid cutting-off tool-slide.

York, Pa. Harry F. Fitzkee



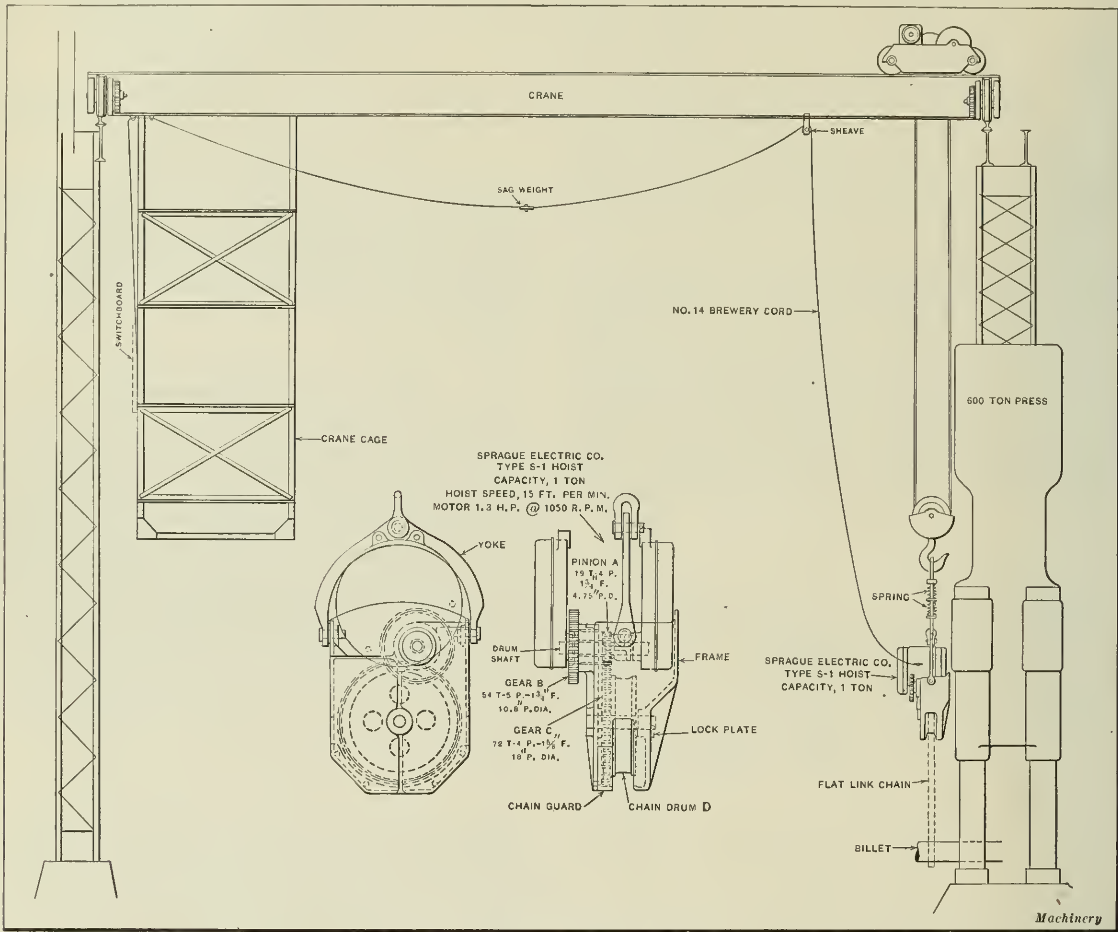
Method of repairing Cutting-off Tool-slide

BILLET TURNING DEVICE

When the sudden demand came for making forgings, some home-made devices had to be used on account of the slow deliveries of market material. The illustration shows an arrangement for turning billets to be forged round under the press. The first plan was to purchase a small motor and make the gears and drum ourselves, but when it was discovered that this required a dynamic brake and controller, which were hard to get in a reasonable time, it was decided to utilize a small one-ton hoist that was not in use, as this had all these requirements combined in one unit.

The cable drum was removed from the shaft and replaced with gear *B* to mesh into the drum-driving pinions of the hoist; gear *B* was keyed to pinion *A* to drive the chain-drum gear *C*. This arrangement gave the proper speed and power in a fairly compact unit, as all were mounted in a casing suspended from the carrying yoke. The crane operator controls this turning device from the cage by means of a switch. The wire is suspended from the crane and arranged in such a manner as to make the line taut at all positions by means of the sag weight, as shown. A flat link chain carries the billet from the drum and rolls it at the operator's will. The large drum contacts give ample resistance against slippage.

South Milwaukee, Wis. L. D. Peik



Crane arranged as Billet Turning Device

A SOCIETY FOR INSPECTORS

Is there a society composed of technical men employed as inspectors? For the past six years the writer has specialized in inspection work; that is, inspecting such work as ordnance materials, automobile parts, machine-shop accessories, and mechanical appliances in general. Since the European War started, he has traveled through different parts of the country, inspecting, mostly, ammunition that was being manufactured by different concerns. This afforded an excellent opportunity to study the different methods, systems and practices in vogue in different shops. After completing the work at one plant, and before proceeding to another, information was generally obtained to the effect that the new place had the facilities of an up-to-date inspection department. But nothing has been found that comes within the meaning of a department devoted exclusively to the inspection of the manufactured product.

It seems strange that so few of the shops and plants visited can say that their inspection department is responsible to the manager for results. Nine cases out of every ten, the inspector is under the supervision of the manufacturing department. Besides, the equipment at the disposal of the men required to keep the product within the limits of acceptance is far from what is actually needed to perform the work in a systematic and efficient manner. The automobile industry, the machine-tool manufacturers, makers of fine tools, and, in fact, nearly all manufacturers have someone who looks after the accuracy and correctness of the finished article. The full value of any inspection department is in proportion to the ability of the men in charge of the department, as well as the equipment and other facilities afforded.

In view of the foregoing, the following questions have suggested themselves: Would an organization composed of men employed as inspectors by different manufacturing concerns have the support of the technical press, engineering societies and manufacturing concerns in general? Would such an organization be of real benefit to the engineering profession as a whole? If such an organization or society were formed, say,

for instance, on the lines of the other engineering societies, would it be possible to secure a membership large and strong enough to warrant its inception?

It would seem to the writer that a society composed of men who test and inspect raw materials, materials in process of manufacture, or the finished article used by the mechanical or engineering professions, that would hold periodical meetings in which it would plan, discuss and adopt standards, methods and systems for doing the work in an economical and efficient manner, educate its members, distribute literature and otherwise further its existence to the best possible interest of engineering and manufacturing would be of inestimable value to the technical world at large.

Woburn, Mass. RUSSELL R. UX

HEALTH INSURANCE

In the December number of MACHINERY, under the title "Health Insurance," Frank F. Dresser presents a plausible argument against health insurance. But to one who has gone more deeply into the subject, it is evident that he has given only a partial presentation. Mr. Dresser evidently fears that health insurance does not improve the public health, and to support this he refers to the fact that the cost of German health insurance has increased since its inception in 1884, that the days of sickness have increased and the duration of illness has lengthened. But he does not state that in the thirty odd years under review, the period for which cash benefits were payable was increased from thirteen to twenty-six weeks, and maternity benefits from four to six weeks; that the basic wage on which cash benefits are computed was raised; and finally, that the total expenditure for medical care had increased seven-fold. That is to say, illness was being cared for more adequately and an increased expenditure was to be expected.

Moreover, figures of this kind drawn from statistics of compensated illness must be used with caution. Such statistics, in the words of Louis I. Dublin, the statistician of the Metropolitan Life Insurance Co., "are largely affected by administrative rulings, and do not always give a true picture of the conditions with which they deal. We are therefore compelled in a measure, to use the facts of death as an index of sickness, realizing that there are limitations to our inferences." The mortality statistics indicate that the health in Germany has been materially improved, for not only has the general death rate been greatly reduced, but the diminution is due in part to the decreasing death rates in the middle age, or wage-earning age, groups. Moreover, this decreasing death rate for adults in the middle-age groups is a marked contrast to the tendency in this country. For example, in Prussia the death rates among males in the age group from forty to fifty have decreased by 25 per cent in the years between 1875 and 1910; in the United States, on the contrary, mortality rates for males and females between 1880 and 1900 increased in the age group from forty to forty-four by 21 per cent, and in the age group from forty-five to fifty by 22 per cent.

To emphasize the part that social insurance may play in creating sickness, the article states, on the authority of a German investigator, Dr. Ludwig Bernhard, that "before the statute, twenty to forty days were sufficient to heal a fractured collar bone," and that "doctors have had to revise that estimate, since it now takes about eight months." This information is taken from an article by Dr. Paul Dittmer of the Convalescent Hospital, Hanover, Prussia, in which Dr. Dittmer was neither referring to nor casting any reflection upon Germany's social insurance. If Mr. Dresser had gone to the original source, he would have found that Dr. Dittmer was not comparing practice under the insurance with practice either before or after its adoption. Instead, his aim was merely to show the discrepancy between prognoses based upon the time in which the union of a fractured collar bone is medically complete and the time in which a laborer is again able to do heavy work. Dr. Bernhard, by taking Dr. Dittmer's fourteen cases from their context and by omitting his significant statement that "the great difference in estimating the period of healing finds its explanation in the different conceptions as to what constitutes a complete healing," has given Dr. Dittmer's account an interpretation never intended by him.

Since the statement was made that the cost of health insurance is problematical, more light has been shed upon this matter by the reports of the California and Massachusetts Social Insurance Commissions. The California Commission of Social Insurance, with Dr. I. M. Rubinow as consulting actuary, on the basis of six months' intensive study, has come to the conclusion that the cost in California would be 3 1/3 per cent of the wages. In Massachusetts, the cost would be about the same, since there the conditions do not vary enough to substantially influence this figure. The cost of health insurance in Massachusetts, according to Mr. Dresser's estimate, would be about $23,000,000 annually. Of this, the wage-earner would contribute approximately $9,000,000, the employers $9,000,000, and the state about $5,000,000. These figures, large as they are, become less terrifying when we realize that in Massachusetts the workingmen and women pay annually over $12,000,000 to four industrial insurance companies for burial benefits for themselves or their families, and of this sum, only $4,000,000 is returned in funeral benefits. Health insurance would make an important saving in this item of expense.

Health insurance will impose no new burden upon the community, for at the present time it is already bearing the cost of caring for sickness and for the dependency resulting therefrom. The Massachusetts Social Insurance Commission estimates that important savings will be effected in these items. For example, it estimates that out of $12,000,0000 annually spent by the Massachusetts State Board of Charities, at least one-half is expended for sickness under conditions that would be met wholly or in part by the proposed health insurance.

The conclusion of the California Social Insurance Commission is that, "health insurance offers a sensible, practical method of eliminating in part the most distressing features of the present social system, economic dependency and charitable relief. Health insurance would distribute a burden which now means hardship, suffering, and lavish public expenditure, in such a way that it would be a burden no longer."

New York City OLGA S. HALSEY

SHIFTING BELTS ON MOVING PULLEYS

Never shift a belt onto a moving pulley by the old-fashioned method of throwing it with a broomstick or even with a belt pole with a steel pin in the end. If the belt is narrow, that is, up to four or five inches wide, there is a "safety first" belt stick end with three rollers which will enable the operator to throw a belt on or off a moving pulley without danger. Under no circumstances should a belt be put on a pulley by a workman climbing a ladder and throwing it by hand. If the belt is too large to be shifted by means of the "safety first" belt stick, the best method is to stop the power or run very slowly. The belt stick ends are manufactured by two or three concerns. The purchaser should choose the one that is made sufficiently strong and is correctly designed for his work. By enforcing the rule to use them, the manufacturers will avoid many distressing accidents.

Bridgeport, Conn. THOMAS FISH

PAINTING CASTINGS BEFORE MACHINING

Shops depending on foundries without a sandblast equipment usually have to do more or less cleaning on the larger castings. Such castings as machine beds, frames, pedestals, etc., having inside faces that are to be left rough are likely not to be cleaned on the inside—and it really makes very little difference on the finished machine. But when the boring-mill or planer hand gets a cut going on these, the sand begins to loosen with the vibration, and no matter how often he turns the casting, he is troubled with the film of dust that works loose. These faces that shed the dust are ultimately given a coat of cheap paint, so if this paint is put on in the first place and allowed to harden for a couple of days, it will hold all the sand that was not jarred loose at the foundry, and the machine hands will keep cleaner and do better work.

Middletown, N. Y. DONALD HAMPSON

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

SOLVING AFFECTED QUADRATIC EQUATIONS

F. H. A.—When the coefficient of x^2 in an affected quadratic equation is not 1, is it necessary to divide through by it before completing the square? Is there not some way of avoiding the two divisions?

A.—One of the divisions may be changed into multiplication when the following method is used, which is, in general, much easier than the regular method, and the results are likely to be more accurate. Let the equation be $ax^2 + bx = c$;

$$\text{then, } x = \frac{-b \pm \sqrt{b^2 + 4ac}}{2a} = \frac{-b \pm \sqrt{b^2 + 4c}}{2a}, \text{ when } a = 1.$$

The first value for x is obtained as follows: Multiplying the terms of the given equation by $4a$, $4a^2x^2 + 4abx = 4ac$; adding b^2 to both members, which does not change the equality, $4a^2x^2 + 4abx + b^2 = b^2 + 4ac$. The left-hand member is now a perfect square; hence, extracting the square root of both members, $2ax + b = \pm\sqrt{b^2 + 4ac}$, or $x = \dfrac{-b \pm \sqrt{b^2 + 4ac}}{2a}$.

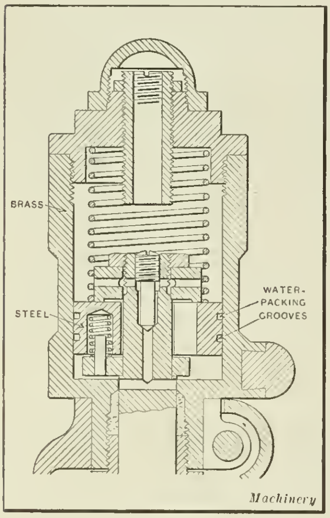
As an example, find x in the equation $2.15x^2 - 9.63x = 20.75$. Substituting in the foregoing expression for x:

$$x = \frac{-(-9.63) \pm \sqrt{9.63^2 + 4 \times 2.15 \times 20.75}}{2 \times 2.15} = 6.0692 + \text{ or } -1.5902 -.$$

J. J.

WATER-PACKING GROOVES

J. B. L.—The accompanying illustration shows part of the oil or regulating chamber of a valve. The piston is grooved, and I would like to obtain information on the theory of action of these grooves in the pistons of dash-pots and other apparatus. What do the grooves accomplish and what are the preferable dimensions for grooves in dash-pots?



Dash-pot with "Water-packed" Piston

A. — The pistons of dash-pots and similar apparatus that must move with a minimum of frictional resistance are commonly grooved, as shown in the illustration, to reduce the slip or leakage of liquid past the piston. The grooves are commonly called "water-packing" grooves, because water, oil or other liquid under pressure accumulates in the grooves, and by capillary attraction and the setting up of eddy currents materially reduces the leakage of the fluid without causing much frictional resistance. No data are available on the sizes of water-packing grooves, but in general it may be stated that grooves about 1/16 inch wide and 1/16 inch deep are commonly used. Smaller grooves than this are likely to fill up with gum and dirt and become inoperative, while larger ones are not so effective.

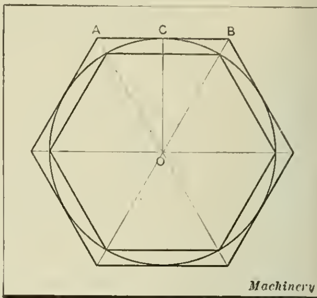
RATIO BETWEEN CIRCUMFERENCE AND DIAMETER OF CIRCLE

D. C. F.—Will you kindly explain the derivation of π, or 3.1416? What I should like to know, if possible, is how it was originally derived.

A.—The first person to calculate the value of π by a purely mathematical process was Archimedes (287-212 B.C.). Before the invention of the calculus (less than 300 years ago), it was customary to use the method of exhaustions in connection with problems that could not be solved by ordinary means, and this was the method used by Archimedes. Referring to the illustration, a regular polygon is shown inscribed in and a similar one circumscribed about a circle. It is evident that if the number of sides of both polygons is doubled, the difference in their areas will be diminished, and the areas of the polygons will more nearly equal that of the circle. If this doubling is continued indefinitely, the area between the polygons will be exhausted, and the area of the polygons will finally become, as nearly as we please, equal to that of the circle; at the same time, the perimeters will approach the periphery of the circle. This was the method used by Archimedes. Starting with a polygon of six sides, he doubled until he had reached a polygon of ninety-six sides. Taking the diameter of the circle as 1, the perimeter of a regular inscribed hexagon is 3 and of a similar circumscribed hexagon is $2\sqrt{3}$, since AC = tan 30 degrees $= 1/3\sqrt{3}$. Denoting the perimeter of the regular circumscribed polygon by P, and of one having twice as many sides by P_1, and letting p and p_1 represent the perimeters of similar inscribed polygons, it is proved in geometry that

$$P_1 = \frac{2pP}{p + P}, \text{ and } p_1 = \sqrt{pP_1}.$$ By means of these two formulas, the perimeters of polygons of twelve sides are calculated; then they are applied again to polygons of twenty-four sides, to forty-eight sides, to ninety-six sides, etc. The values given in the following table were obtained by using a table of logarithms. Archimedes proved that the value of π was less than 3 1/7 and greater than 3 10/71. By using a greater number of decimal places and extending the number of sides to 12,288, P, p and π will agree to seven places of decimals. By means of infinite series, modern calculators have computed π to 730 decimal places and have proved that it is incommensurable and transcendental.

J. J.



Original Method of calculating Value of π

PERIMETERS OF POLYGONS

Number of Sides	P	p
6	3.46410	3.00000
12	3.21539	3.10584
24	3.15965	3.13262
48	3.14608	3.13934
96	3.14271	3.14103

Machinery

HYPERBOLIC LOGARITHMS

G. N. E.—In MACHINERY'S HANDBOOK there is a table of hyperbolic logarithms; how can I find the logarithm of numbers less than 1 and, also, of numbers greater than 10?

A.—As $\log a = \log \dfrac{ac}{c} = \log ac - \log c$, when the number is less than 1, multiply it by some convenient number, preferably 10 or some power of 10, that will make the product come between 1 and 10; find the logarithm of the product by means

of the table, and then subtract the logarithm of the number used as a multiplier. For example, $\log_e 0.7854 = \log_e 7.854 - \log_e 10 = 2.0610 - 2.3026 = -0.2416 = 1.7584$. If the number is greater than 10, $\log a = \log\left(\frac{ac}{c}\right) = \log\frac{a}{c} + \log c$; hence, divide the number by some number, preferably 10 or a power of 10, that will make the quotient come between 1 and 10; find the logarithm of the quotient by means of the table, and then add the logarithm of the number used as a divisor. For example, $\log_e 217.64 = \log_e \frac{217.64}{100} + \log_e 100 = \log_e 2.1764 + \log 100 = 0.7776 + 4.6052 = 5.3828$. It is not advisable to use the table for finding the logarithms of numbers between 10 and 100 by interpolation, as second differences will usually be necessary, and the method here given is much easier and, in general, more accurate. The hyperbolic logarithm of any power of 10 may be found by multiplying 2.302585 by the exponent. Thus $\log_e 10{,}000 = \log_e 10^4 = 2.302585 \times 4 = 9.21034$.

J. J.

A PROBLEM IN GEARING

F. A. N.—In the accompanying illustration, the circles represent the pitch circles of gears, the diameters being as follows: gear *A*, 3.382 inches; gear *E*, 0.441 inch; gear *B*, 1.650 inch; gear *C*, 0.322 inch. The angle $FMD = \phi$ may be any angle, but in this case it is 45 degrees. Please show how to calculate the distances *MD*, *DI*, *JP* and *PI*, *ND* and *JI* being perpendicular to *MD*, *ND* perpendicular to *MD*, and *RS* tangent to gears *A* and *E*.

A.—Draw *PL* parallel to *MD*. Since *RS* is perpendicular to *MN*, angle $LHG = FMD = \phi$. Angle $LKP = LHG + GFP = \phi + 14\frac{1}{2}$ degrees $= \phi + 14$ degrees, 30 minutes, and angle $KPL = 90$ degrees $- (\phi + 14$ degrees, 30 minutes$) = 75$ degrees, 30 minutes $- \phi$. Hence, when ϕ is known angle *KPL* is known. Angle $PFN = 90$ degrees $- 14$ degrees, 30 minutes $= 75$ degrees, 30 minutes; $NF = 0.441 \div 2 = 0.2205$ inch; $NP = (1.650 + 0.322) \div 2 = 0.986$ inch; hence, in the triangle *PFN*, one angle and two sides are known, and the angle *NPF* can be found. Angle $NPL = NPF + KPL$, and as *NP* is known, *NL* (= *JP*) and *LP* (= *DI*) are readily calculated. $MN = (3.382 + 0.441) \div 2 = 1.9115$ inch, and since the angle ϕ is known, *MD* and *ND* are readily calculated. $PI = ND - NL$. In the present case, $\phi = 45$ degrees; consequently, from the foregoing, angle $KPL = 75$ degrees, 30 minutes $- 45$ degrees $= 30$ degrees, 30 minutes. In triangle *PFN*, $\sin NPF = \frac{NF}{NP} \times \sin PFN = \frac{0.2205}{0.986} \times \sin 75$ degrees, 30 minutes $= 0.21651$; from which angle $NPF = 12$ degrees, 30 minutes, 14 seconds, and angle $NPL = 30$ degrees, 30 minutes $+ 12$ degrees, 30 minutes, 14 seconds $= 43$ degrees, 14 seconds. $NL = NP \times \sin NPL = 0.986 \times \sin 43$ degrees, 14 seconds $= 0.67250$ inch. $LP = 0.986 \times \cos 43$ degrees, 14 seconds $= 0.72107$ inch. $MD = 1.9115 \times \cos 45$ degrees $= 1.3516$ inch. $ND = 1.9115 \times \sin 45$ degrees $= 1.3516$ inch. Finally, $LD = PI = 1.3516 - 0.6725 = 0.6791$ inch.

J. J.

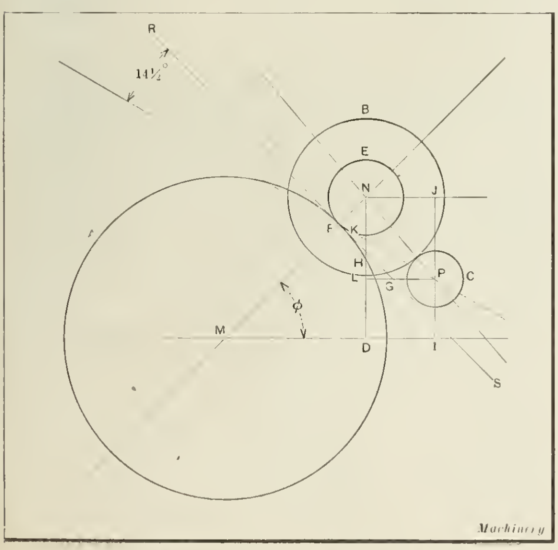


Diagram illustrating a Problem in Gearing

COMPOSITION AND USE OF GUN-METAL

O. G.—What is gun-metal, and for what purpose is it used?

A. Gun-metal or gun-bronze consists of about 90 per cent of copper and 10 per cent of tin with small percentages of lead, iron and zinc. The composition called for by the United States Navy specifications is: Copper, from 87 to 89 per cent; tin, from 9 to 11 per cent; zinc, from 1 to 3 per cent; iron, not exceeding 0.06 per cent; and lead, not exceeding 0.2 per cent. The mixture formed of copper, 88 per cent; tin, 10 per cent; and zinc, 2 per cent, is variously known as "zinc bronze," "Admiralty metal," "government-bronze," and "88-10-2 alloy," although these terms are also frequently applied to all gun-metals. The castings made from gun-bronze are improved by the addition of a small amount of zinc, and the alloy is made harder by the presence of a small percentage of iron, while the small percentage of lead present makes an alloy that is more easily machined. The tensile strength of gun-bronze is from 25,000 to 35,000 pounds per square inch. The United States Navy specifications require a minimum tensile strength of 30,000 pounds per square inch. The elastic limit varies from about 15,000 to 17,000 pounds per square inch, and the metal withstands severe shocks without fracture. The minimum elongation should be about 15 per cent in two inches. Gun-metal is used as a bearing metal and for a great many other purposes, such as valves, valve seats, flanged pipe fittings, etc., where exposed to the action of the sea water.

The following compositions of gun-metal are used in British practice:

1. Copper, 88 per cent; tin, 10 per cent; zinc, 2 per cent. This alloy is known as "Admiralty steam metal." The alloy should have a tensile strength of not less than 22,000 pounds per square inch, and an elongation of 7.5 per cent in two inches. Sometimes this mixture will have a tensile strength up to 32,000 pounds per square inch with an elongation of 14 per cent.

2. Copper, 88 per cent; tin, 11 per cent; zinc, 1 per cent. This alloy is also used for naval work.

3. Copper, 87 per cent; tin, 8 per cent; zinc, 5 per cent. This alloy is used for propeller castings.

4. Copper, 87.5 per cent; tin, 6.25 per cent; zinc, 6.25 per cent. This alloy is used for bolts and has a tensile strength of 30,000 pounds per square inch, with an elongation of about 23 per cent in ten inches when cast in dry sand.

5. Copper, 84 per cent; tin, 12 per cent; zinc, 4 per cent. This mixture is used as a bearing metal for marine work.

The ductility of gun-metal castings is increased by heating them in a muffle furnace to from 1100 to 1500 degrees F., for about thirty minutes, and then cooling them slowly; frequently the castings are quenched in water.

STRENGTH OF BLANKING-DIE HOLDER

G. McI.—Fig. 1 shows a design proposed for a block or holder for a blanking die. The die proper is made in two parts, the split being on the line *A*—*B*. Can you give me a formula for similar constructions to determine the thickness of metal around the die at *T* and *t* necessary to support the die on the sides and to bridge over the gap in the frame? The material to be blanked in the present case is 0.40 to 0.50 carbon steel, ⅜ inch thick, but I would like a formula applicable to other forms and thicknesses.

Answered by John S. Myers, Philadelphia, Pa.

The proportions of such constructions are generally based on experience of similar cases, rather than on mathematical analysis. On account of the uncertainties involved, precise treatment seems impracticable. The method of procedure is to make a drawing of such size as judgment dictates and then apply some rough-and-ready analyses for strength based on

fairly reasonable assumptions. Such a treatment of the problem submitted follows:

Let C = circumference or perimeter of blank to be sheared;
t = thickness of stock;
S = ultimate shearing strength of stock;
P = power or load on punch required to shear out blank.

Then:

$$P = CtS, \text{ approximately} \qquad (1)$$

For the present case, $C = 26.17$ inches, $t = 0.375$ inch, and assume $S = 65{,}000$ pounds. Then $P = 26.17 \times 0.375 \times 65{,}000 = 638{,}000$; say, 640,000 pounds.

Now, under the action of a punch, the natural line of failure due to shear is along oblique lines, such as AB and CD, Fig. 2. This is indicated by the form of punchings from heavy plates. The die, however, restrains the plate on the under side and compels ultimate failure to take place along lines having less obliquity, as EM and GH, Fig. 3. The perpendicular force P may thus be considered to have some resultant direction, such as JL and JK, where it acts upon the die, giving a component F that represents the outward thrust or crowding action upon the die. Assuming the angle α to be in the neighborhood of 18 degrees, we may take this total crowding action as approximately:

$$F = 1/3 P \qquad (2)$$

Then $F = 1/3 \times 640{,}000 = 213{,}000$ pounds.

The amount of this action on each side of the die may be taken in the proportion of the projected length of the blank to its total circumference C. Then the crowding force F in Fig. 4 is $F = \frac{11.375}{26.17} \times 213{,}000 = 92{,}600$ pounds. The shearing stress on a section of the holder, such as at A–A, Fig. 4, is then $S_s = \frac{F}{tb} = \frac{92{,}600}{2.5 \times 14} = 2640$ pounds per square inch. The bending moment upon this section is $M = Fl = 92{,}600 \times 1.625 = 150{,}000$ inch-pounds. The section modulus is $Z = \frac{bt^2}{6} = \frac{14 \times 2.5^2}{6} = 14.58$. The bending stress is then $S_b = \frac{M}{Z} = \frac{150{,}000}{14.58} = 10{,}300$ pounds per square inch.

In Fig. 5, the area in shear on section B–B, for the entire block, is $A = 3.25 \times 37.25 = 121$ square inches. The shearing stress is then $S_s = \frac{P}{A} = \frac{640{,}000}{121} = 5290$ pounds per square inch. The bending moment on this section, taken on the total periphery of the die, is approximately $M = 640{,}000 \times 1.75 = 1{,}120{,}000$ inch-pounds. The section modulus is $Z = \frac{37.25 \times 3.25^2}{6} = 65.6$. The bending stress is then $S_b = \frac{1{,}120{,}000}{65.5} = 17{,}070$. This seems high, and it indicates that the holder might with advantage be made thicker underneath the die; however, failure may not occur here, as part of this bending may be sustained by the die itself.

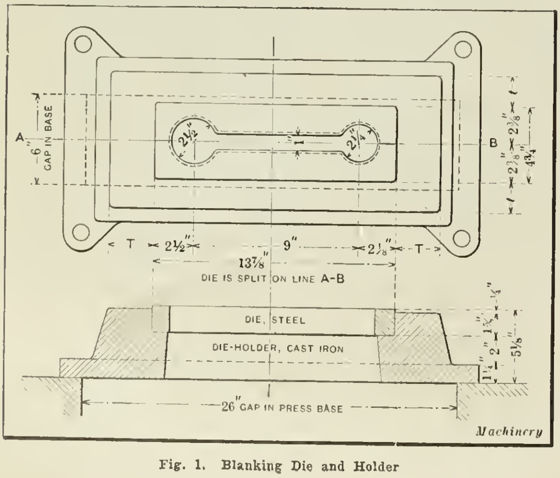
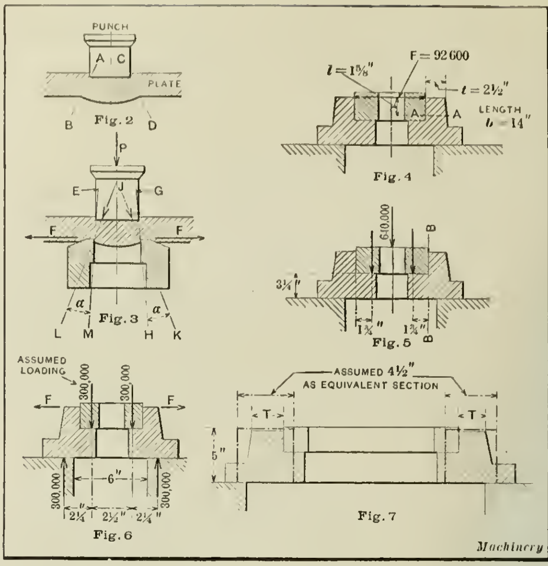


Fig. 1. Blanking Die and Holder



Figs. 2 to 7. Diagrams used in determining Strength of Die-holder

For the thickness of metal on the ends at T, Fig. 6 indicates an assumed loading as a beam from which the bending moment is $300{,}000 \times 2.25 = 675{,}000$ inch-pounds. Fig. 7 indicates the section sustaining this bending as being approximately equivalent to a rectangular section 9 inches wide by 5 inches deep. The section modulus is then $\frac{9 \times 5^2}{6} = 37.5$, and the bending stress is $S_b = \frac{675{,}000}{37.5} = 18{,}000$ pounds per square inch. Actually, the crowding components F develop a bending moment that opposes this, thus reducing the stress. The actual value of this force F is, however, largely a matter of conjecture, Formula (2) arbitrarily assuming a value which was considered to be high enough for safety when this force F acts as a bursting force. In the present instance, it is probably best to neglect this crowding action. As stated, the designer must rely largely upon judgment and experience in such cases, but the foregoing shows, in a general way, how such constructions may be roughly checked for strength.

* * *

TASK-AND-BONUS SYSTEM IN ENGINEERING EDUCATION

At the College of Engineering of the University of Minnesota a new educational experiment is being tried in the application of the task-and-bonus plan to the departments of shop work and design. Every job given to a student carries with it the time allowed, which is estimated on a fair basis. Any time saved by the student is given to him as a credit by means of which his time in college may be shortened, if he accumulates a sufficient amount. It is assumed that the best men can save one-third of the time; and, on the other hand, if they prefer to do more work and not use the credit in reducing the time spent on the subject, they can get one-third more value out of the course. Prof. J. J. Flather reports that the system is working well both in the shop and drafting-room, and that all the instructors are enthusiastic in its application. The output per individual is at least 25 per cent and in some cases 50 or 60 per cent more than was the average before the scheme went into effect. There is an increased enthusiasm on the part of the men; their ambition is stimulated, and no drop in the quality of the work has been apparent. In fact, there is a strong tendency to maintain a high standard, because additional credit is given for superior work, and an extraordinarily good man may earn one-third bonus for quality in addition to the bonus he may earn for quantity.

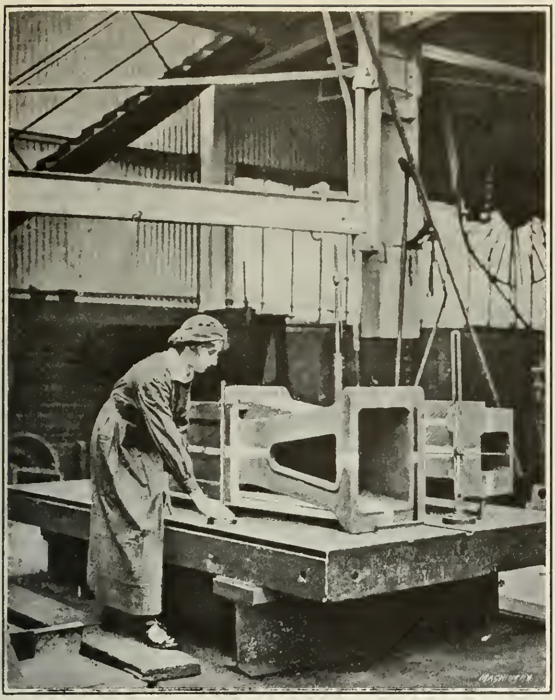


Fig. 1. Marking off Columns of Reciprocating Engine with Surface Gage

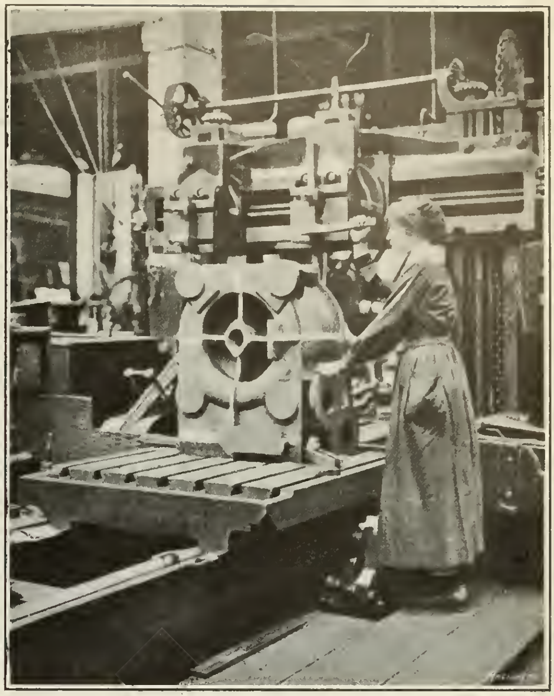


Fig. 2. Planing a Cylinder

WOMEN WAR MUNITIONS WORKERS

One of the most important influences of the European war on the industrial life of the nations involved is the awakening of the people to their own capabilities. This is particularly true in the case of women who have been called to the service of their country as truly as men on the battlefields. The response has been great, and we find today women in many branches of industry, carrying on the work as efficiently, perhaps, as the men. In view of the fact that the women of the United States will probably be called upon to fill the places in many industries of men who are engaged at the front, it is of interest to note what has been done by the women in England. *Engineering*, of London, shows some views of the work being carried on by women in the machine shops, reproduced herewith. It is pointed out that the work of the women in munitions manufacture is not confined to repetitive work, which resolves itself merely into tending a machine that has been set up correctly by men, but they are employed on jobs that demand close attention and a high degree of intelligence. Fig. 1 shows a woman engaged in marking out the columns of a reciprocating engine with a surface gage. The woman in Fig. 2 is setting the tool for planing a cylinder. In Fig. 3 the top of an aero-engine cylinder is being milled on a Becker vertical milling machine. The limit on this work is 0.05 millimeter, and the tool, as well as the work, is set up by the women. Fig. 4 shows a large lathe job—turning the jacket forging for a 60-pound howitzer. It may be mentioned that women are also employed in the foundry on such work as core making, where considerable strength is required for lifting heavy weights; in aeroplane factories, making the various parts of the aeroplanes; and on such precise work as dividing pearl dials for prismatic compasses.

* * *

Notwithstanding its lack of raw materials, Japan has developed its manufactures until there are now in the country 16,000 factories, using 1,125,000 aggregate horsepower and employing 1,500,000 hands, against 4000 factories that used 120,000 horsepower ten years ago. Among other raw materials, these factories import 80,000 tons of old iron annually.

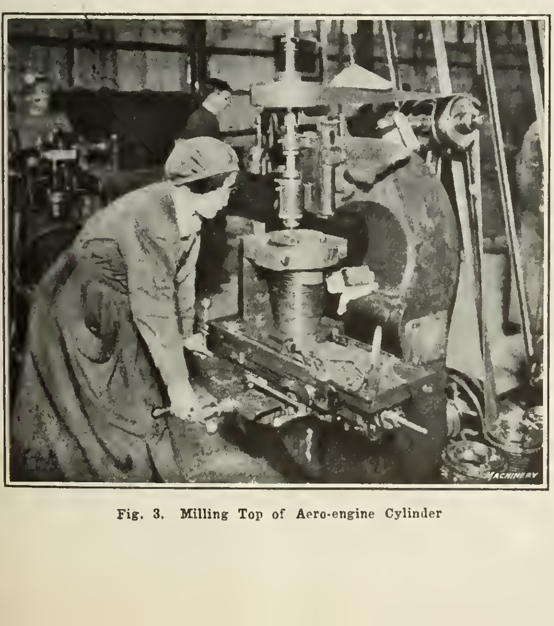


Fig. 3. Milling Top of Aero-engine Cylinder

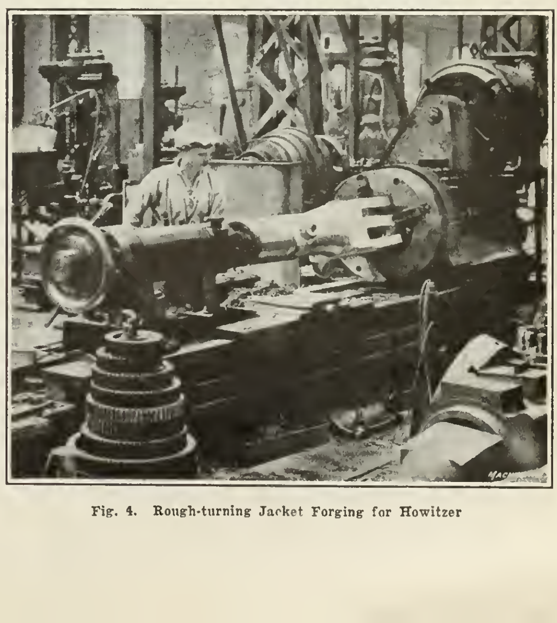


Fig. 4. Rough-turning Jacket Forging for Howitzer

WIRE STRAIGHTENERS

PRINCIPLE OF ACTION AND CONSTRUCTION OF MACHINES

BY FRANK H. MAYOH[1]

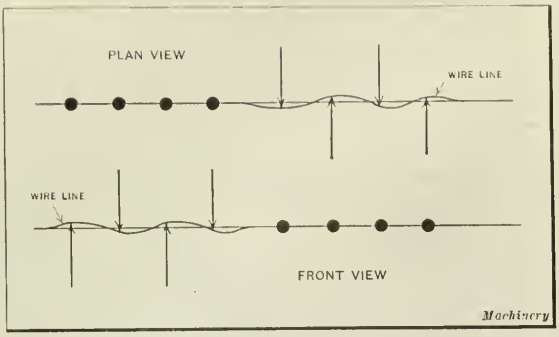


Fig. 1. Diagram of Bending Action in straightening Wire

MANY simple articles require considerable care in their manufacture; for instance, in making the ordinary wire articles that are in everyday use, it is necessary to straighten the wire before bending it into shape. The purpose of a wire straightener is to take out the natural curl of the wire, as it comes from the reel, and any kinks or bends it may contain. This is frequently accomplished by passing the wire through rolls or pins that are staggered, as indicated by the arrows in Fig. 1. The pins or rolls overcome the elastic

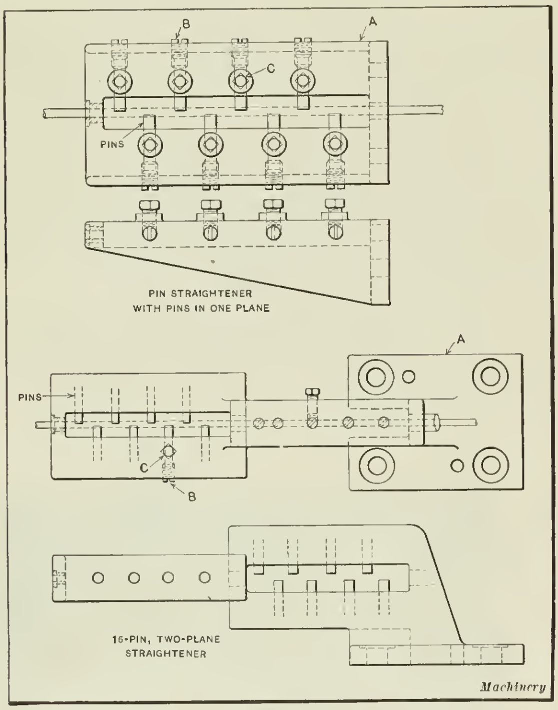


Fig. 2. Wire Straighteners of the Pin Type

tendency of the wire by bending it in opposite directions; these bends become less pronounced as the wire passes through the straightener, until it emerges practically straight. Other machines perform this function by the use of an arbor carrying a number of dies. If the wire had kinks in it when it went into the forming machine, unsightly work would be produced, wire would be wasted, and the working of the machine would be interfered with by the wires catching in the feed slide or forming tools.

The design of a straightener depends on the material being formed, the length of the wire article, and the degree of straightness necessary. Whether it is of the pin, roll, rotary, oscillating die, or any other type, it must not mar the wire and should be adjustable to allow for varying conditions of the wire and the wear of the rolls, pins, dies, etc., through which the wire passes. In addition, it must not stretch the wire; and while a slight tension between the straightener and the feeding unit of the machine is desirable, this must not be great enough to cause slipping of the feeding rolls, as it might cause part of the work to be cut off in short lengths.

Fig. 2 shows simple pin straighteners that consist of a bracket *A* into which the pins are placed, adjusting screws *B*

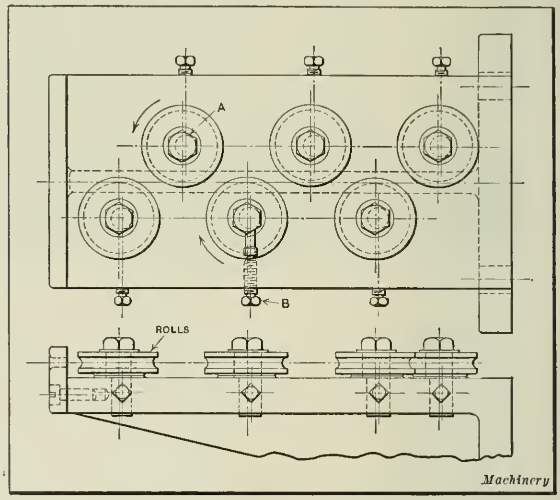


Fig. 3. Six-roll Eccentric-stud Wire Straightener

for the pins, and locking screws *C*. The upper view shows a straightener having pins in one plane only, and the lower view shows pins arranged at right angles to each other, or in two planes. A straightener having six rolls in one plane is shown in Fig. 3. These rolls are mounted on eccentric studs *A*, which are locked by screws *B* when the rolls are set against the wire with the required tension. This is accomplished by the eccentric throw of the studs as they are turned in the direction of the arrow.

The construction of these straighteners depends on the size of the wire and the degree of straightness required. Large wire requires fewer points of contact, or rolls, for straightening than the smaller sizes. The number of rolls is frequently eight for large wire and twelve for the smaller sizes, although there is no particular disadvantage in using twelve or more rolls for all sizes where one machine must be used for a number of sizes of wire. In roll straighteners, much of the friction of pin straighteners is eliminated, so that roll straighteners will handle large wire, whereas pin straighteners can

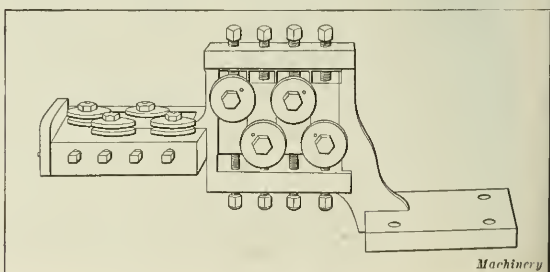


Fig. 4. Eight-roll, Two-plane Straightener

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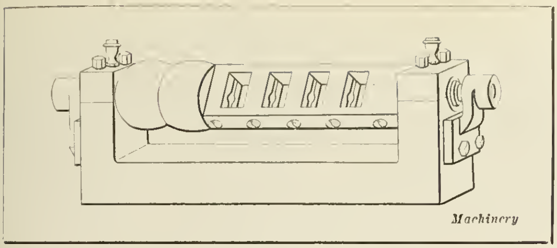

Fig. 5. Five-die Rotary Straightener

be used only with wire of small diameter. Fig. 4 shows an eight-roll straightener in which the rolls are mounted in two planes, at right angles to each other. These rolls are mounted in a bracket, the foot of which is arranged for central, vertical or horizontal attachment to the machine or for mounting on an independent base. The rolls are mounted in independent blocks or slides, and each roll may be adjusted separately.

A type of straightener that will do more accurate work than the foregoing is shown in Fig. 5. It is known as a rotary die straightener because it revolves as the wire passes through it, and the actual straightening is done by dies of a material that is tough, but softer than the wire operated upon, such as

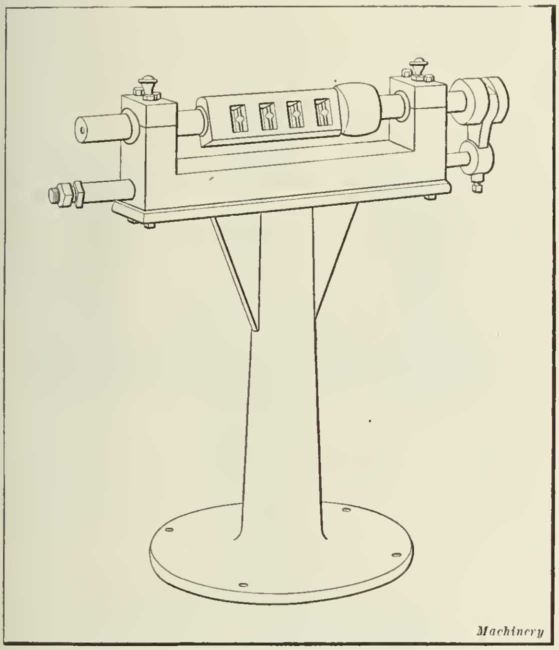

Fig. 6. Rotary-oscillating Wire Straightener of Die Type

babbitt, white iron and gun metal. The construction of the rotary straightening arbors is shown in Fig. 7; this is a sectional view through the center and shows the means of adjusting the dies to bring them in contact with the wire. A rotary straightener, however, cannot be used on formed wire, as the dies, in revolving, will come in contact only with the large parts of the wire; it is customary, therefore, to use a roll straightener on this work.

In Fig. 6 is shown a five-die straightening arbor mounted on a base. In addition to its rotary motion, this arbor is

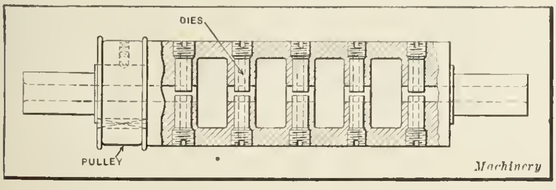

Fig. 7. Section through Rotary Straightening Arbor

caused to oscillate back and forth over the wire. This type of straightener is known as the "rotary-oscillating die straightener." The rotary straighteners are usually revolved by a belt passing over a pulley, while the oscillating motion is obtained by various means, such as a cam and lever, a face cam on the arbor, a plunger with spring return, etc. Any of the roll straighteners shown may be arranged as rotary-oscillating straighteners.

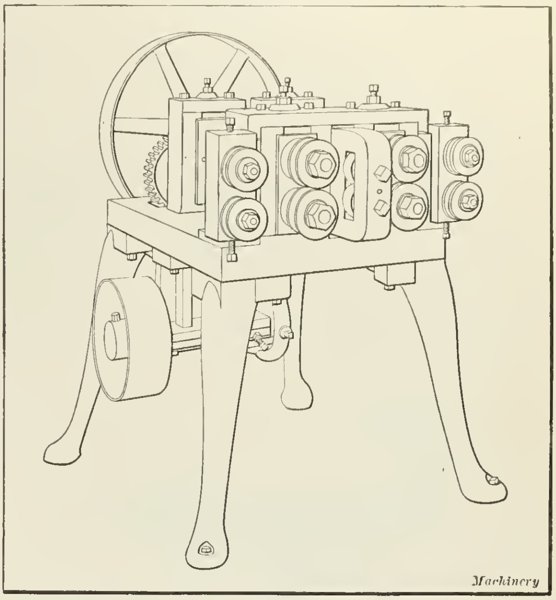

Fig. 8. Straightener for Hot-rolled Bars

As the straightening of wire is a drawing process and is attended with considerable friction, some provision must be made for lubricating the wire. This is accomplished by passing it through a box containing oily waste, as part of the machine, or by the operator hanging a piece of waste over the wire in such a manner that it will not be drawn into the machine; in addition, the rolls and bearings of the straightener should be well oiled. The rolls on a wire straightener

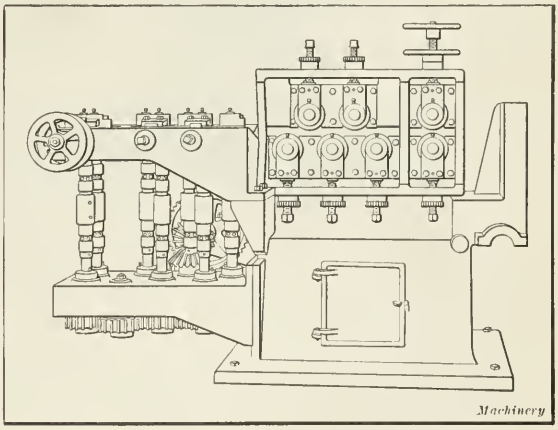

Fig. 9. All-geared, Adjustable-roll, Heavy Wire Straightener

are often made with two or more grooves for handling a number of sizes of wire; these are known as "multi-groove straighteners."

Four types of straighteners embodied as complete units are illustrated in Fig. 10. These are mounted on pedestals and are: a roll straightener with roll feed, a rotary die straightener with roll feed, a rotary die straightener with roll feed and cutting-off attachment for short lengths, and a rotary straightener with a guard, or protecting hood, in place. In Fig. 8 is

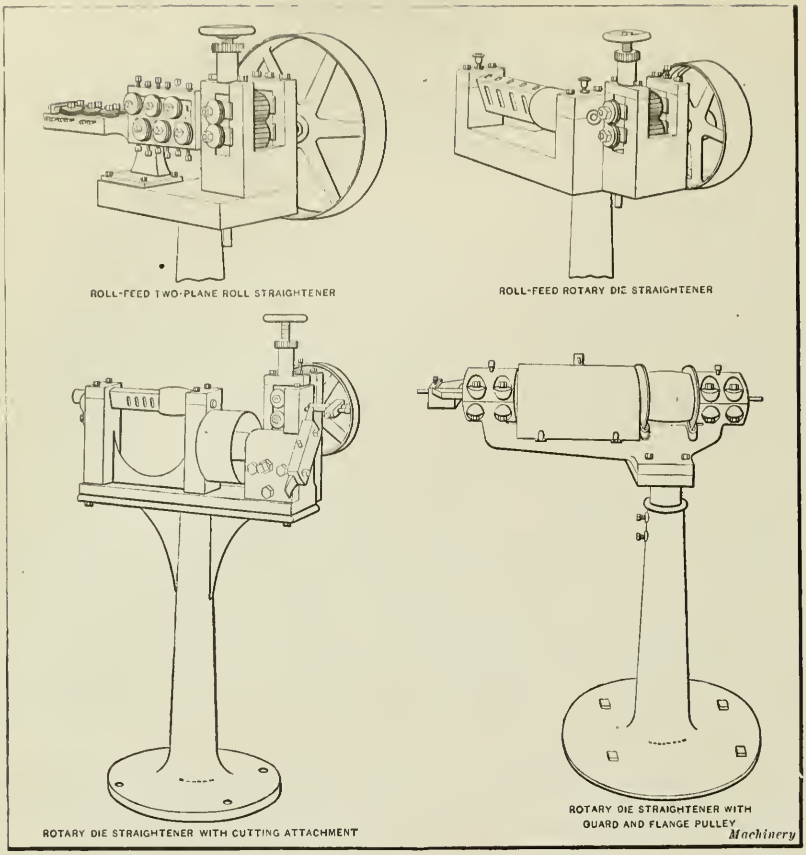

Fig. 10. Four Types of Plain Belt-driven Straighteners

shown a straightener for handling hot-rolled bars. It will be noticed that this machine is heavily constructed and has a roll feed. Its purpose is to straighten the bars and remove the surplus scale preparatory to being operated on in the screw machine.

Another type of wire straightener is illustrated in Fig. 9. This is an all-geared machine with roll feed; its operation is obvious from the illustration. The three lower rolls are fixed, while the two upper rolls are mounted in an equalizing block and are brought into contact with the wire by means of adjusting screws. The rolls in the other plane are, of course, adjusted in the same manner. These machines are of heavy, rigid construction. In the machine shown, the rolls have an independent adjustment in both vertical and horizontal planes. The rolls are driven by the gears, universal joints permitting a large range of adjustment without interfering with the gearing.

The machine illustrated in Fig. 11 is for straightening and cutting off ¾-inch wire of various lengths. This machine has a roll straightener *A* for rough-straightening the wire, while the finish-straightening is done by rotary wire straightener *B*. The wire next passes through two feed rolls *C*, along a grooved guide bar until it strikes a gage, when it is cut off.

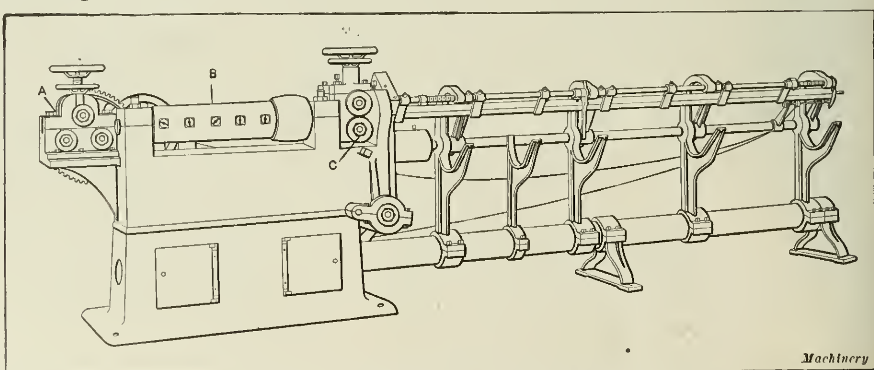

Fig. 11. Wire Straightening and Cutting Machine

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Celluloid will become as soft as jelly if left for a few hours in an ether bath. If dried in a mold, it will retain the shape of the mold.

STANDARDIZATION OF SCREW THREADS

The Engineering Standards Committee of Great Britain, with the active cooperation of the Ministry of Munitions, is making an investigation with a view to simplifying the manufacture and gaging of the Whitworth form of screw threads. It has been urged before the committee that the difficulty experienced in the production of interchangeable Whitworth screw threads is largely due to the fact that a fit must be obtained on all the five elements of the screw thread—namely, the angle, the outside diameter, the pitch or angle diameter, the root diameter, and the lead—and that by suitable modifications in the form of the thread, the necessity of close adherence to some of these dimensions could be avoided without injuring the character or value of the screw thread for its service. The modifications would increase the rate of production and simplify the methods of gaging and inspecting the finished product.

For the purpose of obtaining the views of manufacturers and gagemakers as to whether any modifications in the form of the Whitworth thread are desirable, the subcommittee on screw threads of the Engineering Standards Committee has drawn up a list of questions which are submitted to firms and individuals likely to have an opinion upon the subject. The most important of these questions relates to whether any alteration in the present form of the Whitworth thread is desirable; whether the revised form, if adopted, should be interchangeable with the existing Whitworth thread; whether clearance should be made at the top and roots of the thread; and whether it would be advisable to change the existing angles of Whitworth and British Association screw threads to 60 degrees, as a step toward securing interchangeability with the United States standard or the International standard thread.

Anyone especially interested in this matter, who would like to get the published material issued by the Engineering Standards Committee bearing upon this subject, can obtain it upon application to the secretary of the Engineering Standards Committee, 28 Victoria St., Westminster, London, S.W.-1, England.

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If you think you can't, you won't.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

UNIVERSAL AMPLIFYING GAGE

This is a universal gage adapted for testing work produced in both the tool-room and manufacturing departments of a factory. Two types of machines are built, which are illustrated in Figs. 1 and 2; and an idea of the range of work that can be tested will be obtained from Figs. 4 to 6, which show typical examples of gaging operations. Not only does this machine provide an accurate method of gaging—the limit of accuracy is 0.0001 inch by a direct-reading dial indicator—but being universal in its scope, the machine represents an investment rather than an item of expense, as in the case of special gages which are only suitable for one particular line of work.

Manufacturers who are engaged in the production of interchangeable parts and other work where it is necessary to maintain close dimension limits are always anxious to equip their shops with the best tools. First cost is a secondary consideration, the point of prime importance being to obtain tools that are capable of reducing the cost of manufacture to a minimum. For use in tool-rooms for gaging accurate tool and die work, and also for testing the accuracy of production work, the North Side Tool Works, 267 Air St., Dayton, Ohio, have recently developed a machine known as a universal amplifying gage, which is illustrated and described herewith. The design has been worked out with the view of simplifying the gaging system in a factory. It is rigidly built, and all parts subject to wear are made of hardened steel to insure durability. This machine will take the place of 75 per cent of the snap gages in a shop and is capable of measuring to 0.0001 inch. Work up to 5½ inches may be taken on the plate, and work up to 8 inches may be taken between centers. The arrangement of the machine is such that work may be gaged with extreme rapidity. An important advantage of this method of gaging is that there is no guesswork, measurements being taken by a direct-reading indicator, so that when a piece is over or under the required dimension, the exact amount of error is indicated on the dial of the gage.

Fig. 1. No. 60 Universal Amplifying Gage made by North Side Tool Works

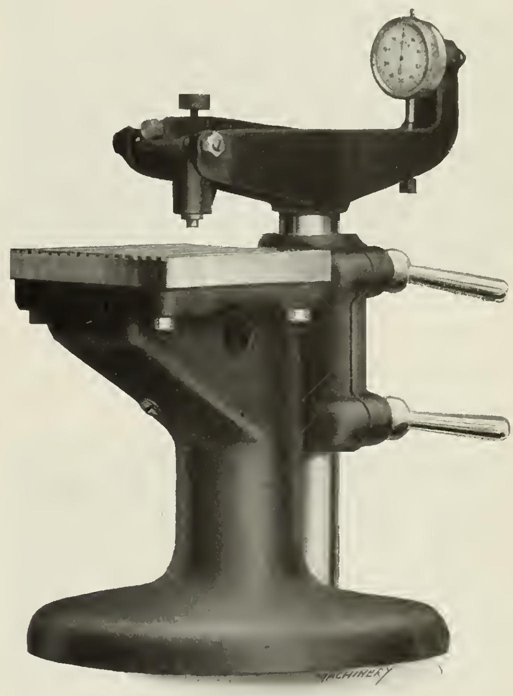


Fig. 2. No. 67 Universal Amplifying Gage made by North Side Tool Works

Fig. 3 shows the method of testing work on centers, and it will be seen that this illustration shows an arbor which is being tried out to ascertain whether it is fit for use in the production of accurate work. This method of testing can be applied to all work finished on centers, or more particularly to work produced on grinding machines, both in the tool-room and in manufacturing departments. A conscientious workman will take time to try out an arbor in the lathe, but in so doing he only has a gage capable of showing results to 0.001 inch.

For surface work, the universal amplifying gage has a hardened plate 5 by 6 inches in size; and when so desired this plate can be removed and a special fixture attached to the bed of the machine either temporarily or as a permanent feature. This arrangement is shown in Fig. 4, which clearly illustrates the method of testing work of this kind. Fig. 5 shows the method of testing work that has a shoulder. This is done by bringing the shoulder into contact with the edge of the table and gaging the diameter of the work by rolling it under the contact point of the dial test indicator. In Fig. 6 the rear center has been removed, and a plug substituted and clamped in place with the same screw that is used to tighten the center. An arrangement of this kind is extremely useful for testing the concentricity of such work as gears, etc.

It will be evident from what has already been said that this is strictly a universal gage, and that it can be used on a great variety of work. The price of the machine is not prohibitive, and as it can be used continually on different classes of work instead of being put in the store-room as soon as a job is over, it will be evident that this method of gaging is far more eco-

Fig. 3. Method of testing Accuracy of Work held on Centers

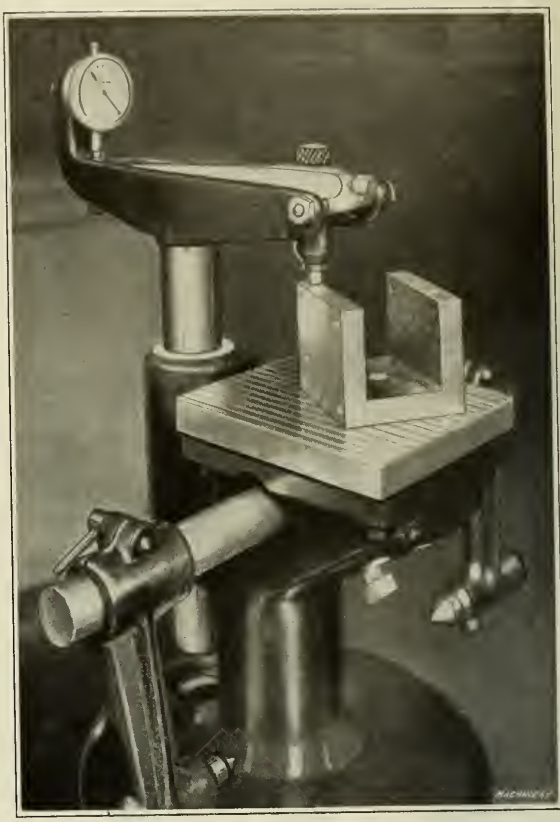


Fig. 4. Procedure followed in testing Accuracy of Surface Work

nomical than to invest in special snap gages, etc. Reference has already been made to the fact that the gage is made to read to 0.0001 inch, and the graduations on the dial are 1/16 inch apart, so that there is no difficulty about making accurate readings. The machine is made in two styles, known as Nos. 60 and 67, which are illustrated in Figs. 1 and 2, respectively; the No. 60 gage weighs 48 pounds, and the No. 67 gage weighs 54 pounds.

Fig. 5. How Universal Amplifying Gage is used to test Work with Shoulder

Fig. 6. Rear Center replaced by Plug to support Work to be tested

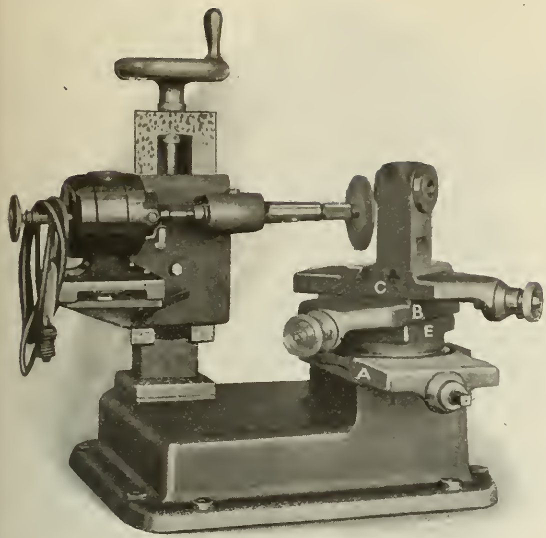


Fig. 1. Profile Grinder built by Cleveland Milling Machine Co.

CLEVELAND PROFILE GRINDER

For use in grinding round corners on milling cutters and for similar classes of work, the Cleveland Milling Machine Co., 18,511 Euclid Ave., Cleveland, Ohio, has recently developed a profile grinder, which is illustrated and described herewith. This machine has a capacity for handling small sizes of cutters, its range being for work all the way from zero to 12 inches in diameter; and round corners may be ground either concave or convex with radii ranging from 1/8 to 3 inches. The Cleveland Milling Machine Co. manufactures a large number of cutters, and for use in this work it requires a profile grinder. To meet this requirement, it became necessary to develop the machine which forms the subject of this article,

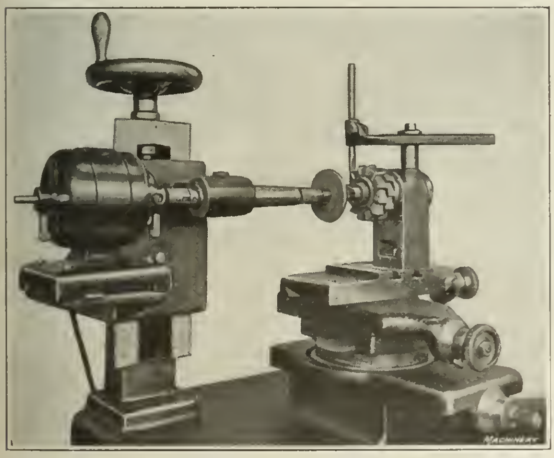


Fig. 2. Close View of Wheel and Work on Machine shown in Fig. 1

and the results obtained were so satisfactory that it was decided to place the grinder on the market.

Direct connection is made between the wheel-carrying spindle and the motor shaft, and the grinder is equipped with a wheel 4 inches in diameter by 1/4 inch face width. A bracket carrying the motor and wheel-spindle is mounted on a vertical housing and adjusted by a screw provided with a micrometer dial. Arbors for holding the work are held in a sleeve that revolves freely in the work-holding posts. Four posts are furnished with No. 9 and No. 7 Brown & Sharpe tapers, one with a 1/2-inch straight hole and one flat block for holding flat tools in order to cover all the classes of work for which the machine is adapted. It will be seen that these posts fit into three T-slots in the upper compound slide *C*, Fig. 1, thus providing for handling a wide range of work. The upper slides *B* and *C* are used to bring the work into the proper sweep across the face of the wheel, and these, in turn, are mounted on a swivel block *E* which is pivoted onto the bottom slide *A*.

A gage is furnished to set the work in the proper relation to the wheel, and when the bottom slide *A* is set for a given radius, the machine will always grind that radius regardless of the continued adjustment of the two upper slides *B* and *C*. A convenient tooth rest is furnished with sufficient range to cover all work within the capacity of the machine. All screws are provided with micrometer dials graduated for adjustments to 0.001 inch, the dials being graduated from zero to 100 for a 10-pitch screw. All slides are accurately scraped and provided with gibs for taking up wear. In addition to its application in grinding round corners on milling cutters, this machine is used to grind concave and convex cutters, cutters for fluting drills, cutters that are irregular in contour but which have a number of true curves, form tools for screw machines, and for rounding the corners of tools used on lathes, planers, shapers, etc. Some of this work is shown in Fig. 3.

The regular equipment furnished includes a type D "Dumore" universal motor with 10 feet of wire and a plug to fit any lamp socket on a 110-volt direct- or alternating-current circuit; one grinding wheel 4 inches in diameter by 1/4 inch face width; one work-arbor, 1 inch in diameter; one tooth rest; four work-posts; one gage for radius setting; one 7/8-inch

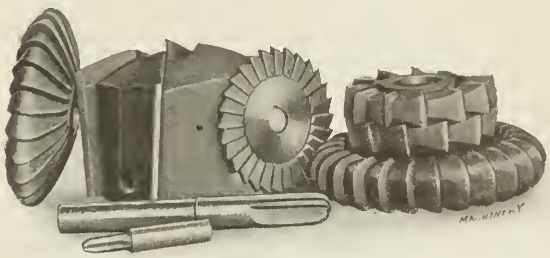
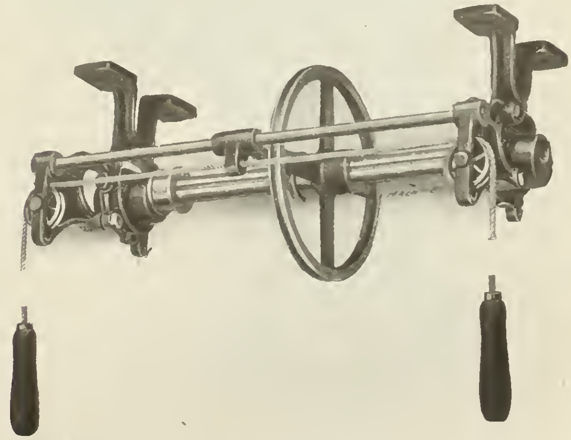


Fig. 3. Examples of Work done by Cleveland Milling Machine Co.'s Profile Grinder

work-arbor, and the necessary wrenches for making all adjustments. The floor space occupied by this machine is 30 by 24 inches, and it has a net weight of 217 pounds.

DALTON GRINDER COUNTERSHAFT

A countershaft especially designed for driving small lathes of all makes using internal or external grinding attachments, has recently been placed on the market by the Dalton Machine Co., Inc., 1911-1915 Park Ave., New York City. In designing this equipment provision has been made for having the driving pulley travel the entire length of the shaft, so that the belt is always in line with the pulley of the grinding attachment. By this method much time can be saved through avoiding the necessity of sliding belts over the countershaft drum.



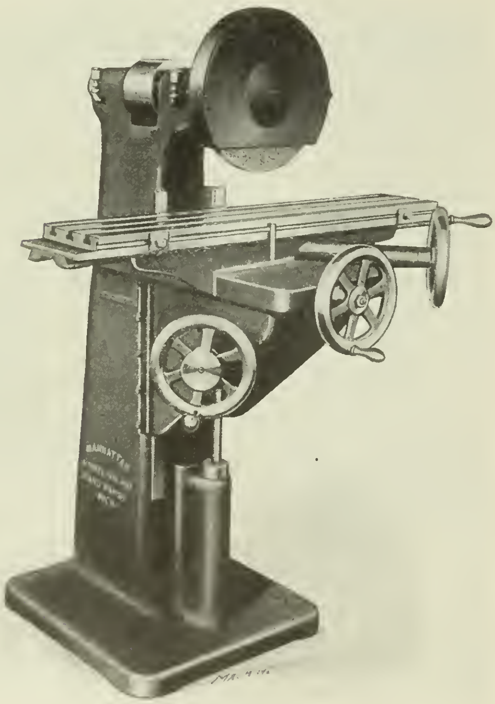
Dalton Machine Co.'s Countershaft for driving Small Lathes with Grinding Attachments

The pulley referred to is of the grooved type and is 9 inches in diameter; it has a travel of 14 inches and is keyed to the shaft. Travel of the pulley is accomplished by pulling on handles attached to a rope, which is of sufficient length to be easily reached by the operator. This rope is attached to a cast-iron arm, which is forked at one end and fitted to a channel in the pulley hub; the other end travels on a rod which is an integral part of the countershaft. The hangers are universally adjustable, so that they can be mounted on the wall or ceiling; and all bearings are of liberal size and provided with ring-oilers.

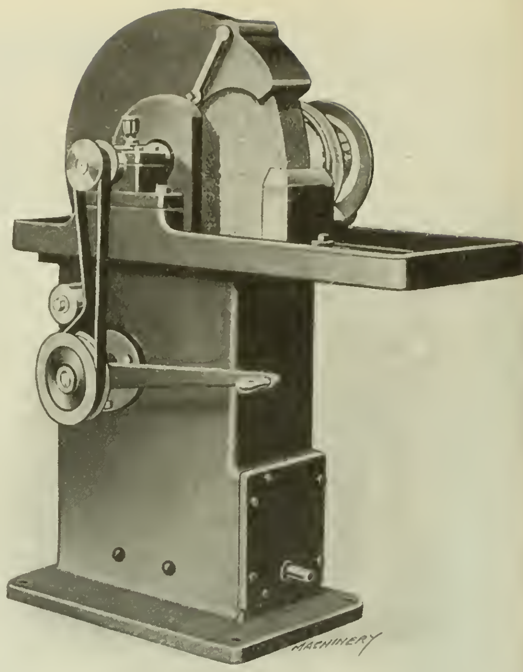
MANHATTAN SURFACE GRINDER

One of the latest additions to the line of machinery built by the Manhattan Machine & Tool Works, 42-50 Market Ave., N. W., Grand Rapids, Mich., is a No. 12 surface grinder which is illustrated and described herewith. This is a heavy-duty grinder and has been carefully designed in order to eliminate vibration. The grinding wheel is so arranged that it may be used for grinding the table of the machine in order to insure having the table at exact right angles to the spindle. A grinding wheel 12 inches in diameter by 1 inch face width is used on this machine, and the spindle has bearings 1½ inch in diameter which run in split brass boxes. These bearings are of the self-oiling type, lubricant being drawn from a large reservoir. Any type of dividing head can be used on this grinder.

The knee is raised or lowered by a screw, and the handwheel is furnished with a graduated dial reading to 0.001 inch having a lock-nut for holding it in any desired position. The cross-head has a screw and handwheel, this wheel also being furnished with a graduated dial. The table is operated by a rack and spiral gear and is furnished with two adjustable stops. Provision may be made for surfacing the entire table of the grinder with its own wheel, as mentioned, the wheel having an overhang of 8 inches from the column. The principal dimensions of this grinder are as follows: diameter of spindle pulley, 5 inches; face width of spindle pulley, 3½ inches; distance from center of spindle to floor, 48 inches; over-all length of table, 48 inches; size of working surface of table, 36 by 7½ inches; size of T-slots in table, ⅝ inch; maximum distance from wheel to table, 13½ inches; and net weight of machine, 860 pounds.



No. 12 Surface Grinder built by Manhattan Machine & Tool Works



Wet Tool Grinder built by Noble & Westbrook Mfg. Co.

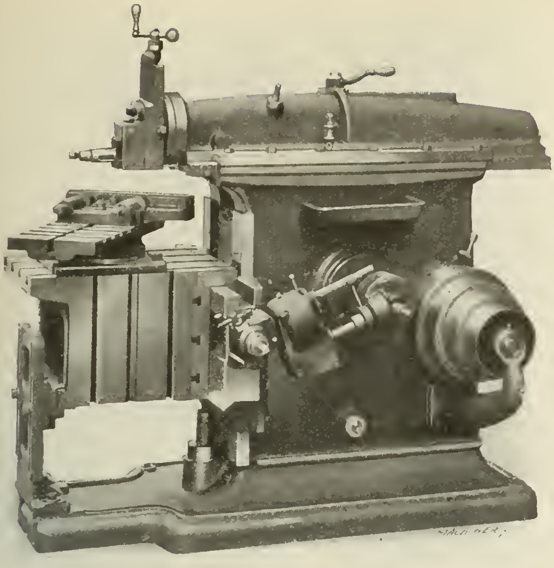
NOBLE & WESTBROOK WET TOOL GRINDER

The Noble & Westbrook Mfg. Co., Hartford, Conn., is now building the wet tool grinder shown in the accompanying illustration. An important feature of the design of this machine is the water carrier which is arranged with a chain in such a way that it will not flood or throw water on the man operating the machine. This is a heavy-duty machine, and in working out the design particular attention has been paid to the development of a rigid, durable construction which will be free from vibration. The arbor is made of high-carbon crucible steel, accurately ground to fit the bearings which are made of cast iron and provided with means of compensating for wear. This cast-iron bearing construction eliminates the expense of re-babbitting which would be involved if babbitt bearings were used.

This machine is made in two sizes known as Nos. 4 and 5. The principal dimensions of the No. 4 machine are: size of grinding wheel, 20 inches diameter by 2½ inches face width; dimensions of machine base, 16 by 24 inches; height to top of rest, 39 inches; length of bearings, 6 inches; diameter of arbor in bearings, 1 9/16 inch; diameter of hole in wheel, 2½ inches; size of tight and loose pulleys on arbor, 7 by 3 inches; speed of wheel, 950 R. P. M.; and weight of machine crated for shipment, 700 pounds. The principal dimensions of the No. 5 machine are: size of grinding wheel, 24 inches diameter by 3 inches face width; dimensions of machine base, 18 by 28 inches; height to top of rest, 38 inches; length of bearings, 7 inches; diameter of arbor in bearings, 1 11/16 inch; diameter of hole through wheel, 2½ inches; size of tight and loose pulleys on arbor, 7 by 4 inches; speed of wheel, 850 R.P.M.; and weight of machine, crated, 850 pounds.

QUEEN CITY SHAPER

In a new 24-inch back-geared crank shaper which has recently been placed on the market by the Queen City Machine Tool Co., Cincinnati, Ohio, it is claimed that work can be produced within 0.001 inch of parallel for the full 24-inch stroke, without having to take any steps to overcome inaccuracies in the machine. All gearing is of the cut helical type which experiments have shown to be well suited for this particular class of service, as it enables the machine to do smooth



Queen City 24-inch Back-geared Crank Shaper

work, entirely free from chatter marks or gear waves. In working out the design, the machine has been made exceptionally low in order to bring all operating handles within easy reach of the operator. Feed-screws are furnished with micrometer adjustments and all swivels are graduated. The length of stroke can be quickly changed and positively locked while the ram is either in motion or at rest. Sixteen changes of feed are instantly obtainable, and these changes may be made without danger of accidents. There are eight available cutting speeds for every change of stroke and these are arranged in geometrical progression as follows: 6.4, 9.3, 13.5, 20, 30, 44, 63, and 92 strokes per minute at 290 revolutions per minute; but with the all helical drive much higher speeds can be used without excessive noise or other indications of trouble. Attention is called to the table support; the table moves automatically up and down with the rail and is self-oiling.

The principal dimensions of this machine are as follows: automatic cross travel, 27 inches; vertical adjustment of table, 15 inches; distance from ram to table, 2 to 17 inches; size of tool used, 1¾ by ¾ inch; length of table and saddle, 24½ inches; width of table and saddle, 17½ inches; height of table and saddle, 15 inches; capacity for keyseating, up to 3½ inches; size of regular vise jaws, 15½ by 2¾ inches; maximum opening of vise, 14 inches; number of changes of speed for ram, 8; slow back-gear ratio, 5½ to 1; and regular back-gear ratio, 26 to 1.

BRADFORD-ACKERMANN LEAD BURNING APPARATUS

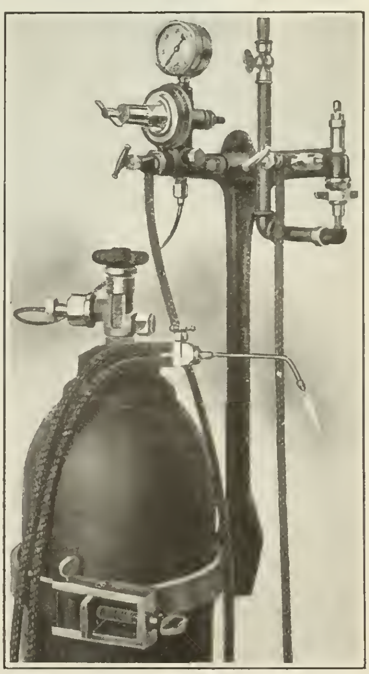
For use in lead burning, hard tempering, etc., the Bradford-Ackermann Corporation, Forty-second St., Bldg., New York City, has recently placed on the market the "Astra" oxy-illuminating gas apparatus, which can be used to advantage in storage battery service stations, garages, and other places where lead burning and similar operations have to be performed. By means of special appliances made by this company, the scope of the apparatus can be broadened to include auto cylinder decarbonizing, oxy-acetylene welding and cutting, and other operations. This equipment is manufactured by Ashton, Laird & Co., of New York City, and sold by the Bradford-Ackermann Corporation.

Lead burning is an operation that calls for specially designed equipment, and this "Astra" oxy-illuminating gas outfit has been particularly developed to meet the requirements of this service. In addition to lead burning, it may be employed for welding brass, aluminum, bronze, and other metals of similar fusing temperatures. The possibility of employing artificial or natural illuminating gas drawn directly from the gas main and employed in connection with tanked oxygen, makes this process both convenient and economical. As regards cost of operation, attention is called to the fact that illuminating gas costs less than one dollar per thousand cubic feet. The apparatus is so assembled that different component parts may be added to an existing welding or decarbonizing apparatus to provide facilities for lead burning; similarly, other appliances may be added to broaden the scope of the lead burning equipment to include hard soldering, brazing, tempering, annealing, cylinder decarbonizing, and oxy-acetylene welding.

Two standard models of "Astra" oxy-illuminating gas low-pressure lead burning apparatus are available, these being known as a stationary type S. L. P. and a portable type P. L. P. The stationary type may be securely fastened to the wall by means of a bracket on which are mounted the regulating device and gage, and also a rugged clamp for the oxygen tank. From the single equipment, the system may be piped to torches at different locations where work may be done simultaneously if desired. The portable type can be easily moved to gas outlets which are conveniently located in relation to the place where the work is to be done. A working radius of 16 feet is provided and greater reach may be obtained by means of additional hose. A compact and well balanced design has practically eliminated danger of breaking the equipment while it is being moved about.

The "Astra" regulator is so designed that it insures precision of adjustment, maintenance of constant control, and accuracy of operation. There are no soldered parts, and the new feature of a one-piece non-corrosive metallic pressure seat, and carefully counterbalanced and adjustable counter springs, provide for obtaining positive operation and a high degree of durability. All parts are interchangeable. Protective devices are provided on the oxygen regulator and oxygen back-pressure release valve for the illuminating gas line, both of which operate automatically and are provided with alarm whistles to attract attention. The regulator is equipped with a detachable and interchangeable tank connection which is adaptable to any tank regardless of thread variation. A scrubber is provided in the tank connection to prevent foreign substances from entering the essential parts of the regulator. This scrubber is easily removed for cleaning.

A two-hose torch furnished with the "Astra" apparatus weighs only 6 ounces. It is said to be as convenient to operate as a single-hose torch. The valve not only provides instantaneous adjustment of oxygen as required, but it also permits the oxygen to be shut off between operations, using only the inexpensive illuminating gas as a pilot light. Five interchangeable nozzles of assorted orifice sizes are provided with the standard apparatus and give suitable flames for various classes of work. A gage is provided on the oxygen regulator to indicate the working pressure at the nozzle; and a high-pressure gage, furnished separately, can be attached to determine the amount of gas in the oxygen tank at any time.



Bradford-Ackermann Oxy-illuminating Gas Welding and Cutting Outfit

NEWTON MULTIPLE-SPINDLE MILLING MACHINE

One of the recent products of the Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa., is a multiple-spindle milling machine which has two vertical spindles mounted in saddles on the cross-rail and one horizontal spindle in a saddle carried on each of the housings. The first of these machines to be built has a capacity of 66 inches between the ends of the horizontal spindles and a maximum height of 54 inches under the vertical spindles. The finished surface of the work-table is 54 inches wide and of sufficient length to mill work 30 feet long. The right-hand horizontal spindle may rotate independently of all other spindles, and the same is true of the left-hand horizontal spindle; both vertical spindles must rotate in unison and the right-hand horizontal spindle must rotate at the same time. All spindles are made of forged steel and receive their final finish by grinding. Each spindle has a tapered end bearing and a through cutter-retaining bolt. The cutters are driven by means of broad-faced keys, and the spindle driving gear teeth are cut from a bronze ring, these teeth being of the spiral or worm type according to the size of the machine on which they are used.

The worms that drive the spindles are of hardened steel, fitted with roller thrust bearings. Lubrication of the driving mechanism is obtained by having the various worms and worm-wheels contained in oil-tight boxes so that they may be kept flooded with lubricant. The spindle speeds are independent of the table feeds, and the spindles rotate in a clockwise direc-

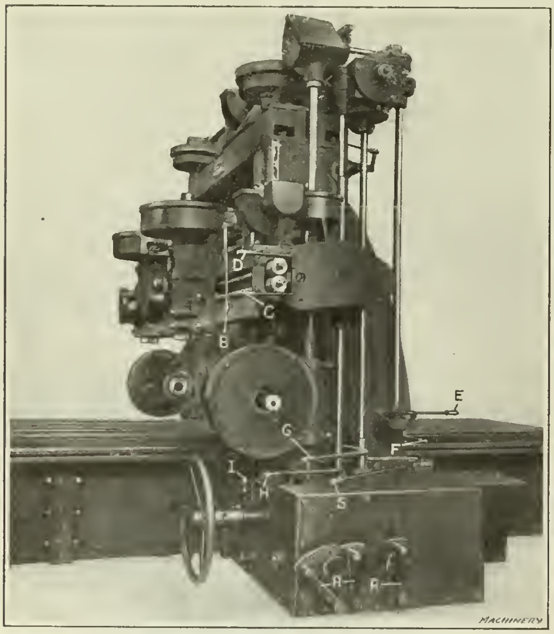


Fig. 1. Newton Planer Type Multiple-spindle Milling Machine

tion unless otherwise specified. There are nine available spindle speeds ranging from 16½ to 99 revolutions per minute, or proportionately greater or less according to the material to be machined. These spindle speeds are obtained through three sliding sleeves mounted in an oil-tight gear-box on top of the machine. All speed change-gears are made of steel or bronze. The spindle sleeves are adjusted by a hand-operated rack and pinion through a worm and worm-wheel; and they can be clamped in fixed positions when so desired.

All the spindle saddles are made alike, whether one or two are mounted on the cross-rail. The saddles have square lock bearings and adjustments are made by taper shoes; the horizontal spindle saddles have the narrow guide construction to provide control of alignment. Both rail saddles have hand adjustment and reversing cross-feed and reversing rapid cross traverse. When two saddles are mounted on the rail, both must be fed in the same direction if they are operated in

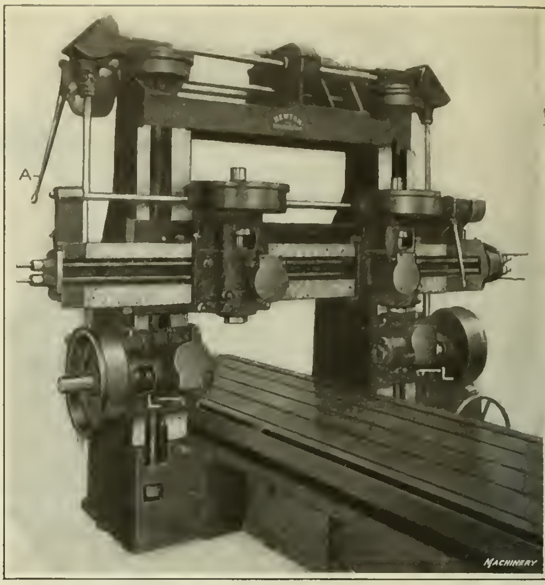


Fig. 2. Opposite Side of Newton Milling Machine shown in Fig. 1

unison by power. The saddles on the uprights are counterweighted by weights mounted inside the uprights; and they have only hand vertical adjustment. Provision is made for clamping these saddles to the rail for power elevation, and also to control alignment when a horizontal cutter-arbor is used and supported from its outer ends. The vertical spindles have twelve changes of reversing cross-feed ranging from 0.178 inch to 6½ inches per minute; and reversing fast power motion of 15 feet per minute, each being controlled from the table mechanism.

The cross-rail has square bearings on the uprights with narrow guide construction to control alignment. The rail has reversing fast power vertical adjustment and is supported by screws with bottom tension bearings. The cross-rail is not counterweighted. A heavy box type of construction has been adopted for the work-table which is surrounded by an oil pan; this table has square bearings on the base and T-slots planed in the top from solid metal. The table feeds are independent of the spindle speeds and are twelve in number, ranging from 0.355 inch to 13 inches per minute, these rates of feed being obtainable in both directions. Changes are obtained through gearing in an oil-tight feed-box which is equipped with cut bronze or steel gears mounted on sliding sleeves that are controlled by latch levers fitted through openings in the cover. Table movement is obtained through an iron or steel angular rack and a steel or bronze worm pinion which rotates in a bath of oil. Provision is also made for obtaining hand adjustment. Rapid traverse of the table is independent of the feeds and spindle speeds, and is available in both directions at the rate of 30 feet per minute except on heavy-duty machines when the fast table traverse is reduced to 20 feet per minute.

A heavy box type of construction has been adopted for the machine base which has a solid closed top and double cross-ribs. Cheeks are furnished for the attachment of uprights. The standard design calls for a bed 1½ times the length of the

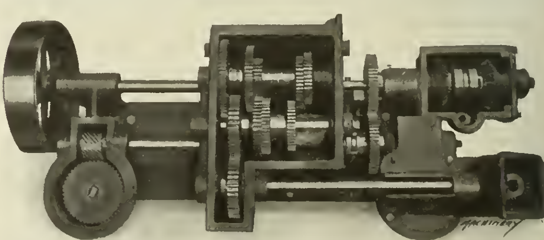


Fig. 3. Gearing in Speed Box of Newton Multiple-spindle Milling Machine

work that the machine is rated to mill. The uprights are of heavy box type construction and extend right down to the floor line; they are keyed and doweled to the base which has a broad faced key cast integral with the base to control vertical alignment. The drive is through a single pulley, which is suitable for use in connection with a countershaft speed of 495 revolutions per minute.

A feature of the machine is centralized control of all parts of the mechanism. The cross-rail gibs are scraped to a running fit when bolted tight and therefore require no adjustment in each setting in accordance with planer practice. This permits the mechanic to remain in a local position and reach the following levers: *A*, clutch lever for drive to left-hand horizontal spindle; *B*, clutch lever for drive to vertical spindles; *C* and *D*, clutch levers for feed and fast power traverse of vertical spindle saddles across rail; *E* and *F*, levers for changing speeds of all spindles; *G*, clutch lever that engages, disengages and reverses table feeds and fast power traverse, and also heads on cross-rail; *H*, clutch lever that transfers feed and fast power movements to heads on rail or to table as desired; *I*, clutch that controls engagement of table feeds; clutch that engages power feeds or fast power table movements; levers that control sliding sleeves for feed gears to give change of rate of feed; *L*, control for horizontal spindle saddle hand elevation; and spindle sleeve independent hand adjustment control.

The principal dimensions of this machine are as follows: height under vertical spindles, 54 inches; width between uprights, 71 inches; maximum width between ends of horizontal spindle, 66 inches; diameter of spindles in driving worm sleeve at large end of taper, 5 3/16 inches; independent hand adjustment of each spindle sleeve, 8 inches; maximum distance from center of horizontal spindles to top of table, 42 inches; minimum distance from center of horizontal spindles to top of table, 5 inches; and minimum distance between centers of vertical spindles, 24 inches.

CINCINNATI PLANER

The accompanying illustrations show opposite sides of a 30- by 30-inch planer, which is a recent product of the Cincinnati Planer Co., Oakley, Cincinnati, Ohio. This machine has a bed in which the space between the vees is closed up in the casting except at the gearing sections, making a very strong box section and eliminating possibility of injury to the operator. The bed is bored to receive the shaft bearing, and all driving gears inside the bed are supported by two bearings, thus entirely eliminating an overhung construction. The loose pulleys on this planer are equipped with self-oiling bronze bearings and the driving pulley is made of aluminum. A new design has been worked out for the belt shifting mechanism in which the cam slots are milled in the outside of a round casting. This cam is supported in a substantial bracket bolted against the housings, which serves the additional purpose of supporting the belt arms. A drip pan is attached to the lower side of the bracket to catch oil from the belt shifting device, thus leaving the belts absolutely dry.

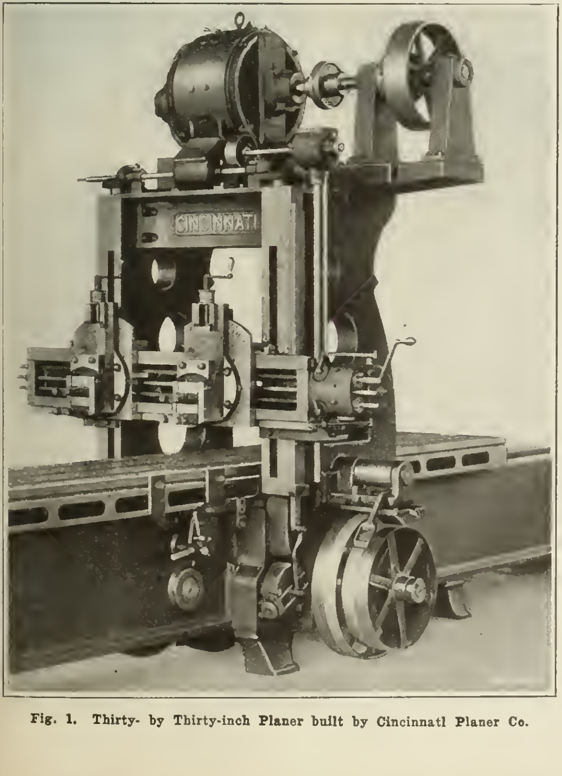


Fig. 1. Thirty- by Thirty-inch Planer built by Cincinnati Planer Co.

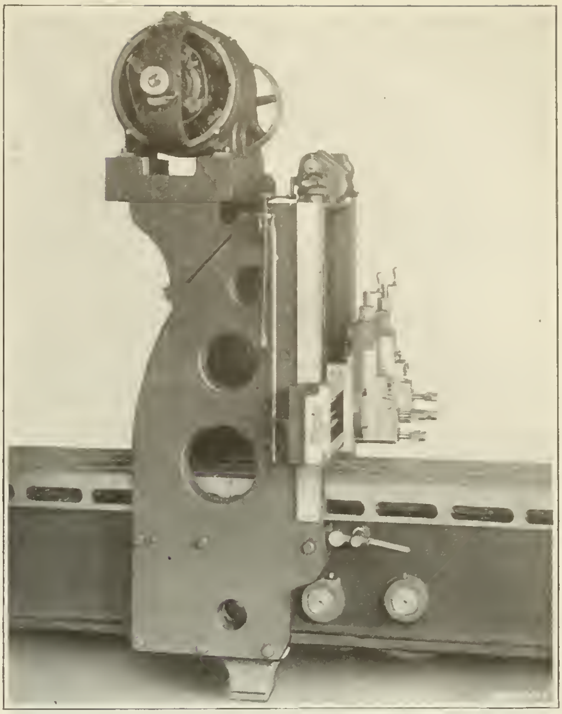


Fig. 2. Opposite Side of Cincinnati Planer, showing Improved Elevating Device

A box type construction is used for the table, which is closed at the bottom as well as at the top. The housings are also of box section and are carried right down to the bottom of the bed. Bolts and dowel-pins fasten the housings to the sides of the planer bed, and they are further secured by a tongue and groove construction. A departure has been made from preceding practice in working out the design of the cross-rail. A reinforced arch at the back is made a true half circle and this section is used to give additional strength for the torsional stresses imposed by overhung cutting tools. The saddle is taper gibbed at the top and the clapper box is provided with a rectangular shaped clamp instead of the circular clamp arrangement previously employed.

Figs. 1 and 2 show a machine provided with rapid power traverse to the rail heads. This feature is an advantage for the rapid manipulation of the heads and has been found quite a time saver. The drive is taken from the top of the machine through a pair of bevel gears and a friction clutch, which is manipulated from the end of the cross-rail within easy reach of the operator at all times. The device is absolutely foolproof in that it is impossible to engage the feed and rapid traverse simultaneously. A set of pads is provided for the housings onto which the brackets can be fastened for motor drive at any time after the machine has been placed in service. Ordinarily this planer is equipped with a two-speed countershaft giving two cutting speeds and constant reverse.

Fig. 2 shows the left-hand side of the machine, and in this illustration the automatic limit stop for the elevating device may be seen. This is an added feature of the present Cincin-

nati planer and consists of a vertical rod with two collars, which is connected to the shifting levers of the standard Cincinnati elevating device. These levers operate friction clutches at the top of the planer for raising and lowering the rail. A bracket is fastened onto the back of the cross-rail through which this rod passes, and the collars on the rod are set to a predetermined height. It will seen that when the bracket on the rail comes into contact with one of the collars, the vertical rod is moved either up or down, thus causing levers on the elevating device to be moved in either one direction or the other, thereby disengaging the frictions when the rail has reached its maximum position in either direction. All gears are thoroughly covered to provide for the safety of the operator.

S. & S. GAGE STANDARDS

Manufacturers have placed far less reliance in the value of so-called "trade secrets" since the practical application of science in industrial and engineering work. This is the natural sequence of events because the scientist is able to determine the details of manufacturing processes and to find out why certain results are obtained; he attaches no value to methods which his training does not show him are based upon scientific truths. Nevertheless, there are certain lines of manufacture, the control of which has remained in the hands of a few men in Europe, and the reputation of these manufacturers has become so celebrated that it has been almost generally acknowledged that these men are the only ones who are capable of producing satisfactory products of certain kinds. Typical examples are the manufacture of high-grade steel balls and the production of gage standards.

Fig. 1. Set of Gage Standards in Case, with Series of Blocks assembled in Holder ready for Use

The cases mentioned are industries that have flourished in different sections of Europe, but since the war cut off exports from those countries, necessity has once more proved the mother of invention, and the enterprise of American manufacturers who have branched out into these lines has been crowned with a large measure of success. It will undoubtedly prove of considerable interest to manufacturers in this country who use gage blocks to learn that very satisfactory standards of this kind are now being made by Wismach & Co., New York City, and that Schuchardt & Schütte, 90 West St., New York City, are the sales agents. Mr. Wismach has spent practically his entire life in this line of work. He started in this industry abroad, where he was engaged in making gage standards for testing the accuracy of rifle parts. Later he came to America, where he took up the same line of work.

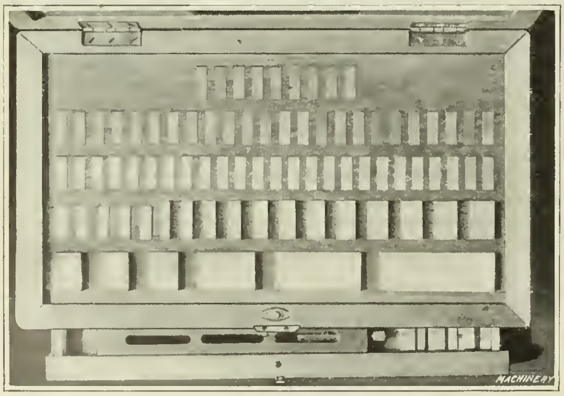


Fig. 2. Close View of Gage Blocks in Case shown in Fig. 1

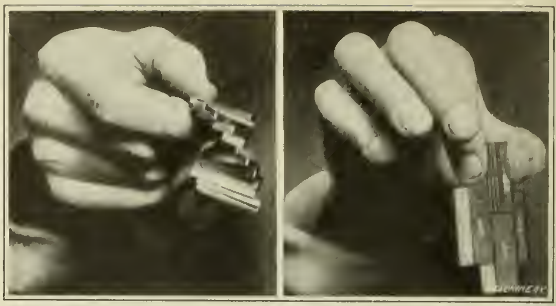


Fig. 3. Accuracy of Finish of Gage Blocks allows Air Pressure to hold them together

It will be apparent from Figs. 1 and 2 that these gage blocks are packed in a substantial wooden case which affords adequate protection against damage while the blocks are not in use. A feature of this case is that a lower drawer is provided with spaces for the various sizes of holders in which the blocks are assembled for use. The spaces are made of sufficient size so that a holder with a set of blocks assembled in it may be placed in the drawer over night, in case the same assembly of gage blocks will be in use again the next day. This is the means of saving a lot of time in assembling and taking apart sets of blocks. The precision with which the S. & S. gage standards are finished is indicated by the fact that if two blocks are rubbed together they will remain in contact; this is due to the fact that all the air is expelled from the surfaces between the blocks, and thus the air pressure acting from the outer sides holds the blocks together. This condition is clearly illustrated in Fig. 3, which shows how a number of blocks can be held together in this way. A severe test of accuracy is shown in the same illustration, where a combination of blocks is made up and held by the projecting ends of one set of blocks at the middle. It will be evident that unless all the blocks in this combination were of absolutely the proper size, it would be impossible to hold them in this way, because those that were either over size or under size would prevent the surfaces of some blocks from coming into proper engagement. These gages are made in ten different sets with various combinations of gage blocks and holders to meet the requirements of shops engaged in the production of different classes of work. The blocks are guaranteed accurate to 0.00001 inch at 62 degrees F.

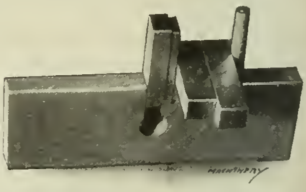
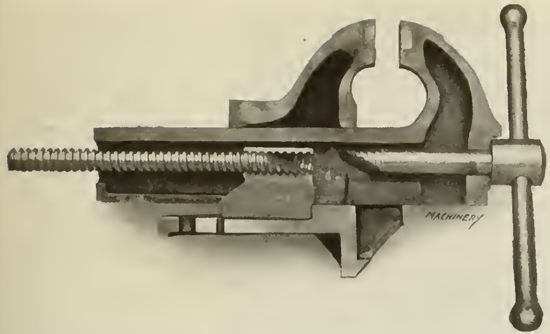


Fig. 4. Example of Use of Gage Blocks, showing how Air Pressure holds Blocks together

COLUMBIAN MALLEABLE IRON VISES

To provide additional strength and resistance against breakage through sudden shocks, the Columbian Hardware Co., Cleveland, Ohio, is now making a line of malleable iron machinists' vises, a cross-sectional view of one of these vises being shown in the accompanying illustration. It will be seen that



Cross-section of Columbian Malleable Iron Vise, showing Hollow Jaw Construction

the vise jaws are hollow, which is the means of accomplishing a great deal more than merely lightening the vise. This is due to the fact that the hollow jaw construction provides for obtaining the malleable iron skin on both the outside and inside of the jaws, and it is a well-known fact that the strength of malleable iron is due to annealing the surface of the metal. Hence the hollow jaw construction is claimed to virtually double the strength by having twice the amount of surface annealed to convert it into malleable iron.

The jaws are faced with tool steel plates secured in place by screws, and each part of a given size vise, including the steel jaw plates, the screw, handle, nut, and, in fact, the entire jaw, is interchangeable with corresponding parts in other vises of the same size. The screw is forged from one solid piece of steel, of which the head is an integral part. The manufacturers of this vise claim that it is practically indestructible. It is said to be absolutely impossible to break the vise by pounding it with a hammer or by subjecting it to other severe shocks; also, it is claimed that the metal in the vise will not be bent by such treatment.

JONES-MOWRY FROSTING TOOL

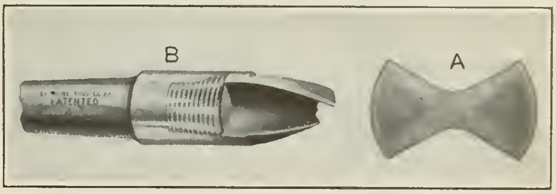
A tool designed for frosting and spotting finished surfaces on machinery has recently been developed by the Jones-Mowry Mfg. Co., Jackson, Mich. The use of the tool calls for no particular skill, so that frosting and spotting can be done by other than experienced men. This tool is said to be a great time-saver, as it is claimed that work formerly requiring from two and a half to three hours can be done in twenty minutes. The tool is made of steel tubing which has ample strength and durability. Two steel tubes and a rod holding the cutting tool comprise the essential parts. The outer tube is knurled to afford a suitable hand-hold, and the inner tube, which is hardened, contains an angular groove in which runs a pin on the central rod. Moving the hand up and down, while the tool rests on the surface to be frosted, imparts a vibratory motion to the tool, which should be held at an angle of 45 degrees. By honing the tool different ways numerous designs can be obtained including the "double gooseneck" and "halfmoon." Heretofore these designs have always been made by hand, but with the Jones-Mowry tool they can be done more rapidly and more accurately.

Frosting and Spotting Tool made by Jones-Mowry Mfg. Co.

LATROBE HIGH-SPEED DRILLS

The following is a description of high-speed drills made by the Latrobe Tool Co., Latrobe, Pa., and sold by McKenna Bros., Ross St. and First Ave., Pittsburg, Pa. These are two-piece twisted and milled drills and may be furnished with either a Morse taper or a straight shank; the working part of the drill is made of "Red Cut Superior" high-speed steel and permanently inserted into a carbon tool steel shank. Referring to the accompanying illustration, it will be seen that a transverse section of the double-grooved high-speed steel bar from which the drill is made is shown at *A;* and when this bar is twisted it gives approximately the correct shape for the grooves of the drill. The shaded portions of this cross-sectional view indicate compression of the steel, which is about 1/8 inch wide at the outer edge and meets at the center, so that when the steel is twisted the toughest part of this section is in the exact center and surrounding portion.

In conducting the process of manufacture, the next step is to center the blank at each end and support the work on centers in a milling machine to provide for taking a cut in each groove. This insures having the grooves of equal depth and properly tapered from the point to the shank. After this operation has been completed, the groove is ground by hand and polished. A phantom view of the section of the drill containing the joint between the drill and carbon steel shank is shown at *B*. This shank is fitted to the drill with a taper thread and the two parts are firmly connected by brazing. Drills are made by this method in all sizes from 37/64 inch to 3 inches, inclusive; drills 9/16 inch and under are made of high-speed steel and electrically welded to a carbon steel shank, after which they are finished according to the practice followed in manufacturing milled one-piece drills.

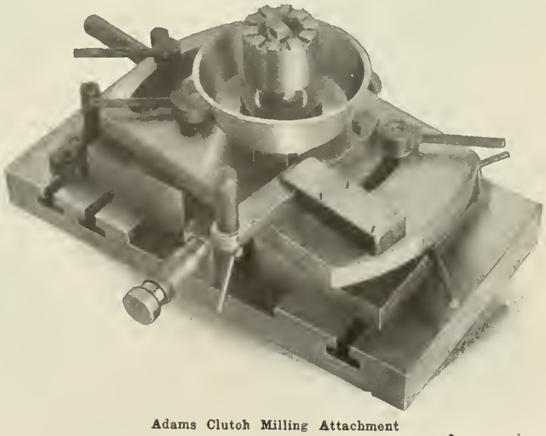


Cross-sectional View A of Double-grooved Bar and Phantom View B of Joint between Drill and Shank

ADAMS CLUTCH MILLING ATTACHMENT

William C. Adams, 40 Cleveland Ave., Hartford, Conn., has made a departure from standard methods of manufacturing and selling, in working out a method of placing his clutch milling attachment on the market. Instead of selling the complete attachment, his plan is to deliver rough castings to the customer, together with a set of blueprints that give instructions for machining the castings and assembling parts of the attachment. This attachment is intended for use on a hand milling machine, and the chief claim made for it is that it provides for performing clutch milling operations on a moderate priced machine, leaving the universal millers and other large, expensive machines free for the performance of those classes of work for which they are really required.

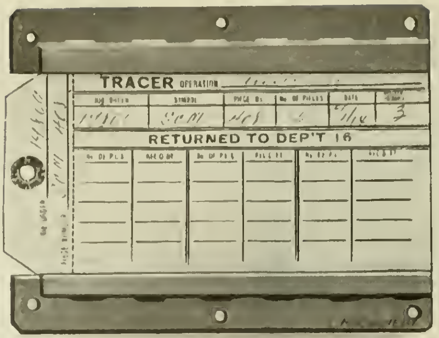
Reference to the accompanying illustration will show that this clutch milling attachment consists of a base, slide and swivel, controlled by positive stops, and a spindle revolving



Adams Clutch Milling Attachment

within the attachment. Any type of clutch with up to 32 teeth can be milled with this outfit. It can also be used for regular milling operations usually done with an indexing attachment. The spindle has a Brown & Sharpe taper hole, so that standard arbors, etc., may be used.

DETROIT UNIVERSAL CARD-HOLDER



Card-holder made by Detroit Stamping Co.

For use in attaching cards to truck loads of work which are being transferred from department to department in industrial plants, and for a great variety of other purposes where it is desired to attach various forms of instruction or identification cards, the Detroit Stamping Co., 955-957 W. Fort St., Detroit, Mich., is now making a universal card-holder, which is shown in the accompanying illustration. Features of this device are that one size of holder can be used for various sizes of cards, and they may be arranged to hold cards in either a vertical or a horizontal position. These card-holders take up very little space while in transit or in the store-room. The holders are fastened so that nearly the entire card is exposed to view, and cards may be easily put in or taken out as desired.

FULTON TAPPING AND DRILLING MACHINE

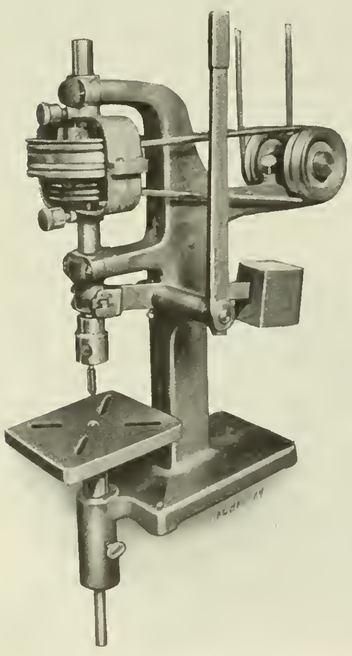
The Fulton Foundry & Machine Co., 25 Furman St., Brooklyn, N. Y., has just added a new type of tapping and drilling machine to its line of tapping machines. This is a vertical type, having an adjustable work-table and movable head. The tap or drill, as the case may be, can be fed by either hand or foot, and the head which carries the friction disks, chuck, tap, etc., is counterbalanced by a weight giving a constant unvarying balance. The friction pulleys are carried by ball bearings which take both the thrust and radial loads. Friction surfaces for the tapping drives are flat, giving great sensitiveness, and they are concentric with the spindle, thus doing away with spindle strains.

The machine is extremely simple, having no gears, positive clutches or tension adjusting devices. It will tap or drill holes up to 3/8 inch in diameter. The change from tapping to drilling can be made in less than one minute, and in no way affects the tapping efficiency. Drill speeds may be had up to 2000 R. P. M. and tapping speeds up to 1000 R. P. M. Two speeds are available for either tapping or drilling. The machine is capable of drilling a 7/32-inch hole through 1-inch brass in eight seconds. A stop is provided for drilling or tapping to a fixed depth, and a self-oiling countershaft is provided, with an improved belt shifter, for the bench type machine. The belt shifting device is carried on the jackshaft for pedestal type machines, enabling it to be set directly under a lineshaft.

DEMCO HIGH-SPEED DRILLING MACHINES

In the October, 1916, and February, 1917, numbers of Machinery, descriptions were published of bench and floor types of sensitive drilling machines built by the De Mooy Machine Co., 706 Frankfort Ave., N. W., Cleveland, Ohio. Recently this concern has added to its line a high-speed ball bearing drilling machine of similar design, which is also built in bench and floor types as illustrated herewith. These machines are especially adapted for drilling small holes where it is necessary to have the drill run at an extremely high speed in order to cut through the metal instead of forcing the drill through the metal. Operation at high speed not only increases production but reduces the breakage of drills. These new "Demco" drilling machines are fully equipped with ball bearings and adapted for operation at a maximum speed of 12,000 revolutions per minute.

They are particularly adapted for drills from 3/16 inch in diameter down, but drills from 3/16 to 3/8 inch in diameter may be used at slower speeds, three changes of speed being provided. The spindle is provided with a carefully balanced three-jaw geared nut chuck of the key type. Changes of speed are made by moving a lever on the sector which fits into a rack and allows changes to be made quickly. Two pulleys running on ball bearings are attached to the idler with a belt adjust-



Tapping and Drilling Machine built by Fulton Foundry & Machine Co.

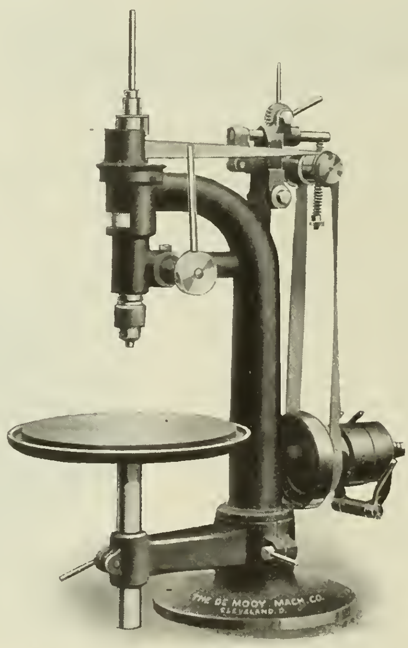


Fig. 1. "Demco" No. 22 Bench Type of Ball Bearing Drilling Machine

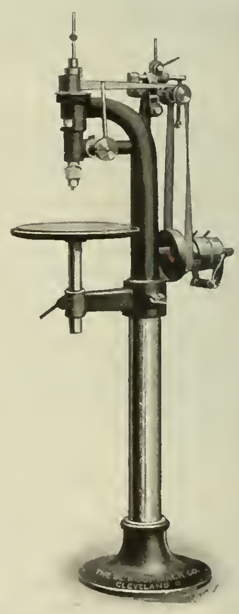


Fig. 2. "Demco" No. 23 Floor Type of Ball Bearing Drilling Machine

ment having an automatic take-up. Power is transmitted by an endless flat canvass belt, which gives great flexibility for the high speed at which it is required to travel. The spindle is made of high-carbon, heat-treated steel, accurately ground and carried in ball bearings.

Fig. 1 shows what is known as a No. 22 bench machine, the principal dimensions of which are as follows: distance from spindle center to column, 7½ inches; traverse of spindle, 4 inches; traverse of table, 7 inches; maximum distance from chuck to table, 8¾ inches; minimum distance from chuck to table, 1 inch; diameter of working surface of table, 12½ inches; diameter of table outside oil-groove, 14 inches; diameter of spindle, 7/16 inch; diameter of spindle pulley, 1½ inch; diameters of countershaft cone pulley steps, 3, 4½ and 6 inches; diameter of driving pulley, 4 inches; maximum spindle speed, 12,000 R.P.M.; maximum countershaft speed, 3000 R.P.M.; height of machine, 34 inches; and weight of machine, 135 pounds. Fig. 2 shows the No. 23 floor type machine, and the following dimensions of this machine differ from those already given for the bench type machine: distance from spindle to center of column, 7 inches; traverse of table arm, 25 inches; height of machine, 65 inches; and weight, 200 pounds.

Fig. 1. Surface Plate made by T. P. Walls Tool Co.

Fig. 2. One Use of T. P. Walls Tool Co.'s Surface Plate

KELLY "PRODUCTION" TOOLS

One of the recent additions to the line of tools manufactured by the Kelly Reamer Co., Cleveland, Ohio, is a line of what are known as "production" tools. It will be seen from the halftone illustration, Fig. 1, that these are multiple boring

Fig. 1. Kelly "Production" Tool for Simultaneous Performance of Five Operations

and facing tools, provided with pilots for maintaining concentricity. The tools are adjustable, and in the case of the tool illustrated herewith, five operations, *i. e.*, boring and facing

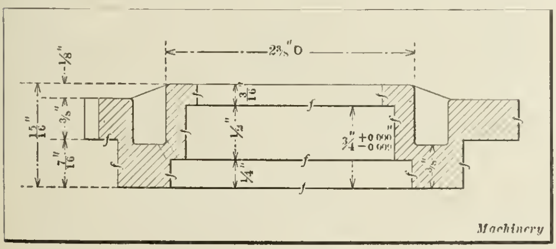


Fig. 2. Work done by Kelly "Production" Tool shown in Fig. 1

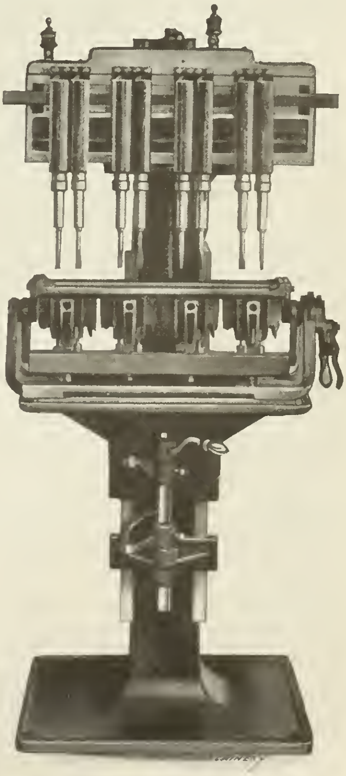
operations for diameter and depth, may be performed at one pass of the turret. Fig. 2 illustrates work for which this tool is especially adapted, and these two illustrations of the tool and its work will fully explain the purpose of this new product of the Kelly Reamer Co. without requiring further description.

T. P. WALLS SURFACE PLATES

T. P. Walls Tool Co., 75 Walker St., New York City, is now selling iron surface plates which are thoroughly seasoned before the plates are machined in order to assure the maintenance of accuracy. To further insure durability and the maintenance of an accurate and flat surface, the under side of these plates is well ribbed. After completing the machining operation, each plate is carefully inspected and tested. A substantial wooden cover is provided to protect the finished surface while the plate is not in use. Twelve different sizes of plates are made, covering a range of 6 by 6 inches minimum up to 24 by 48 inches maximum.

BRIERLEY VALVE GRINDING MACHINE

The Brierley Machine Co., 1736 E. 22nd St., Cleveland, Ohio, is now building an eight-spindle valve grinding machine, which forms the subject of the following description. On this machine a quick-acting mechanism is provided for raising and lowering the table to engage and disengage the work, and to permit the cylinders to be removed from the machine. Another feature is adjustable rotation of the ball bearing spindles. This machine has sufficient capacity to grind at one time four complete cylinders of two valves each, either single or *en bloc*. The spindles are adjustable with a minimum center distance of 1¾ inch. An interesting feature of this machine is the



Brierley Eight-spindle Valve Grinding Machine

enclosed pulley clutch, which enables the operator to start and stop the drive by moving a lever located at the top of the machine. Suitable adjustment is provided for grinding the valves in any automobile cylinder. The machine is driven by a 2½-inch single belt and can be arranged for motor drive using a two-horsepower constant-speed motor. The weight of the machine is 1200 pounds.

NEW MACHINERY AND TOOLS NOTES

Forging Press: Morgan Engineering Co., Alliance, Ohio. A steam-hydraulic forging press built in various sizes up to 12,000 tons pressing capacity. These presses are adapted for the rapid production of solid homogeneous forgings ranging in size from small die forgings up to the larger sizes of shafts, etc.

Air Compressor: National Motor Supply Co., Cleveland, Ohio. This machine is of the double-opposed type with a 2-inch bore and 2½-inch stroke. Both pistons and the yoke are cast in one piece, and the crankshaft is a drop-forging. All bearings are bronze-bushed and the cylinders are water-cooled.

Quick-acting Vise: F. C. Sanford Mfg. Co., Bridgeport, Conn. A vise combining the old-style screw with a quick-action cam. The adjusting screw runs in a floating nut to which the cam is attached. In operation, the vise jaws are brought up to the work by a thumb-nut; then the operation of the cam locks the work tightly in place.

Compound Bench Plates: A. P. McCulloch Machine Co., Boston, Mass. A compound bench plate especially designed for the use of machine shop inspectors. It consists of a flat plate, to one end of which is attached a vertical plate equipped with T-slots, vees, round holes and slots. Seven standard plugs of different sizes are furnished which fit into the holes and slots in the angle-plate.

Duplex Drilling Machine: Martin Machine Co., Greenfield, Mass. This bench drilling machine is designed especially for drilling, reaming, milling and countersinking operations on small metal goods. The spindles are hardened and ground and run in taper bronze bearings. They run in a sliding yoke controlled by a foot-lever which is so adjusted that either or both of the spindles may be operated at one time.

Inclinable Power Press: Loshbough-Jordan Tool & Machine Co., Elkhart, Ind. An open-back inclinable power press equipped with a solid-web flywheel which has a three-point clutch. A toggle control used in connection with the clutch prevents the press from repeating; and upper and lower knock-outs are provided. This press occupies a floor space of 34 by 43 inches and weighs 2000 pounds.

Tool-room and Heavy-duty Lathes: Joseph Crawford Jr. Co., Erie, Pa. The tool-room lathe swings 16½ inches over the ways and 9½ inches over the carriage; and the capacity between centers is for work up to 36 inches in length. The quick-change heavy-duty lathe swings 21½ inches over the bed and 14½ inches over the carriage; and the capacity between centers is for work up to 46 inches in length.

Lathe Accessories: Mechanical Development Co., Los Angeles, Cal. A line of four lathe accessories which include a universal tool-holder, an extension grinding machine, a boring-bar, and a universal tool grinding attachment. All of these accessories were designed for use on the same machine, and their employment singly or in combination increases the range of work that can be handled on a lathe.

Drill Chuck: Quick Action Chuck Co., Grand Rapids, Mich. A quick-acting drill chuck that enables the operator to remove a tool and substitute another in its place while the machine is in operation. When the operator wishes to change the tool, it is merely necessary for him to lift a collar to enable the collet to be removed from its housing and another one to be inserted. After this has been done, lowering the collar locks the second collet in place.

Industrial Truck: J. E. Haschke, 115 W. Redondo St., Los Angeles, Cal. A storage battery industrial truck with the motor mounted on a yoke that also carries the front wheel, this wheel being of the caster type; a high-speed electric motor is used, which can be operated at various speeds without requiring the use of resistance in the circuit or paralleling the field coils or the cells of the battery. This truck weighs approximately 1500 pounds.

Cleaning Tank: Spicer Tabulating Machine Co., Washington, D. C. A cleaning tank for use in cleansing tools and small parts. This tank is for use in removing oil, grease, chips and other dirt with gasoline or other inflammable liquids without involving danger of fire. A self-closing cover is fitted to the top of the tank, and when this is in place it brings into action a pump that raises fluid from a storage chamber and discharges it against the work to be cleaned.

Cold Saw: Earle Gear & Machine Co., 4705 Stenton Ave., Philadelphia, Pa. A special type of Lea-Simplex cold metal saw which has been illustrated and described in MACHINERY. The present machine is designed for handling bars in multiple. There is a cradle in the form of a carriage running on rollers on a structural steel frame at the rear of the machine. By means of this carriage and a handwheel operating a lead-screw, work is fed to the successive positions for cutting.

Industrial Truck: Covel Mfg. Co., Benton Harbor, Mich. A storage battery industrial truck primarily designed for use in saw mills, lumber yards, etc. However, this truck can also be employed in industrial plants for conveying loads of any kind that may be placed on wooden platforms or supported in a special carrier. A feature of this truck is that it provides for depositing the load in exactly the desired position. This truck can move either forward or backward and can be turned in a very small space.

Turret Lathe: Oliver Machinery Co., Grand Rapids, Mich. A 16-inch heavy-duty turret lathe which is of the double back-geared type driven by a three-step cone pulley and 3¾-inch belt. The headstock column is provided with a door and corner brackets to support shelving. A close fitting stud supports the turret head, and it is claimed that except for taking very heavy cuts, it is unnecessary to use the clamping lever at each operation. Forcing the turret slide back by means of a handwheel causes the locking plunger to be automatically released and the turret to be revolved to the next station.

Portable Elevator: New York Revolving Portable Elevator Co., Jersey City, N. J. A machine known as a "revolvator" which consists of a portable elevator with a swivel connection between the truck and structure on which the elevating platform is carried, to provide for rotating the platform to face in any desired direction. This outfit is used for stacking materials in industrial plants and warehouses, for transferring heavy dies from storage racks to the bolsters of machines on which they are to be used, for setting up heavy electric motors and countershafts, and for numerous similar purposes.

Box-tool: W. K. Millholland Machine Co., Indianapolis, Ind. A box-tool for turret lathes, which has a turning capacity of from ½ up to 1¾ inch bar stock. The turning tool is clamped down on a hardened steel tool-block by two set-screws, and the toolpost is a malleable iron casting supported on a large hardened and ground steel stud. By means of a tool-clearing cam lever the operator can release the tool on the back stroke of the turret so that no tool marks are left on the finished surface. Two adjustable stock-supporting rollers in this box-tool are provided with both adjustable and clamping screws.

Forming Press: Toledo Machine & Tool Co., Toledo, Ohio. A double-action toggle press especially constructed for use in forming side rails for automobile frames, and for similar operations which call for a combination of accuracy and uniformity. This machine is self-contained and employs only two motions; one slide comes down and clamps the flat blank or sheet, thus holding the blank flat, while the second movement of the machine forms the sides of the channel or frame. The work is lifted clear of the die so that it may readily be swept off without the necessity of prying out the work, which would result in the loss of a lot of time.

Cutter and Tool Grinder: Factory & Mill Supply Co., Boston, Mass. To provide for grinding cutters, small tools, fixtures, gages, and similar classes of work, this company is selling a universal cutter and tool grinder. On this machine the spindle runs in phosphor-bronze bearings which may be adjusted to provide compensation for wear. All feed movements are furnished with the usual indicating dials. Provision is made for sliding the tailstock on the base of the machine, and the tailstock spindle is also adjustable. An internal grinding attachment is furnished for use on the machine, making it adaptable for handling both internal and external work.

Machine Tool Testing Equipment: Fosdick Machine Tool Co., Cincinnati, Ohio. To provide means for testing machine tools without requiring them to be taken to some place in the shop where power is available, this company has developed a testing outfit that consists of an adjustable speed motor mounted on a three-wheel truck. This truck is set at right angles to the machine so that the motor may be belted to the machine to be tested. Using an idler pulley provides for obtaining satisfactory results with a short belt. A friction clutch controls the transmission of power and four lag-screws in the truck are driven into the floor to anchor the testing outfit securely in place.

Tapping Attachment: Hammond Mfg. Co., Cleveland, Ohio. A tapping attachment developed for use on the high-speed, ball bearing, swinging arm radial drilling machine of this company's manufacture. There are two pulleys in the head, one for forward drive and the other for reverse, both pulleys being driven by open endless chain belts which are furnished with an adjustment for tension. The spindle drive is through a double cone friction which is ordinarily held in contact with the lower or driving pulley by means of three springs. When the tap has been advanced to the desired depth, the friction cone is shifted into contact with the upper or reverse pulley, this result being obtained by pushing down a horizontal lever under the head. This results in backing out the tap at a 50 per cent increased speed.

WAR REVENUE AND SECOND-CLASS POSTAGE RATES

BY M. J. O'NEILL [1]

The House of Representatives passed the war revenue bill, May 23, practically as the bill was presented by the Ways and Means Committee two weeks earlier. The vote on the bill was 329 to 76, with 4 voting "present." Readers are familiar in a general way with the various provisions of this important bill, which undertakes to raise by direct taxes the sum of $1,870,000,000 for war purposes.

There is a decided difference of opinion among financiers and other competent people as to the necessity for raising so large a sum of money at the outset; but there is absolutely no doubt in the mind of any live American that we should raise all the money needed now and hereafter to make war, since we are in it, with all the vast resources and unparalleled power of this great democracy. If ten thousand millions of dollars instead of two thousand millions are needed, the people of this republic will furnish the money and will be found equal to the utmost effort and the greatest sacrifices. They always have been. It is proved by the battlefields of this hard-fought land, the graves of its dauntless dead, the unburied heroes of many a gallant sea battle, whose dirge the indifferent tides ceaselessly sing, making no distinction between those who fought for and those who fought, blindly and bravely enough, against democracy. This is a heroic, if peace-loving, land, and whenever the standards are raised our people flock to them, prepared to go through.

But in common with other peoples to whom war is an unfamiliar and unattractive business, we put off doing anything about it until too late, and when we begin we always make serious blunders. We appear to be making a characteristic start in the new revenue bill. This bill is, or should be, primarily a taxation measure. It should have no other purpose. The only reason for it is to raise the money to pay for the war. It is out of the labors and business of the people that wars are and must be paid for. There are no other sources of revenue. The greatest conqueror that ever lived and waged war maintained and equipped his armies out of the produce of the people. However he got it, that was what fed and equipped his armies. Very little of accumulated wealth is in form to use for war purposes. And as it is out of the current labors and business of the people that war must be paid for, the very first consideration for statesmen is to so lay their measures of taxation that the wheels of industry will continue to revolve. Taxes on profits and incomes are wise, if not too excessive; for businesses and individuals should be perfectly willing to pay their full share of war costs out of their profits and incomes. But taxes which have the effect, whatever their purpose, of destroying a business are not the offspring of broad and sagacious statesmanship. Yet the effect of the revenue bill provisions in regard to the postage rate on periodicals would be to harm seriously, if not destroy, the industrial press of this industrial nation.

Going back to the beginnings of this republic, a postage rate of one cent per pound was established on second-class matter on account of its educational value to the people; under that favorable rate journals representing practically every product and industry have been developed, and have effectually stimulated the development of the industries they represent. The people have supported these business and technical journals, which is proof of their practical educational value; and the benefit of the favorable postage rate has been passed to readers in subscription rates so low that the total amount subscribers now pay MACHINERY, for example, is less than the cost of the paper upon which the reading pages are printed, to say nothing of the cost of the journalistic service, which has been expanded and developed to an extent undreamed of by publishers twenty years ago. We need hardly emphasize this to readers of MACHINERY.

The proposal seriously made by Congressman Moon, holding the responsible position of chairman of the Post Office Committee of the House, was that periodicals be placed on the parcel post basis, parcel post zone rates applying to each copy mailed. Under this plan it would cost 36 cents to send a copy of MACHINERY to San Francisco, 20 cents to Chicago, 15 cents to Cincinnati, and 31 cents to Denver. The subscription price of MACHINERY is slightly under 17 cents per copy. Alarmed by this extraordinary proposal, the trade and technical press of the country sent a committee of representative publishers to explain to members of the House exactly what this meant to one of the country's great industries. Thanks to the energetic efforts of this committee, and the spirit of fairness which dominates the House in general, the Moon proposition failed of adoption. But the influence behind the persistent efforts to lay this crushing blow upon the already heavily burdened trade and technical press, succeeded finally in getting into the revenue bill provisions greatly increasing the postage rates on periodicals. The newspapers are hardly affected by the zone principle of postage, for the reason that practically all their circulation is local, and locally the rates are scarcely affected. Consequently, the newspapers, with hardly any exceptions, are silent on this proposition to so heavily tax the industrial press of the country. It is clear that if the facts are to be adequately laid before the people of the country, it must be done chiefly by the business press, which is our sole reason for stating the facts here.

The present postage on a copy of MACHINERY is about three cents, and we have for a long time favored a higher rate. Unfortunately, post office accounting is of such a character that it is impossible for anyone to tell with any degree of accuracy how much per pound it costs to handle and deliver periodicals. If that can be determined, that cost, regardless of the educational nature of the technical press, should be paid in the postage rate. That is our belief and we will stand for that principle always, whatever it may mean to MACHINERY. But under the revenue bill which passed the House May 23, the annual postage rate on MACHINERY goes up from a total of $7200 a year to about $20,000. Under that rate it will cost 9 cents to send a single copy of MACHINERY to Cleveland or Cincinnati, 12 cents to Omaha, 15 cents to Denver, and 18 cents to San Francisco. These increases are from 300 to 600 per cent. Yet no one in the post office or in Congress knows what relation these new and punitive postage rates bear to the actual cost of handling and delivery.

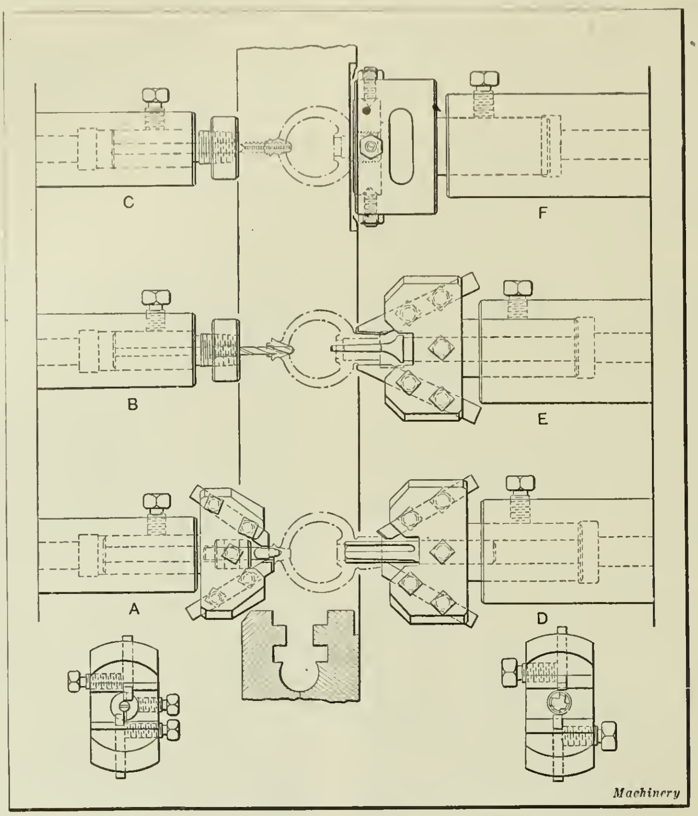
Publishers of journals like MACHINERY are now paying 100 per cent more for paper than a year or two ago, and all other costs have increased from 25 to 60 per cent. The Postmaster General himself recommended that no increase be made at present in the postage rate on second-class matter, but there seems to be a determination somewhere to lay this toll upon the industrial press of the country. We are not inclined to attribute unworthy motives to our representatives in Washington, who have their troubles and must work out their war revenue problems, which are new and involve manifold difficulties. But no industry has been singled out for such destructive legislation as the publishing of periodicals. These publishers, like all other business people, must pay the profits and income taxes, and to a greater extent than almost all others, will pay the government the heavy taxes represented by the increases in postage on letters, post cards, circulars, etc. To these taxes, however, publishers make no opposition. They apply to all, and each pays according to the benefits derived. But the destructive taxes laid down for periodicals, in the form of second-class postage rates, are leveled against a single industry, and there is no justification for them.

The bill is now in the hands of the Senators, and readers of MACHINERY who believe in fair play, and who realize, as politicians do not, the practical educational value of journals like MACHINERY, should consider it a duty to write or wire the Senators from their state, protesting against this heavy increase in the postage rates on trade and technical journals. It is generally believed that the Senate will pass the bill by June 10 or earlier. The Senators are considered open-minded on the proposition.

[1] General Manager of MACHINERY.

MACHINING SPRINKLER HEADS

The method of machining sprinkler heads used by the largest manufacturers is somewhat different from the methods described in MACHINERY for September, 1916, and May, 1917. While the sprinkler heads are finished well, the productions are much below standard commercial practice. These pieces are now handled by makers of large quantities of sprinklers in one setting on No. 53 New Britain automatic chucking machines, manufactured by the New Britain Machine Co., New Britain, Conn. The only operation not completed on this machine is the back-facing of the top of the orifice; this is done in a small lathe provided with suitable stops on both the cross- and the lengthwise feeds.



Tool Lay-outs for machining Sprinkler Heads on Automatic Chucking Machines

The automatic chucking machine is of the double-head type and has six spindles. The operations are as follows: Left-hand head: Spindle *A*, spot, turn and face; spindle *B*, drill; spindle *C*, tap. Right-hand head: Spindle *D*, bore face and chamfer; spindle *E*, bore and taper-turn; spindle *F*, thread. As all the operations are performed at the same time, a completed piece is turned out in the time of the longest operation. The production is from 280 to 350 pieces an hour. Spindles *A* and *B* make 1050 revolutions a minute, and have a 3/8-inch feed and a 1 3/4-inch stroke; spindle *C* makes 300 revolutions a minute; spindles *D* and *E* have a 1 1/8-inch feed, a 1 3/4-inch stroke, and a speed of 300 revolutions per minute; while spindle *F* has a speed of 200 revolutions a minute. End views of tools *A* and *D* are shown at the bottom of the illustration.

As the opposite spindles in the two heads of the machine are in alignment, the operations on the two ends of the sprinkler head are in line and concentric. Furthermore, as the operation of the machine is entirely automatic, except for chucking and unchucking the work, all pieces are sure to be exactly alike, which means much on work that is subjected to rigid inspection by insurance underwriters. With this method of machining, it is possible to face and turn the small end of the sprinkler head while the other operations are going on. These operations are usually necessary, and require a separate setting when handled by the methods described in the articles mentioned.

* * *

MASTER MECHANICS' AND MASTER CAR BUILDERS' CONVENTIONS CANCELLED

The committees of the American Railway Master Mechanics' Association and the Master Car Builders' Association have decided to cancel the annual convention which was to have been held in Atlantic City in June; the war emergency makes it imperative for all railway employes to be at their posts. Many other railway associations have cancelled their annual meetings on account of the present emergency.

GUTTA-PERCHA

Gutta-percha is derived from the secretions of the bark of certain trees found in the Straits Settlements and the Malaccan Archipelago. At temperatures between 32 and 80 degrees F., it resembles dark brown leather; at temperatures above 80 degrees F., it softens; and at 150 degrees F., it becomes plastic and can be molded. Upon cooling, it again becomes non-plastic. It oxidizes when exposed to the air, changing its color and becoming brittle. The chief use of gutta-percha is for electrical insulating purposes. It appears in commerce in the forms of blocks or cakes of a grayish appearance. When used for insulation, it is shredded into warm water, kneaded, strained and rolled into sheets. It is applied to the wire that is to be insulated by special tubing machines or wound upon the wire in the form of strips. Gutta-percha may be used as an insulating material in the pure state, without admixtures of any kind. It is less porous than rubber, and is therefore more waterproof. For this reason, it is the best material to use as an insulation for submarine cables. Its specific gravity is almost exactly equal to that of water.

* * *

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

of MACHINERY, published monthly on the 1st at New York, N. Y., for April 1, 1917.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the state and county aforesaid, personally appeared Matthew J. O'Neill, who, having been duly sworn according to law, deposes and says that he is the General Manager of MACHINERY and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, The Industrial Press	140-148 Lafayette St., New York
Editor, Fred E. Rogers	" " " " "
Managing Editor, None	
Business Managers { Alexander Luchars, President	" " " " "
Matthew J. O'Neill, Gen'l Manager	" " " " "

2. That the owners of 1 per cent or more of the total amount of stock are:

The Industrial Press	140-148 Lafayette St., New York
Alexander Luchars	" " " " "
Matthew J. O'Neill	" " " " "
Fred E. Rogers	" " " " "
Louis Pelletier	" " " " "
Erik Oberg	" " " " "

3. That there are no bondholders, mortgagees or other security holders.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

MATTHEW J. O'NEILL, General Manager.

Sworn to and subscribed before me this 2nd day of April, 1917.

THOMAS R. WILLIAMS,

(SEAL) Notary Public, New York County, No. 254.
(My commission expires March 30, 1918.)

SPRING CONVENTION OF N. M. T. B. A.

The spring convention of the National Machine Tool Builders' Association was held in Cincinnati, May 21 and 22, the Hotel Sinton being the headquarters. President J. B. Doan, of the American Machine Tool Works, presided. On Monday morning, following the usual routine matters, a symposium on the elements of cost in machine tool building was presented under the following heads:

"Pig Iron," by James Albert Green, Matthew Addy & Co.
"Steel," by Royal Mattice, American Steel & Wire Co.
"Lumber," by S. B. Stanbery, Chicago Lumber & Coal Co.
"Supplies," by William J. Radcliffe, E. A. Kinsey Co.
"Labor," by Murray Shipley, Lodge & Shipley Machine Tool Co.
"Overhead Burden," general discussion.

Resolutions of respect were passed by standing vote for the late F. E. Reed and William Lodge.

The program for the afternoon included the following:

"Lessons and Opportunities of the World War for American Manufacturers," by William Hard, investigator and contributor to the *Metropolitan Magazine.*
"Machine Tool Protection Devices," by H. W. Dunbar, Norton Grinding Co.
"Trade Acceptances," by Z. Chafee, Diamond Machine Co.

Tuesday forenoon was devoted to meetings of standing committees and executive session. In the afternoon a joint session was held with the American Society of Mechanical Engineers, at which Dean Herman Schneider of the University of Cincinnati presented a paper, "The Human Side of Engineering," following which was "The Human Potential in Industry," by Dr. Otto P. Geier. At the close of the joint session, MACHINERY's motion picture, showing the machining operations on the British 9.2-inch high-explosive shell, as performed in the plant of the A. P. Smith Mfg. Co., East Orange, N. J., was shown. This motion picture, which has been made under the direction of Chester L. Lucas and Victor Brook of MACHINERY's staff, was received with great interest, as it shows in an unusually clear manner the operations and indicates the use to which motion pictures might be put in the mechanical industries for instruction purposes. The picture was accompanied by a talk by Mr. Lucas, which aided in making clear every point in the process of machining.

The smoker at the Business Men's Club, Tuesday evening, under the direction of Fred A. Geier, provided a unique entertainment greatly enjoyed by an audience that taxed the capacity of the place. Patriotic airs were played and sung, accompanied by novel lighting effects. Features were a mock trial in which some of the characteristics of prominent engineers were parodied. A short play on fitting men to their jobs took off the cooperative school work. This and other entertainments gave fresh proof of the hospitality of Cincinnati.

* * *

SPRING MEETING OF A. S. M. E.

The spring meeting of the American Society of Mechanical Engineers was held jointly with the National Machine Tool Builders' Association in Cincinnati, May 21-24, inclusive, the Hotel Sinton being the headquarters. It was a notable meeting, coming at a time when engineers have presented to them problems that never have been placed before the engineering fraternity. The feature of the spring meeting was the session on the manufacture of munitions and related problems. Excursions were made to a number of manufacturing plants in Cincinnati, among which were the Lodge & Shipley Machine Tool Co., Cincinnati Milling Machine Co., Cincinnati Planer Co., Cincinnati Bickford Tool Co., and Lunkenheimer Co.

President Ira N. Hollis delivered an address Monday evening on the meaning of war to America and the part played by the engineer. The regular program began Tuesday morning with the presentation of the following papers:

"Tests of Uniflow Steam Traction Engines," by F. W. Marquis.
"Relation of Efficiency to Capacity in the Boiler Room," by Victor B. Phillips.
"Radiation Error in Measuring Temperature of Gases," by Henry Kreisinger and J. F. Barkley.
"Development of Scientific Methods of Management in a Manufacturing Plant," by Sanford E. Thompson, William O. Lichtner, Keppel Hall and Henry J. Guild.
"Disk-wheel Stress Determination," by S. H. Weaver.

The machine shop session followed with:

"A Foundation for Machine Tool Design and Construction," by A. L. DeLeeuw.
"Machine-shop Organization," by Fred G. Kent.
"Metal Planers and Methods of Production," by Charles Meier.

Gas power and industrial safety sessions were also held, at which these papers and drafts of codes were presented:

"The Problem of Aeroplane Engine Design," by Charles E. Lucke.
"Test of a Motor Fire Engine," by Horace Judd.
"The Design of Motor Truck Engines for Long Life," by John Younger.
"The Relation of Port Area to the Power of Gas Engines and Its Influence on Regulation," by J. R. DuPriest.
Tentative Draft of Code of Safety Standards for Industrial Ladders.
Tentative Draft of Code of Safety Standards for Power Transmission Machinery.

The spring meeting was characterized by two munitions sessions, the first being held Wednesday forenoon. The program was as follows:

Opening remarks by Lieutenant T. S. Wilkinson, Jr., U. S. N Bureau of Ordnance.
"Munitions Contracts and Their Financing," by Frederick A Waldron.
"Organizing for Munitions Manufacture," by Arthur L. Humphrey.
"Organization for Munitions Manufacture," by Harry L. Coe.
"Procuring Special Machines for Munitions Manufacture," by H. V. Haight.
"Practical Wartime Shell Making," by Lucien I. Yeomans.

The second munitions session, Thursday forenoon, comprised the following:

"Munitions Design for Quantity Manufacture," by J. E. Otterson.
"Procuring Materials for Munitions," by C. B. Nolte.
"Limits and Tolerances for the Manufacture of Munitions," by A. W. Erdman.
"Gages and Small Tools," by Frank O. Wells.
"The Importance of Intelligent Inspection in Munitions Manufacture," by E. T. Walsh.

The interest in the war problems confronting engineers and manufacturers was shown at the munitions sessions. The papers were discussed at length from many angles by men actively engaged in making shells, fuses and tools. The gravity of the situation is keenly realized, and cooperative effort is being made to place data at the disposal of all needing them.

* * *

CONVENTION OF AMERICAN GEAR MANUFACTURERS ASSOCIATION

The first convention of the American Gear Manufacturers' Association was held in Pittsburg, May 14 and 15, at which were present representatives from the following manufacturers:

Bilgram Machine Works, Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Cincinnati Gear Co., Cincinnati, Ohio.
Crofoot Gear Works, Inc., Boston, Mass.
Earle Gear & Machine Co., Philadelphia, Pa.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Frost Gear and Forge Co., Jackson, Mich.
William Ganschow Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Hamilton Gear & Machine Co., Toronto, Canada.
Horsburgh & Scott Co., Cleveland, Ohio.
D. O. James Mfg. Co., Chicago, Ill.
W. A. Jones Foundry & Machine Co., Chicago, Ill.
Meisselbach-Catucci Mfg. Co., Newark, N. J.
Newark Gear & Machine Co., Newark, N. J.
R. D. Nuttall Co., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Pittsburg Gear & Machine Co., Pittsburg, Pa.
Simonds Mfg. Co., Pittsburg, Pa.
Van Dorn & Dutton Co., Cleveland, Ohio.

The papers presented at the meeting were:

"The Ins and Outs of an Industry Organization," by S. L. Nicholson.
"The Spiral or Curved Tooth Bevel Gear," by James E. Gleason.
"Job Gearing—to what Extent can it be Standardized," by Frank Burgess.
"Advantages of Gear Standardization," by William Ganschow.

An address was made by Phillie Gear which caused great applause and laughter. F. M. Sinram was elected president; Henry E. Eberhardt, vice-president; Frank D. Hamlin, secretary; and Frank Horsburgh, treasurer. Ten new members joined the association at the meeting.

When

Put that grinding job on a Brown & Sharpe Machine. Not alone because accuracy is then assured but because work to the closest limits can be handled easily and rapidly—in keeping with present-day demands. In the tool-room Brown & Sharpe Universal Grinding Machines, because of their great range, prove a profitable investment. These efficient, many-purpose machines grind straight and taper, external and internal cylindrical surfaces, sharpen tools and cutters and prove their usefulness and dependability on numberless miscellaneous grinding jobs.

There Is Plenty of Work In Every Tool Room

for these machines and in many shops they are considered among the most profitable equipment installed.

Detailed description of the many features of these machines — the automatic cross feed mechanism, universal back rests, complete separation of speeds and feeds, etc.—gladly sent on request.

Built in Four Sizes

No. 1
taking work 10 in. diameter, 24 in. length.

No. 2
taking work 12 in. diameter, 30 in. length.

No. 3
taking work 12 in. diameter, 40 in. length.

No. 4
taking work 12 in. diameter, 60 in. length.

A tool-room foreman on being shown the above photograph said, "When we bought our first one the superintendent questioned whether I would have enough work for it. It did not take us long, however, to find out that we could not only keep one busy, but really needed another."

Brown & Sharpe Mfg.

OFFICES: NEW YORK, N. Y., 20 Vesey St. PHILADELPHIA, PA. 652-654 The Bourse. CHICAGO, ILL., 626-630 Washington Blvd. ROCHESTER, N. Y., 415 Chamber of Commerce Bldg. SYRACUSE, N. Y., Room 419 University Block. PITTSBURGH, PA., 2538 Henry W. Oliver Bldg. CANADIAN REPRESENTATIVE: MONTREAL, TORONTO, WINNIPEG, CALGARY, VANCOUVER, ST. JOHN, SASKATOON, The Canadian Fairbanks-Morse Co., Ltd.

PERSONALS

George W. Cope, editor of the *Iron Age*, has resigned and retired from business. Mr. Cope joined the editorial staff of the *Iron Age* in 1883.

Robert B. Luchars, son of Alexander Luchars, and secretary of MACHINERY, has joined the Reserve Officers Training Camp at Fort Myer, Va.

W. E. Best, for the past five years superintendent of the National Cash Register Co., Dayton, Ohio, has resigned.

William H. Blount, formerly chief draftsman with Sleeper & Hartley, Inc., Worcester, Mass., has been appointed superintendent of the company's plant No. 1 on Prescott St.

David W. Taylor, chief constructor, chief of Bureau of Construction and Repair, United States Navy, was presented with the Franklin medal by the Franklin Institute, May 16.

John G. Barry has been appointed general sales manager of the General Electric Co., Schenectady, N. Y. Mr. Barry will also continue to act as manager of the railway department.

Charles Whiting Baker has resigned as editor-in-chief of the *Engineering News-Record* of New York City, and has been succeeded by Frederick E. Schmitt. Mr. Baker will act as consulting editor.

Edwin J. Peirce, Jr., has opened offices at 253 Broadway, and is making a specialty of investigating conditions governing plants and suggesting methods whereby their production cost can be decreased.

R. F. Ingram, formerly in charge of tool purchasing with the New England Westinghouse Co., East Springfield, Mass., has joined the sales department of the Cleveland Milling Machine Co., Cleveland, Ohio.

Henry F. Russell has resigned from the sales force of the Lumen Bearing Co., Buffalo, N. Y., after a service of thirteen years, to become sales manager of the gray iron foundry division of Farrar & Treffts, Buffalo, N. Y.

Joseph W. Wunsch, a contributor to MACHINERY, has established the Paramount Pattern & Model Works, with offices at 207 Center St., New York City, for the purpose of manufacturing patterns and models, aluminum and composition castings, and experimental machinery.

F. Quattrone, chief engineer of the Italian State Railways, has arrived in the United States as a special delegate of the Italian State Railways to be attached to the Italian Embassy at Washington, and will have charge of the purchase and shipment of all materials contracted for by the Italian government.

Keith R. Rodney, for many years connected with the Midvale Steel Co. and for the past two years supervisor of heat-treating with the Winchester Repeating Arms Co. of New Haven, has recently become associated with the Bullard Machine Tool Co., Bridgeport, Conn., as metallurgist and special counselor in the selection and treatment of steels.

Gustaf Akerlund, formerly chief engineer of the Standard Gas Power Co., has established a consulting and contracting engineering business in the gas producer and gas power line, in partnership with George W. Semmes, who was formerly assistant chief engineer with the Standard Gas Power Co. Their office is located at 17 Battery Place, New York City.

L. H. Metzger, formerly sales manager with Kearney & Trecker, Milwaukee, Wis., has become associated with the sales department of the Cleveland Milling Machine Co., Cleveland, Ohio. Mr. Metzger has had wide experience in machine tool sales. He has been connected with the Motch & Merryweather Co., Cleveland, and Manning, Maxwell & Moore, at St. Louis and Cleveland.

OBITUARIES

Lewis R. Pomeroy, for years a consulting engineer in the railway and electrical field, died suddenly May 7 at his home in Orange, N. J., of heart disease, aged sixty years. From 1874 to 1880 Mr. Pomeroy was engaged in commercial business as a bookkeeper, draftsman and designer of cars and locomotives; from 1880 to 1886 he was secretary and treasurer of the Suburban Rapid Transit Co. of New York City; and for the following four years was a special representative of the Carnegie Steel Co. for basic boiler steel used for locomotives and special railway forgings. Subsequently, he became connected with the Cambria Steel Co. and the Latrobe Steel Co. jointly in experimental research work. In 1899 Mr. Pomeroy went with the Schenectady Locomotive Works as assistant to A. J. Pitkin, which position he held for three years. The following six years were spent as special representative of the General Electric Co. in the mechanical railway field. Later he was assistant to the president of the Safety Car Heating & Lighting Co., and subsequently he was engaged in independent consulting work. He is survived by a son and a daughter.

William Lodge

WILLIAM LODGE

For more than thirty-five years William Lodge was so closely associated with the machine tool industry that a history of his manifold activities during that period would almost be a history of machine tool progress in this country—and especially is this true of the development of the industry in the city of Cincinnati.

Born in Leeds, England, on May 12, 1848, Mr. Lodge had reached a vigorous old age when he died suddenly on April 30 last. Like nearly all successful mechanics, he began his life work early, starting as an apprentice in the machine shop of Fairbairn & Co. of Leeds, England, when he was fourteen. In 1869 he came to Philadelphia, and in 1872 settled in Cincinnati, with which city and its great machine tool industry he was closely identified to the day of his death. He obtained employment with John Steptoe, a well-known machine tool manufacturer of that day, with whom he remained for eight years, and then, having saved a thousand dollars, formed a partnership with William Barker and another Steptoe workman named Bechle, under the firm name of Lodge, Barker & Co., making lathes. The business made substantial and continuous progress until 1886, when the firm name was changed to Lodge, Davis & Co., Mr. Barker retiring and Mr. Davis taking his place. In 1889 the business was incorporated as the Lodge & Davis Machine Tool Co., from which Mr. Lodge retired in 1892, starting a new company under the name of the Ohio Machine Tool Co. In August, 1892, he associated himself with Mr. Murray Shipley under the name of the Lodge & Shipley Machine Tool Co., and this association and friendship continued until the day of his death.

Mr. Lodge became widely known on account of being the first, or one of the first, machine tool builders to specialize in the manufacture of a single tool instead of making several kinds, as was then the custom, and by adhering strictly to this policy he was able to produce a superior machine at a price that insured a wide and steady market. Many of the Cincinnati machine tool concerns were founded by men who were at one time employed by Mr. Lodge, or obtained their start through orders for tools or parts placed with them by his firm. Mr. Lodge's name was known wherever machine tools are used, not only because of his advanced methods of manufacturing, but on account of his whole-souled geniality and wonderful faculty of making friends, of whom he had a multitude. Mr. Lodge never forgot the days when he was a workman, and for that reason was especially successful in handling his employes. He was a member of the Queen City, Commercial, Engineers' and Business Men's Clubs, the American Society of Mechanical Engineers, the Machinery Club of New York, and was a thirty-second degree Mason. Mr. Lodge was one of the organizers of the Machine Tool Builders' Association, which was formed at a meeting in New York, June 12, 1901, and was its second president.

COMING EVENTS

June 11-12—Annual meeting of the Electric Power Club in Washington, D. C.; New Willard Hotel, headquarters. C. H. Roth, secretary, 1410 W. Adams St., Chicago, Ill.

June 12-15—Summer meeting of American Society of Civil Engineers in the "Twin Cities," Minneapolis and St. Paul; Radisson Hotel, headquarters.

June 20-22—Semi-annual meeting of American Institute of Chemical Engineers in Buffalo, N. Y. J. C. Olson, secretary, Cooper Union, New York City.

June 23-30—Industrial exposition and export conference at Springfield, Mass. John C. Simpson, general manager.

June 25-26—Summer meeting of the Society of Automotive Engineers at the Bureau of Standards, Washington, D. C.

June 25-30—Annual convention of American Institute of Electrical Engineers in Hot Springs, Va.; Homestead Hotel, headquarters. F. L. Hutchinson, secretary, 29 W. 39th St., New York City.

June 26-30—Annual meeting of American Society for Testing Materials in Atlantic City, N. J. Edgar Marburg, secretary, University of Pennsylvania, Philadelphia, Pa.

June 28—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

August 30-September 1—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Museum of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

SOCIETIES, SCHOOLS AND COLLEGES

University of Vermont, Burlington, Vt. Catalogue for 1916-1917, with announcements for 1917-1918.

Newberry College, Newberry, S. C. Catalogue for the sixtieth session, 1916-1917, and announcements for 1917-1918.

University of Missouri, School of Mines and Metallurgy, Rolla, Mo. Catalogue 1916-1917, with calendar for 1917-1918.

Hebrew Technical Institute, Stuyvesant and 9th Sts., New York City. Annual report of the institute for the year 1916.

Hebrew Technical Institute, Stuyvesant and 9th Sts., New York City. Catalogue for 1917, giving the courses of instruction, conditions of admission, etc.

New York University, New York City. Preliminary announcements of the day and evening sessions of the School of Commerce, Accounts and Finance for 1917-1918.

International Correspondence Schools, Scranton, Pa. Booklet entitled "A Solution of the Vocational-Education Problem," describing the educational methods of the International Correspondence Schools.

Railway Car Manufacturers' Association has opened an office in Room 2216 at 61 Broadway, New York City. Dr. W. F. M. Goss, formerly dean of the College of Engineering of the University of Illinois, is the president.

Franklin Institute, Philadelphia, Pa., has awarded Franklin medals to Hendrik Antoon Lorentz, president of the Royal Academy of Sciences, Amsterdam, and to David Watson Taylor, chief of the Bureau of Construction and Repair, United States Navy.

Louisiana State University, Baton Rouge, La. Catalogue 1917, containing general information relating to the university, admission requirements, outlines of courses of the college of agriculture and engineering, and announcements for the year 1917-1918.

Lowell Textile School, Lowell, Mass. Bulletin for the year 1917-1918, containing a brief description of the Lowell Textile School and its equipment, an outline of the courses, and the subjects required for entrance, as well as a register of the day students during the term 1916-1917.

Providence Engineering Society, Providence, R. I., gave its second annual dinner in Providence, May 2, to about 400 people, including the leading engineers of Rhode Island. The dinner was a patriotic affair; the speakers dwelt upon the part played by engineers in war, the need of conserving resources and improving the efficiency of industries, etc.

NEW BOOKS AND PAMPHLETS

Report on the Price of Gasoline in 1915. 224 pages, 6 by 9 inches. Published by the Federal Trade Commission, Washington, D. C.

Temperature Measurements in Bessemer and Open-hearth Practice. By George K. Burgess. 29 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards No. 91.

Structure of the Coating on Tinned Sheet Copper in Relation to a Specific Case of Corrosion. By Paul D. Merica. 18 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards No. 90.

Facts and Fallacies of Compulsory Health Insurance. By Frederick L. Hoffman, statistician of the Prudential Insurance Co., Newark, N. J., being an address read in part before the section on social and economic science of the American Association for the Advancement of Science, December 28, 1916, and the National Civic Federation, January 22, 1917. Published by the Prudential Insurance Co., Newark, N. J.

Storage Batteries Simplified—Operating Principles—Care and Industrial Applications. By Victor W. Page. 208 pages, 5 by 7¼ inches; 89 illustrations. Published by the Norman W. Henley Publishing Co., New York City. Price, $1.50.

The book is a non-technical treatise on the development of the modern storage battery, outlining the principle of operation of the leading types and the methods of construction, charging, maintenance and repair. A glossary of storage battery terms is included.

The Driving of Machine Tools. By Thomas R. Shaw. 221 pages, 4½ by 7¼ inches; 139 illustrations. Published by Scott, Greenwood & Son, London, England, and D. Van Nostrand Co., New York City. Price, $2.

This book is based on a series of lectures on machine tools given by the author at the Royal Technical Institute, Salford, and its object is to give some simple and rational methods of arranging a drive to give the desired results and to include such formulas, rules and data as are required. After discussing the importance of durability of machine tools and accessibility of construction, the author takes up cone pulleys and gearing, applications of the cone pulley, characteristics of all-geared drive, applications of electric motor drive, the peculiarities of planing machine drives, drives for various machine tools and miscellaneous matters. The work contains a large amount of valuable information and data pertaining to machine tool drives in small compass.

Organization in Accident Prevention. By Sydney W. Ashe. 130 pages, 6 by 9 inches; 76 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $1.50.

The aim of this book is the development of the "safety habit" by the employes, and the opening chapter tells how this may be obtained through fellowship, system, education and discipline. Special emphasis is laid on the need of education, but it is pointed out that before a suitable educational course can be laid out, the accident data of the company must be systematized and studied. About one-half of the book is devoted to specific accidents that may be reduced in number; then come discussions of the medical and physical examinations of employes, with special reference to tuberculosis and hernia, and emergency hospitals and first aid; then the methods of keeping accident records, analyzing them, and the drawing of ratio curves are described, after which accident relationships are discussed. It is stated that the best safety habits are found among workers approximately thirty-seven years of age, that the tendency to accidents is greatest between 9 and 10 o'clock in the morning, and that in this country Monday is the worst day of the week.

A Preliminary Study of the Alloys of Chromium, Copper and Nickel. By D. F. McFarland and O. E. Harder. 60 pages, 6 by 9 inches; 68 illustrations. Published by the Engineering Experiment Station of the University of Illinois, Urbana, Ill., as Bulletin 93. Price, 30 cents.

The growing interest in special acid-resisting alloys and the many uses found for them have stimulated both the search for efficient materials of this nature and the causes underlying their inertness. As a result of previous studies at the University of Illinois, it has been shown that the almost perfect insolubility of certain alloys in nitric and other acids seems to be conditioned upon a proper mixture of chromium, copper and nickel, together with smaller quantities of such added metals as tungsten or molybdenum. As a result of the studies, methods have been developed for making castings of alloys of chromium, copper and nickel. More than 300 corrosion tests have been made to measure the effects of acids upon the metals. In general, the results indicate that certain of the alloys of chromium, copper and nickel give promise of becoming of great commercial importance, not only in the construction of laboratory apparatus, but in manufacturing and chemical processes.

NEW CATALOGUES AND CIRCULARS

Link-Belt Co., Chicago, Ill. Catalogue 260 on link-belt and sprocket wheels for sawmills.

Scovill Mfg. Co., Waterbury, Conn. Annual report of accident statistics for the year 1916.

Enterprise Machine Works, 115 W. Redondo St., Los Angeles, Cal. Circular giving general specifications of the Enterprise electric industrial floor trucks and tractors.

Link-Belt Co., Chicago, Ill., is distributing a wall hanger printed in colors containing a portion of President Wilson's proclamation. Copies will be sent on request.

Lamb Knitting Machine Co., Chicopee Falls, Mass. Circular of the Lamb grinder provided with self-aligning, double-row ball bearings and the Lamb automatic oiling system.

Cooper Hewitt Electric Co., 8th and Grand Sts., Hoboken, N. J. Bulletin 67, giving specifications for types P, L, H and K indoor electric lamps for use with direct current.

J. H. Williams & Co., 61 Richards St., Brooklyn, N. Y. Catalogue in Spanish of the J. H. Williams wrenches, lathe tools, cutting-off tools, threading tools, dogs, and clamps.

Link-Belt Co., Chicago, Ill. Booklet 303, entitled "Some Modern Coal Tipples," describing equipment installed by the Link-Belt Co. at the plants of various coal and coke companies.

Cooper Hewitt Electric Co., 8th and Grand Sts., Hoboken, N. J. Bulletin 66, giving specifications for Cooper-Hewitt types E and F indoor electric lamps, for use with alternating current.

Link-Belt Co., Chicago, Ill. Catalogue 305, containing an article on "Traveling Water Screens for Condenser Intakes," by Henry J. Edsall, which was reprinted from the "Practical Engineer."

Stow Mfg. Co., Binghamton, N. Y. Miniature bulletins 101 and 102 on flexible shaft and electric tools, respectively. These bulletins are the same as the regular catalogues, but are issued in small sizes for convenience.

Ready Tool Co., Bridgeport, Conn. Circular of welded "Stellite" lathe tools, consisting of "Stellite" tips welded to machine steel shanks, thus giving the user the advantages of a solid forged high-speed tool at comparatively low cost.

North Side Tool Works, Dayton, Ohio. Circular of "Universal" amplifying gages for gaging tool and production work. The gages are made with attachments and fixtures to suit them to all conditions and classes of work within their capacity.

Albany Lubricating Co., 708-710 Washington St., New York City, issues a monthly publication called "The Bearing," treating of the lubrication of bearings of various kinds, with especial reference to the use of "Albany" grease and "Albany" grease cups.

Onondaga Steel Co., Syracuse, N. Y. Circular on the "Onondaga" process for converting high-speed steel odds and ends into new high-speed steel. The economic importance of the process at the present time, when tungsten is scarce and high priced, is obvious.

General Electric Co., Schenectady, N. Y. Bulletin 43503, entitled "The Application of 'Novalux' Units to Ornamental Street Lighting," containing thirty-six pages of illustrations showing lighting units for business streets, residential streets and outlying districts.

Royal Mfg. Co., Rahway, N. J. Booklet entitled "Producing the Fittest in Waste," relating to cotton waste of the quality handled by the company. The booklet describes the method of sorting, grading, mixing, pulling, screening, and handling waste for the machinery trades.

Link-Belt Co., Chicago, Ill. Bulletin 253, entitled "The Ideal Drive for Cement Mill Equipment," describing the large Link-Belt silent chain drive installed at the plant of the Nazareth Cement Co., Nazareth, Pa., which consists of 32 Link-Belt silent chain drives, totalling 3500 horsepower.

Sleeper & Hartley, Inc., 68 Prescott St., Worcester, Mass. Bulletin 269 on wire nail machines which are so designed and constructed as to produce wire nails from a coil at much greater speeds than have heretofore been possible, and with a great reduction of noise characteristic of wire nail making machines in general.

Columbian Hardware Co., Cleveland, Ohio. Catalogue of Columbian vises and anvils. The catalogue comprises 36 pages, illustrating, describing and giving dimensions of blacksmiths' vises, arsenal vises, hand vises, clip horn anvils, blacksmiths' anvils, machinists' vises, gage-makers' vises, pipe vises, and patternmakers' vises.

Barnes Drill Co., 814 Chestnut St., Rockford, Ill. Catalogue of Barnes self-oiling, all-geared drilling and tapping machines. These machines are made in sizes of 20, 22, 24 and 26 inches. In addition to the single-spindle type, these machines are also made in the gang type with from two to six spindles mounted on one base.

Goodell-Pratt Co., Greenfield, Mass. Tool book 13, showing more than 1500 tools made by this company, among which are drills, punches, adjustable wrenches, screwdrivers, awls, bits, levels, drill chucks, ratchet bit braces, speed indicators, universal calipers, tool sets, hacksaw blades and frames, polishing and grinding heads, rules, etc.

New Departure Mfg. Co., Bristol, Conn. Sheets Nos. 95 FE to 98 FE, inclusive, for loose-leaf catalogue, showing the application of ball bearings to friction clutch for lineshaft pulley, the remodeling of plain bearing equipment, use of ball bearings in the electrical drive for elevator worm-gearing, and ball bearings for vertical shaft and drive pulley support.

American Steel Export Co., Woolworth Bldg., New York City. Booklet entitled "Export Engineering and Contracting," advertising the service which the company is in a position to render. Estimates, designs and equipment are furnished for a large line of different kinds of machinery, including mining, paper mill, saw mill, welding, foundry, and special machinery.

Cooper Hewitt Electric Co., 8th and Grand Sts., Hoboken, N. J. Bulletin entitled "Economics of Industrial Lighting," which comprises a treatise on the application of the principles of illuminating engineering to the lighting of factories, shops and works. The book is illustrated with views of factory in-

teriors showing the illumination obtained with Cooper-Hewitt electric lights.

Springfield Grinding Co., Chester, Mass. Catalogue of "MaxF" grinding wheels, giving price lists for straight wheels, taper wheels, cup wheels, cylinder wheels, and special shaped wheels. "MaxF" wheels are manufactured by four different processes, namely, vitrified, silicate, elastic and vulcanite. Tables of grades indicating the various degrees of hardness of these wheels and tables for selecting the grades are included.

Bradford-Ackermann Corporation, Forty-second St. Bldg., New York City. Bulletin 101 on "Astra" oxy-illuminating gas apparatus for lead burning. The apparatus was developed with the needs of storage battery manufacturers and service stations in view. It makes possible the use of artificial or natural illuminating gas drawn directly from the mains in connection with tanked oxygen for lead burning or welding.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 3311, covering the "Imperial" type X duplex steam-driven compressors suitable for general industrial application of compressed air. The catalogue gives tables of sizes and capacities. Form 8507, descriptive of "Little David" pneumatic drills, showing a large number of types and sizes and giving recommendations for the particular type of work for which each is adapted.

Thomas Elevator Co., 22 S. Hoyne Ave., Chicago, Ill. Bulletins on the "Barker" wrench and wrenchless chucks, illustrating construction, application and use. The wrenchless chuck is so designed that it can be used on any engine lathe, and means are provided by which the rotation of the spindle is caused to close or open the jaws, thus saving the strength and time of the operator and insuring a powerful grip on the work.

Greenfield Tap & Die Corporation, Greenfield, Mass., has issued a manual containing instructions for the use of its employes. It contains information concerning pay regulations, absence from work, use of materials, machines and tools, workmen's compensation act, dining-room service, house and room register, benefit associations, library, educational classes, employment department, sanitation and health, social and athletic interests, etc.

Hyatt Roller Bearing Co., Newark, N. J. Engineering bulletin 408 on Hyatt roller bearings for drilling machines. The data given will enable the manufacturer and designer of drilling machines to select the correct size and type of bearings and to provide for their proper housing. Tables of dimensions of high-duty bearings and planished race type bearings are given, and the application of these bearings is clearly illustrated by line drawings.

Link-Belt Co., Chicago, Ill. Data book 125 on the "Link-Belt Silent Chain," bound in flexible leather covers. The book contains 128 pages, 6 by 9¾ inches, showing numerous illustrations of the application of Link-Belt silent chain for the transmission of power. Over 200,000 installations have been drawn on for the information presented. Tables of data that should be of considerable value to engineers and users of power in selecting drives are included.

Webster & Perks Tool Co., Springfield, Ohio. Circular of No. 1 grinder, floor or bench type. The company is also distributing a convenient pocket slide-rule for grinding wheel operators. On one side is given a table of circumferences in feet for wheel diameters in inches, and on the other side a table of grinding wheel speeds for wheel diameters in inches and millimeters for surface speeds of 4000, 5000 and 6000 feet. This convenient slide-rule makes the calculation of grinding wheel speeds for any diameter and speed ordinarily used a quick and easy matter.

Tate-Jones & Co., Inc., Pittsburg, Pa. Booklet entitled "Heat-treatment of Steel," which is intended as a reference book of formulas, heat-treating methods and general information. The book has been made brief and compact, and is written in a simple, untechnical style, for the use of shopmen. The subjects covered are annealing, hardening, tempering, cooling baths, scaling, hardening heats and tempering heats. The section headed "Different Thermometer Temperatures" gives rules for changing Fahrenheit to Centigrade, Fahrenheit to Reaumur, Centigrade to Reaumur, and vice versa.

Fellows Gear Shaper Co., Springfield, Vt. Treatise entitled "Commercial Gear Cutting." This book, covering 93 pages, 6 by 9 inches, gives a complete and well illustrated description of modern commercial gear cutting, dealing particularly with the production of spur, helical, and internal gears on the Fellows gear shaper. The book is divided into ten chapters, entitled: Profit the Final Test; The Gear Shaper Cutter and How It Works; Generating a Cutter; Comparisons; The Generated Cutter at Work; The Essentials of Profit in Gear Cutting; Description of No. 6 Fellows Gear Shaper; Description of No. 65 Helical Gear Shaper; Description of Different Sizes of Gear Shapers; A Few Examples of Work Cut on the Gear Shaper. Throughout the text there are sixty-four halftone and line engravings, the latter, especially, being exceedingly clear and provided with explanatory descriptive matter, making it easy to grasp the construction of the machine.

American Steel Export Co., Woolworth Bldg., New York City, is distributing copies of a reprint from the "Iron Trade Review" of an article by Samuel A. Benner, entitled "What Peace Means to Steel Trade." Mr. Benner refers to the fact that for over two years the United States has occupied the unique position of being the only country able to supply iron and steel for the international markets. Following the end of the war there will be some demand from Europe for steel for reconstruction purposes, but this demand will not be great nor for long. There will be a demand for constructive work in the United States and the replenishment of stocks everywhere, following which will be the resumption of active foreign competition. Mr. Benner points to the important need of cooperation of manufacturers to reach foreign buyers and supports the Webb bill, which would permit cooperation between American manufacturers without violation of the anti-trust laws.

TRADE NOTES

Oxy-acetylene Products Co. has moved from Chicago, Ill., to 630 Brooklyn Ave., Kansas City, Mo.

Cincinnati Lubricant Pump Co., 125 Opera Place, Cincinnati, Ohio, has changed its name to Fulflo Pump Co.

Herman A. Holz has moved from 50 Church St. to the Metropolitan Tower, 1 Madison Ave., New York City.

Zenite Metal Co., Indianapolis, Ind., is building a large addition to its factory and is installing enough new presses to double its present capacity for stamped steel work.

Wilmarth & Morman Co., 1180 Monroe Ave., N.W., Grand Rapids, Mich., manufacturer of grinding machines, is making a two-story brick and steel addition to its plant, 74 by 84 feet.

Hyatt Roller Bearing Co., Newark, N. J., has advanced the prices of Hyatt flexible roller bearings, owing to the advance in the cost of materials and the higher wages paid to workmen.

New Departure Mfg. Co., Bristol, Conn., has erected a steel and concrete building, four stories high, 220 by 250 feet, which will be devoted exclusively to the manufacture of steel balls. The total floor space in the building is 178,000 square feet, or nearly 4½ acres.

T. A. Willson & Co., Inc., 3rd and Washington Sts., Reading, Pa., recently filled an order for army goggles for the United States government. An order has also been placed with this company by the British government for industrial goggles to be used by field troops and by industrial workers at home.

August Mietz Corporation, 128-138 Mott St., New York City, announces that the business of August Mietz has been sold and transferred to the August Mietz Corporation. The officers are Emma C. Rueff, president; Emil Rueff, vice-president and treasurer; Otto V. Schrenk, secretary; and Louis C. Eitzen, general manager.

Sprague Electric Works, 527-531 W. 34th St., New York City, is erecting a new reinforced concrete machine shop at Bloomfield, N. J. The main building is six stories in height, 75 by 550 feet, with an ell 75 by 179 feet, the walls of which are faced with brick. The work is being done by John W. Ferguson Co., Paterson, N. J.

Lapointe Machine Tool Co., Hudson, Mass., is constructing an addition to its main building, 40 by 100 feet, two stories high; a one-story addition, 10 by 40 feet, to its hardening room, and a one-story addition, 32 by 60 feet, to its shipping room, all to be made of brick. The contract has been let to the J. J. Prindiville Co., Framingham, Mass.

Goodell-Pratt Co., Greenfield, Mass., is erecting a new building, four stories high, of reinforced concrete construction throughout. The building will be 58 by 260 feet, with a four-story ell 58 by 110 feet, and will increase the floor area of the concern by more than 86,000 square feet. The work is being done by the Aberthaw Construction Co., Boston, Mass.

Bound Brook Oil-less Bearing Co., Bound Brook, N. J., has awarded the contract for a new foundry to be erected at Lincoln, N. J., two miles east of the Bound Brook plant. The new building will be of steel and brick construction, 60 feet wide by 180 feet long. It will be two stories high and modern in every respect. This addition has been made necessary by the rapidly increasing business of the firm.

Sleeper & Hartley, Inc., 68 Prescott St., Worcester, Mass., designer and builder of automatic wire coiling machinery, has leased additional manufacturing space in Worcester, and has begun the construction of a new plant to be devoted entirely to the manufacture of improved wire nail machinery. A. L. Lewis, formerly superintendent of the company's present plant, will take charge as superintendent of the new plant.

Boris V. Constantinov, 29 Broadway, New York City, mechanical engineer, has for the past two years been establishing connections with firms and private individuals in Russia and Siberia, and studying the needs of the Russian market. He is prepared to make arrangements with non-competitive firms for distributing their goods in Russia, and to act as a representative. Mr. Constantinov will open a general office in Moscow.

American Steel Export Co., Woolworth Bldg., New York City, has appointed Charles S. Vought assistant manager of sales. Mr. Vought was formerly one of the managers of the order department of the Cambria Steel Co. and is well fitted to fill the position and responsibilities of his new position, having familiarity not only with the various export markets of the world, but also knowledge of mill conditions and the technicalities of the production of steel.

S. K. F. Ball Bearing Co., Hartford, Conn., announces that the S. K. F. Ball Bearing Co. of California, Inc., has been organized in order to more readily supply the rapidly increasing demand for S. K. F. bearings on the Pacific coast. The main office of the company, under the direction of A. M. MacLaren, has been opened at 341 Larkin St., San Francisco, where a large stock of S. K. F. bearings will be carried. Engineering service will also be available.

S. K. F. Administrative Co. has been formed to manage the Hess-Bright Mfg. Co. of Philadelphia and the S. K. F. Ball Bearing Co. The directorate of the S. K. F. Administrative Co. consists of Frank A. Vanderlip, Thatcher Brown, F. B. Kirkbride, S. Wingquist, Alexander Corlander, Marcus Wallenberg, a banker of Sweden, and B. G. Prytz, president of the S. K. F. Ball Bearing Co. Plans are being made for increasing the plant facilities of the organization.

Fostoria Press Steel Co., Fostoria, Ohio, has been incorporated at $100,000, and will make all the pressed steel parts required by the Allen Motor Co. The plant will turn out complete sheet metal products, enameled and japanned. The factory will have 20,000 square feet of floor space and will be of fireproof brick construction. The officers of the new corporation are Henry Rothrock, president; George E. Kirk, vice-president; E. C. Wolfe, secretary; and C. D. Pifer, treasurer and general manager.

Hoover Steel Ball Co., Ann Arbor, Mich., will erect three new buildings and equip them with machinery to increase the production from 25,000,000 to 40,000,000 balls per day. The entire expansion in 1917 means an investment of $250,000. The buildings will be of brick and concrete construction and of the same type erected heretofore. An idea of the rapid growth of the company's business is indicated by the fact that the production has increased approximately 800 per cent within the past three years.

Lewis-Shepard Co., Boston, Mass., has moved from 262-280 Dover St. to 48 Binford St., South Boston, where quarters affording about 4000 square feet of floor space are provided. The company has purchased sixteen new machines, including drilling machines, grinders, lathes and a screw machine; it has also added to its equipment of small tools and fixtures. The larger quarters and increased tool equipment will facilitate the manufacture of the company's "Jacklift" master truck, which is classified as an elevating truck.

American Forge & Machine Co., Canton, Ohio, has announced a general wage increase of 10 per cent in all departments, taking effect May 1. This makes a total increase of 30 per cent during the past year, in addition to bonuses; the bonus plan gives each workman who has been in the employ of the company additional pay at the end of three months, six months and up to ten years. The company is turning out forgings from ½ pound to 15 tons in weight, and has recently installed some new equipment in the way of large hammers and presses to take care of its constantly increasing business.

Lincoln-Williams Twist Drill Co., Taunton, Mass., has increased its capitalization from $200,000 to $1,000,000, and will largely increase its manufacturing facilities. The name of the company has been changed to Lincoln Twist Drill Co. The president is Frederick H. Payne; vice-president and general manager, Edward Blake, Jr.; treasurer, James H. Ball. Alfred L. Lincoln, who has retired from active management, retains a position as director and owns a large stock interest in the company. Mr. Blake, vice-president and general manager, will be the active head of the factory.

Independent Pneumatic Tool Co., Chicago, Ill., announces the election of John D. Hurley, president, to succeed the late James B. Brady. Mr. Hurley has been vice-president of the company since its organization, and is well known in the pneumatic tool business, having been identified with the industry since pneumatic tools were first placed on the market. Ralph S. Cooper, who has been the manager of the New York office for the past twelve years, was elected vice-president, and Robert T. Scott, manager of the company's Pittsburg branch, was elected a director and member of the executive committee.

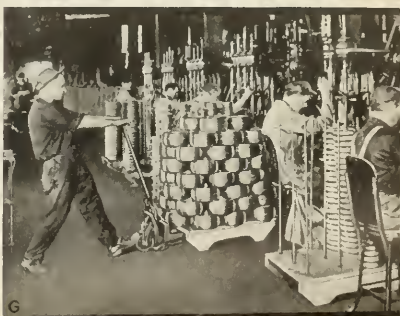
Michigan Tool Co., 268 E. Jefferson Ave., Detroit, Mich., manufacturer of high-grade milling cutters, hobs, dies, tools, jigs and fixtures, has increased its capital stock from $25,000 to $70,000, which is all paid in. The officers of the company are D. R. Peterson, president; Robert H. Anderson, vice-president; S. F. Wall, secretary and treasurer; T. M. Olson, general manager; and Otto Lundell, superintendent. All the members of the firm have had years of extensive experience as specialists in the manufacture of small tools and labor-saving devices. The factory is equipped with the most modern standard tools, as well as special machines and devices of their own invention.

Municipal Civil Service Commission, New York City, announces an examination for mechanical engineer, Grade D, for which applications will be received at Room 1400, Municipal Bldg., until June 13 at 4 P. M. The examination will consist of three subjects: technical, 5; experience, 3; mathematics, 2. Suitable credit will be given to graduates of technical schools of recognized standing. The duties are to perform engineering work in connection with power or heating plants, the mechanical equipment of building, or the design of machinery. The positions pay salaries from $1800 to $2400 per annum. The engineering service of the city offers excellent opportunities for advancement, paying a salary as high as $3000 a year. For further particulars apply to the Municipal Civil Service Commission, Municipal Bldg., New York City.

Walter Kidde & Co., 140 Cedar St., New York City, has been incorporated to carry on the engineering-construction business established in 1900 by Walter Kidde. The company undertakes the entire construction and equipment of factories, producing finished plants ready for operation. The organization includes departments of construction, hydraulics, steam and mechanical engineering, electrical engineering and chemical engineering. The officers are Walter Kidde, president; B. G. Worth, vice-president; I. R. Lewis, secretary and treasurer. The board of directors includes, in addition to the officers of the company, Henry Lang, vice-president of the Ingersoll-Rand Co., and E. S. Boyer, of the American Hard Rubber Co. The engineering board is composed of A. B. Miller, Walter S. Wainwright, M. I. Buttfield, and E. Schwarz. Thorlief Hiflet is chief draftsman.

Factory Transportation

by Edward K. Hammond[1]



IN order to obtain the maximum efficiency in manufacturing it is essential for all the men and machines in a plant to be kept constantly supplied with work. No matter how cleverly methods of machining may have been worked out, nor how suitable the mechanical equipment may be, a satisfactory rate of production cannot be hoped for unless there is a uniform supply of raw material or pieces in course of production to keep all the machines and operators constantly at work. In studying conditions in a variety of manufacturing plants engaged in the production of many different kinds of work, it frequently becomes apparent that there is loss of production and profits due to the management's failure to appreciate the importance of this point. In such plants production may be high for periods of considerable duration, but due to lack of foresight in anticipating some unusual delay, a whole department may be held up for some time because of failure to bring a supply of work from one of the preceding departments.

Efforts made by manufacturers to reduce production costs in order to meet competition and make profits have led to many improvements in manufacturing operations. But in many plants where great care has been taken to develop efficient methods of manufacture, the same attention has not been paid to developing methods of transporting material and product through the factory. Obviously, this is poor management, because any delay in the delivery of work to machines results in non-productive time for both machines and their operators. It is the purpose of the present article to describe various methods of lifting and transporting material and work in course of production. A study has been made of methods of handling work which are used in leading industrial plants, and the article is based upon the result of this investigation.

Cooperation between Management and Workers

To successfully solve the problem of transporting material and product through an industrial plant requires a detailed study of manufacturing conditions in that plant made by experienced industrial engineers who are capable of recommending those forms of equipment best adapted to meet the requirements found. But there is one condition which the industrial engineer cannot control, namely, the intelligent use by workmen of the equipment provided. Cooperation between the employes and management of

A—Train of Cars hauling Forgings to Machine Shops of Timken-Detroit Axle Co. Special Tractor equipped with Motor of Ford Automobile
B—Elwell-Parker Electric Storage Battery Truck hauling Load of New Britain Tote Boxes filled with Steel Balls at Plant of New Departure Mfg. Co.
C—Buda Electric Storage Battery Truck hauling Load of Gears up Incline; Batteries mounted beneath Truck Platform to give Additional Loading Space
D—Barrett-Cravens Elevating Truck delivering Load of Stock to Power Press Operator; Stand raised so that Operator reaches Work without stooping
E—National-Chapman Elevating Truck in Headstock Assembling Department of Jones & Lamson Machine Co.
F—Motor Truck with Detachable Body being lifted from Truck by Trolley Hoists which will carry Load into Plant
G—Cowan Elevating Truck used in Connection with Special Stands for holding Pieces with Hole in Center

an industrial plant is of primary importance in order to handle material with the maximum rapidity, and various methods of securing such cooperation have been adopted, the most successful of which is some form of bonus system. Where carefully planned methods of handling material and conducting machining operations have been worked out in sufficient detail to include giving definite instructions concerning the method of handling each piece, and where the incentive to follow these instructions is created through payment of a bonus to efficient workers, some marvelous production records have been made, and in this connection it is noteworthy that these results have been secured through the development of common-sense time-saving methods of working, and not through the expenditure of extraordinary effort on the part of the men. For the manufacturer who realizes the necessity of improving his operating conditions, the bonus system is worthy of most careful consideration, as the incentive offered a man to work for higher wages will be more effective than trying to make him work by any direct form of supervision.

How Factory Lay-out Affects Transportation Problems

Every year industrial engineering becomes a more complex profession, because constantly increasing competition between manufacturers leads them to rely upon the industrial engineer to suggest methods of reducing production costs which would either have been considered too complicated to justify their adoption under conditions that existed a decade ago, or which were seemingly of so trivial a nature that it took time to make apparent the savings that might be effected through their use. One of the most obvious methods of facilitating the work of handling materials and products, and one which has been made the subject of frequent comments in the technical press, is to arrange all the departments in a factory and all the machines in each department so that the work follows a continuous route through the plant without the expenditure of unnecessary time and labor in carrying it back and forth. A great deal of profitable work has been done in rearranging the lay-out of departments in factories and of the equipment in departments in order to provide a continuous route over which materials are carried without the necessity of long hauls between departments, and to avoid the congestion which is likely to arise when the same aisles have to be used by trucks which pass in opposite directions.

One simple expedient, which is capable of producing a marked increase in efficiency in handling materials and products on trucks, is the maintenance of open aisles in all departments and in passageways connecting different departments of the plant. This point is often entirely overlooked by the management of factories which otherwise show ample evidence of efficiency. Such shops frequently have the aisles so cluttered up with a heterogeneous collection of materials, products and tools that it is virtually a case of "breaking a trail" for a truck that must be pushed through the shop. In many factories where a decision has been reached in favor of maintaining open aisles, the aisles are marked on each side by a white paint line; but men in a shop are only human, and if some advantage may be secured by having a box or bar of steel extend slightly over the aisle line, or if it is easier to pass another truck by running the wheels of a truck a little way into the part of the shop reserved for strictly manufacturing operations, it is not probable that the white paint line will have any great restraining influence. While these may seem trivial infractions of rules, they are likely to cause serious delays if allowed to go unheeded. Realizing this fact, the Timken-Detroit Axle Co., Detroit, Mich., adopted an expedient which has proved of material value. Down each side of all aisles in the factory, two- by four-inch scantlings are nailed to the floor, and they are protected by angle-irons, so that they are not subject to damage by truck wheels, etc. They are painted white so as to be always visible, and have been found an effective means of preventing minor accidents and delays caused by trucks intruding upon space in the factory reserved for manufacturing work, and also of preventing machine operators from pushing boxes of castings or partially finished work out into the aisles where they block the progress of trucks carrying work from department to department.

Rearrangement of existing plans is well worth while. We have in mind one small factory engaged in the manufacture of machine tools which has recently increased its output over 50 per cent by completely rearranging the lay-out of departments and equipment, without buying any new machinery or hiring more men. But in cases where complete new plants are designed, built and equipped for the production of a specified quantity of work, it is possible to obtain far greater efficiency than where existing factories are remodeled with the view of increasing efficiency. This is because, under the best conditions, rearrangement of an existing plant must leave many features that could be greatly improved, while in case an entire plant is laid out on a drawing-board before starting construction, every detail can be carefully considered and means provided for overcoming many difficulties which are foreseen by the industrial engineer as a result of his experience with similar problems in other factories. In the automobile industry we probably see some of the best examples of efficient methods of handling work. Viewing the subject broadly, there are several explanations which may be offered for the high degree of efficiency which has been attained in this industry, but they may be narrowed down to the fact that many of these companies have been organized and their factories have been built to provide for securing a specified rate of production, and in this industry, as in no other, has the advice of the best industrial engineering talent been taken in regard to the installation of time and labor-saving appliances. A plant that is required to make and assemble the parts to turn out several hundred complete automobiles a day is certainly faced with a great task, and were it not for the fact that the automobile industry has taken advantage of every possible means of increasing production, it would have been a physical impossibility to meet the demand for motor cars that has existed during recent years.

Analysis of Transportation Problem

Handling of material and product in industrial plants is subject to a fundamental sub-division according to whether the material is to be lifted into position on a machine or to a higher floor in the building, or whether the object is to carry the work to some other part of the factory. A variety of equipments are used for both lifting and carrying work, but these overlap each other to a considerable extent, so that in the following lists, which show the different types of equipment in general use, it will be seen that considerable duplication exists under the heads of "lifting" and "transporting." An interesting phase of this problem, although it is one that offers grounds for considerable complication, arises from the fact that many different types of equipment are used for exactly the same classes of service, so that selection of the best form of equipment to meet a given set of conditions is dependent upon a number of factors. Chief among these are the volume of material to be handled, first cost of equipment suitable for that purpose, and the labor and overhead expenses incident to operating under these different systems of transportation. This subject will receive further consideration in a later part of the article, but at this time the point may be made clear by comparing conditions in two shops which are machining a piece weighing, say, 1/4 pound, but where one shop produces 500 pieces a day while the other is required to turn out 100,000 pieces a day. In selecting means of handling this work the small shop could probably do no better than decide to adopt the use of boxes carried by elevating trucks; but the large production of the other shop would call for an excessive number of trucks and men to pull them, and aside from the high labor cost incident to the adoption of such a system, laborers employed on this work would certainly create considerable congestion in the plant. For these reasons the experienced industrial engineer would probably adopt the use of some form of conveyor system for handling the large output of the shop.

Factors Governing Selection of Motor-driven Hoists and Chain Blocks

When a manufacturer or his engineer is selecting hoists to be used for lifting material or parts in course of manufacture or for transferring them to some other point in the shop, he

Fig. 1. An escalator is used in plant of Chain Belt Co., Milwaukee, Wis., for carrying men and loaded trucks to platform from which trucks can be wheeled into freight car. Three men are shown in successive positions, and it will be seen that escalator for trucks is provided with cleats to prevent wheels from slipping

Fig. 2. Where hand trucks are used in factories with swinging doors between departments, it is common practice for truckers to open doors by bumping truck against them. The Timken-Detroit Axle Co. found this practice was destroying doors, and overcame the difficulty by providing each truck with a semicircular buffer

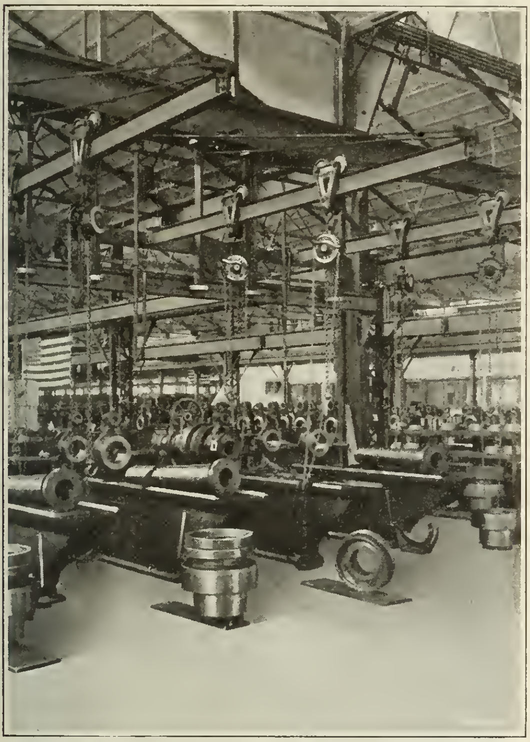


Fig. 3. Where the distance a load is to be carried is too great for a swinging jib crane, advantageous use is often made of the so-called "wall" type of crane, in which a cantilever beam is supported by a truck at one end. The truck wheels run on rails secured to the wall. Wall cranes are used to advantage in the Gisholt Machine Co.'s factory

Fig. 4. Under efficient management, a point will be made of having each hand truck carry approximately the maximum load which a man can push on a level floor. With such practice it will ordinarily be required to provide extra labor to help men push trucks up an incline. Here a Yale & Towne triplex hoist and trolley is used to raise the truck

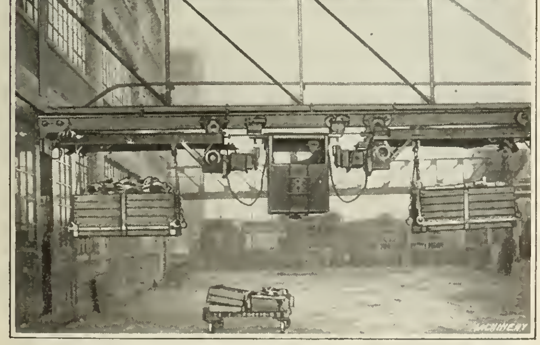


Fig. 5. Where it is desired to transport small pieces on trolleys, it is necessary to equip trolleys with a carrier in order that a load approximating the trolley's capacity may be carried at each trip. This view in the Ford Motor Co.'s plant shows trolleys with carriers for handling small castings, built by the Sprague Electric Works, New York City

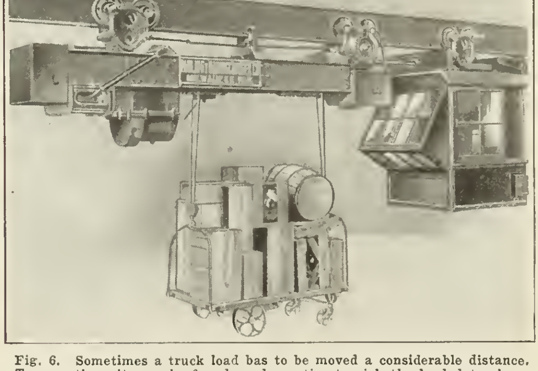


Fig. 6. Sometimes a truck load has to be moved a considerable distance. To save time, it may be found good practice to pick the loaded truck up from the floor by means of a trolley and carry entire load through shop in this way. A monorail crane built by the Pawling & Harnischfeger Co., Milwaukee, Wis., is shown handling a loaded truck in this manner

Fig. 7. Where proper care is taken in laying out shop equipment, it will often be possible to group machines so that one jib crane and trolley will be able to serve a number of machines. In this illustration a view is shown in the Gisholt Machine Co.'s factory, where one jib crane is able to serve as many as five machines

Fig. 8. Where there is plenty of head room, traveling cranes, jib cranes and trolleys may be equipped with vertical air cylinder hoists. Only in cases where head room is limited is it considered good practice to place the cylinder in a horizontal position. This illustration shows Vulcan Engineering Sales Co.'s Q.M.S. air hoists in use in a car shop

has a choice between the use of a hand-operated chain block or a motor-driven hoist; similarly, the type of trolley which he decides to use may be motor-driven or hand-operated. There are numerous factors governing the selection of the type of equipment for a given installation, but, generally speaking, it is a case of balancing first cost and depreciation charges against efficiency of operation. Where motor drive is used for operating both hoist and trolley, it is obvious that the equipment will cost more than where hand chains are used for performing both these functions, and as the motor-driven equipment has a more complicated mechanism, depreciation costs will be greater than in the case of the hand-operated hoist and trolley.

To offset these limitations, attention is called to the fact that motor drive enables hoisting and transfer of material to be performed more rapidly than it can be done with hand-operated equipment. Also, the use of electric motors is likely to be the means of effecting a material increase in production for the following reasons: (1) The work is done more rapidly. (2) The workman is not unduly fatigued, and so there is no marked falling off of his efficiency during the latter part of the day. (3) The workman does not hesitate for a minute or so before applying himself to the work of raising a load by hand. The third reason is what might properly be called psychological, but the results of time studies show that it is really important, because when a man begins to tire during the late afternoon he is likely to waste several minutes before applying himself to the work of lifting and transferring a heavy load by the manipulation of hand chains, whereas no particular exertion is required to pull the cord governing hoisting or traversing motors.

In addition to trolley hoists in which both trolley and hoist are motor-driven or in which both are operated by hand, equipments are built in which the hoist is motor-driven and the trolley hand-operated, or *vice versa.* In many shops insufficient attention is paid to the selection of the trolley hoist

Fig. 9. Work handled on boring mills, planers and other heavy-duty machine tools is often of such size and weight that it is impossible for the work to be lifted by hand. It is necessary to provide means for lifting work and placing it on the machine table. A hoist and trolley facilitate handling lighter pieces. This illustration shows use of an Ingersoll-Rand "Imperial" pneumatic motor hoist and trolley

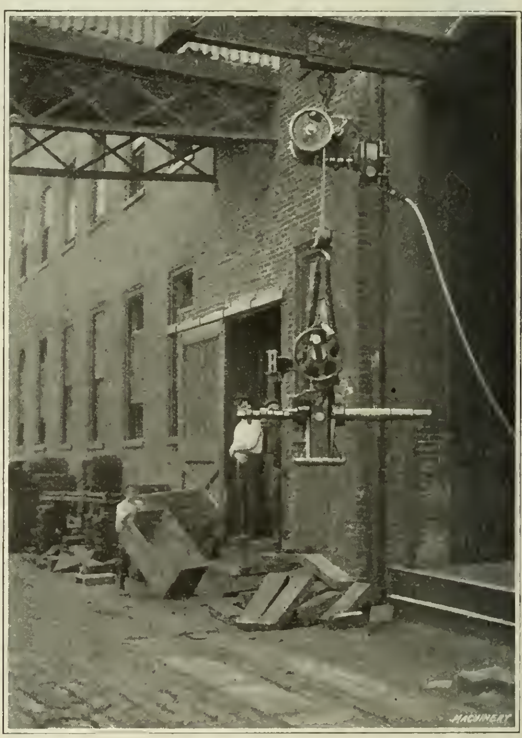


Fig. 10. Where heavy materials come to a plant by railroad or motor truck and a trolley system is used for carrying them to various departments in the plant, it will be found good practice to have a beam extending out over the railroad or roadway, with an extension of the trolley rail supported on this beam. This illustration shows such an arrangement, with an Ingersoll-Rand "Imperial" hoist and trolley

Fig. 11. Where large pieces of sheet metal are to be worked on punching or shearing machines, a trolley hoist will be found convenient to assist in handling the work. This illustration shows a jib crane and pneumatic motor hoist, built by the Chicago Pneumatic Tool Co., Chicago, Ill., in use at the plant of the Duluth Boiler Works

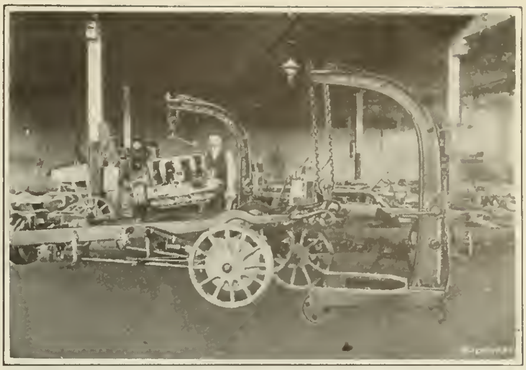


Fig. 12. Portable cranes are used for many purposes. Their chief field is for lifting work in confined spaces that cannot be served by traveling cranes or trolleys. They can also be used to advantage where there is not enough work to warrant installing a crane or trolley system. Canton Foundry & Machine Co.'s portable cranes are shown in use in a garage

equipment best suited for a given class of work, and it is not unusual to see trolley hoists of an unsuitable type responsible for a serious loss in production. In plants where the purchasing agent, who is a non-technical man, is given too much leeway, he is likely to show preference for hand-operated equipment because it may be purchased at a price ranging from one-sixth to one-third that of the full motor-driven outfits. On the other hand, shopmen who are partial to motor drive are likely to select full motor-driven equipment when the higher first cost and maintenance expenses of such an equipment is not warranted by existing conditions.

Legitimate fields for hand-operated and motor-driven trolley hoists overlap to a considerable extent, so that it is difficult to lay down any hard and fast rules governing their selection. In general, it may be stated that where moderate loads are to be lifted at infrequent intervals, and where the distance that these loads are to be carried by the trolley is not great, both hoist and trolley should be hand-operated in order that first cost and depreciation charges on the equipment may be as low as possible. If either the height to which the load is lifted or the distance through which it is carried is considerable, the hoist or trolley should be motor-driven; and if both lift and traverse are considerable, a full motor-driven equipment will probably be found to give the best results. Not only is the motor drive more rapid, but where trolley hoists are used at frequent intervals, the motors offset the otherwise harmful effect of the so-called "fatigue factor," which is the cause of a serious falling off in production in many shops during the latter part of the day.

Electric motor drive gives a hoist from six to eight times the speed of a hand chain hoist, so that this increased rapidity of operation may more than offset the additional price of the electrical equipment. The output of a machine tool is dependent upon the facility with which work is brought to or taken away from it. Large shop cranes may be used to serve machine tools, but it often happens that work which must be performed by traveling cranes is so diversified and distributed that when cranes are relied upon to serve individual

Fig. 13. A hoist equipped with an electromagnet may be used to advantage for lifting heavy castings onto machine tools. This illustration shows a case in which the work to be handled would be difficult to hold with any other form of lifting device. One advantage is the rapidity with which a magnet may be attached and released

Fig. 14. Electromagnets are adapted for handling a great variety of iron and steel products. This illustration shows how coils of wire may be advantageously handled. Anyone who has tried to lift one of these coils knows that it is bulky and hard to hold, but, as shown, a Cutler-Hammer lifting magnet is able to pick up a large number easily

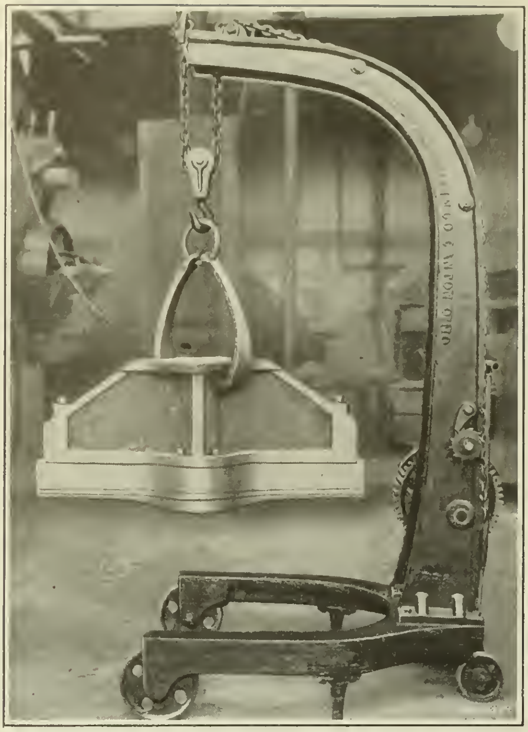


Fig. 15. One class of service for which portable cranes are found useful is in handling heavy castings that must be set up on machine tools and removed after completing the operation. For this purpose their chief advantage is the fact that the load may be placed in almost exactly the desired position. The Canton Foundry & Machine Co., Canton, Ohio, is the manufacturer of the portable crane shown in this illustration

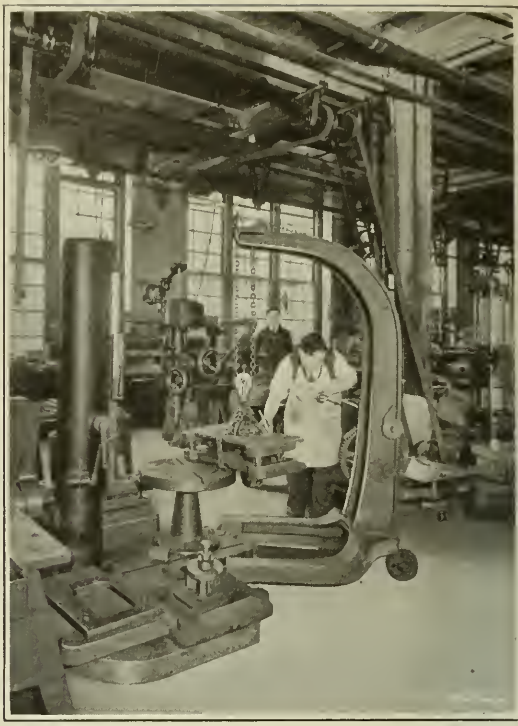


Fig. 16. In setting up heavy pieces on machine tools, it may be difficult to handle work on a traveling crane, due to the inability of that kind of equipment to reach the desired point. This illustration shows a view in the Cadillac Motor Car Co.'s factory, where a portable crane built by the Franklin Machine Works, Franklin, Pa., is engaged in setting up work on the table of a radial drilling machine

tools, waiting for a crane causes frequent periods of idleness at times when it is necessary to change work. This may be of sufficient importance to make it desirable to install individual trolley hoists to serve such machines. A combination of trolley hoists and one or more heavy cranes may also be the means of securing greater returns from the cranes, owing to the fact that they are always available for handling those classes of work for which they are best adapted. Also, with a hoist always available for service, there is a minimum amount of idle time to be charged against the machine and operator.

Under modern conditions of manufacturing, competition has so far reduced normal profits that it is necessary for the management of most plants to analyze carefully their methods of operation with the idea of increasing profits through eliminating all avoidable sources of loss. Three elements largely determine the success or failure of efficiency methods, and these are: (A) Cost of productive labor. (B) Cost of material. (C) Cost of non-productive labor. In many plants item (C), *i. e.*, non-productive labor, could be materially reduced through installing labor-saving machinery for handling materials. The possibility of effecting such reductions is often overlooked, with the result that the overhead expense is unnecessarily large.

Types of Traveling Cranes

Heavy-duty electric traveling cranes are almost invariably made with three motors for operating the hoist and traversing the trolley and bridge, respectively. In the case of traveling cranes for moderate and light work, the equipment may be either hand-operated or of the one-, two- or three-motor type. The conditions governing the selection of one of these four types of equipment are essentially the same as those referred to in connection with hand-operated and motor-driven trolley hoists. A hand-operated crane, in which hoist, trolley and bridge are all worked by hand chains, is used in cases where the distance of traverse is not great and where the crane is used at infrequent intervals. Motor drive is used in any case where the distance which the load is to be lifted, the length of the bridge or the distance that the bridge is to be traversed is great enough to make the saving of time resulting from use of motor drive sufficient to offset the increased cost of equipment and maintenance expenses; and motor drive is also employed in cases where the apparatus is used at such frequent intervals that the assistance rendered by the motors in keeping men working at full efficiency for the complete day is of sufficient importance to more than offset the greater charges which must be made against the work.

Where shops are equipped with compressed air it will often be found economical to employ an air-operated hoist of the cylinder or pneumatic motor type. A choice between three types of equipment may be made, because the cylinder hoist may be arranged with the cylinder in a horizontal or vertical position. Where there is plenty of head room, so that a vertical cylinder hoist may be employed without interference, this will probably be found the most economical form of equipment of the three, because it uses the smallest amount of compressed air. Tables 1, 2 and 3 show the conditions of operation for these three types of hoist.

Use of Transfer Bridges for Shifting Trolleys from One Line of Track to Another

Where trolley systems are employed for moving the material and product in a plant, the usual method is to employ switches for diverting the trolleys from one line of track to another. These switches are easily operated and constitute a satisfactory form of equipment where the number of lines of track is not great. There is a common type of shop construction in which a central bay runs through the middle of the building, with second and third bays extending out at each side; these side bays are generally in a section of the building that is not as high as the central part. A common arrangement in shops of this kind is to have one or more electric traveling cranes in the central bay and trolley systems in the side bays. In many cases there will be a large number of trolley tracks running at right angles to the line of travel of cranes in the central bay. Where such an arrangement is used it may be found practicable to have switches and a line of track running lengthwise to provide for carrying trolleys from one of these cross

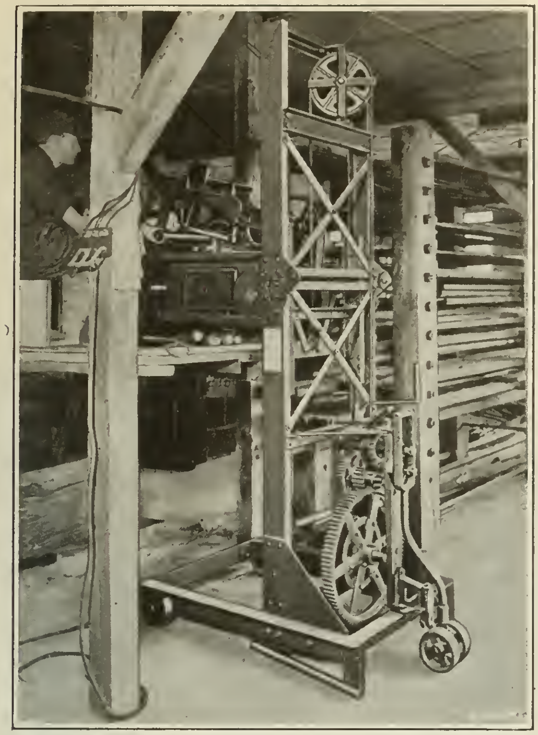


Fig. 17. Not every manufacturer is enterprising enough to install an elevator at his steel stock rack. The Mechanical Appliance Co., Milwaukee, Wis., uses a portable tiering machine built by the Economy Engineering Co., Chicago, Ill., for lifting a hacksaw to the required level so that a bar of steel may be drawn out on the rack and cut off. While this may seem a somewhat complicated arrangement for handling a simple shop operation, it saves time and avoids confusion

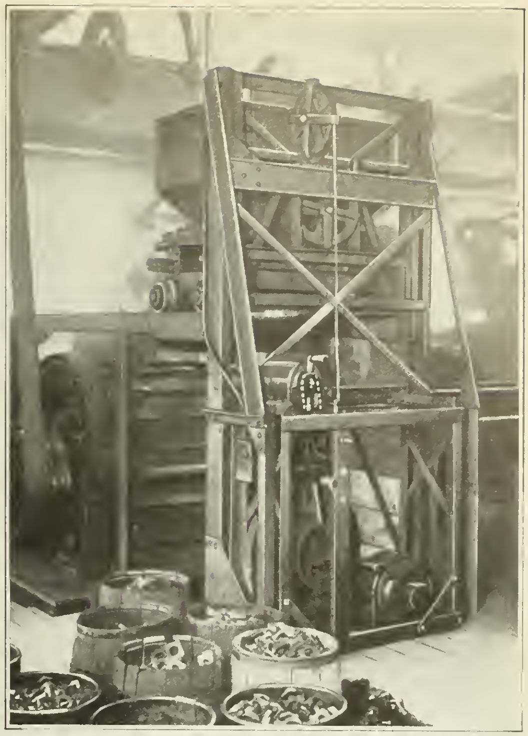


Fig. 18. Loading blank punched nuts into tumbling barrels and removing the nuts and distributing them in bins is heavy work. At the Boss Nut Co.'s factory in Chicago, use is made of a special tiering machine built by the Economy Engineering Co., of Chicago, Ill. It has a cantilever type of platform with two arms which carry the flanged wheels of a small transfer truck. This truck carries rails which support a small hopper-bottom car with a capacity for holding 2000 pounds of nuts

lines of track to another, but if there are a great number of cross tracks, the complication of the switches and trolley system in general will be so great that satisfactory results will not be obtained.

Where such a condition exists, a better practice is to have what is known as a "transfer bridge" running on the tracks provided for carrying cranes in the central bay of the factory. With such a system the bridge carries a section of trolley track which is in line with the cross tracks in the side bays. This bridge and the track carried by it may be run into line with any trolley track in the shop, so that the trolley and its load may be run under the bridge. The bridge and its load are then run down the shop to bring the transfer track into line with the track onto which it is desired to run the trolley. A particular advantage of this system is that it provides for running a trolley from either track in one side bay onto either of the tracks in the bay at the opposite side of the building. Where traveling cranes are used in the central bay, the only way it would be possible to do this with a trolley track and switches would be to have the track extend around the end of the shop, which would involve having the trolley run all around the building to get to its destination at the opposite side, thus consuming an unnecessarily large amount of time; also there would be the objectionable complication of tracks and switches to which reference has already been made.

Use of Lifting Magnets

Magnets are extremely useful for lifting iron or steel because of the ease and rapidity with which they may be connected with the load and disconnected after the desired service has been performed. An idea of the efficiency with which lifting magnets operate and their ability to reduce labor costs will be gathered from the following: The ordinary day's work of a man lifting pig iron from the ground and loading it into a railway car is from 12 to 13 tons per day. Substitution of a lifting magnet for manual labor enables one man, who merely has to operate the controller, to handle about 900 tons per day, *i. e.*, about seventy-two times as much as was accomplished by hand, and thirty times the amount of work possible under the best conditions of scientific management.

Lifting magnets have been adopted for handling materials in a variety of branches of the iron and steel industry. Among the classes of work for which they are used are lifting pig iron, scrap, castings, billets, tubes, rails, plates, crop ends, etc. They are exceptionally useful for loading and unloading cars or vessels. Wherever magnetic materials are to be handled in considerable quantities, the lifting magnet is one form of equipment which should receive careful consideration before determining upon the type of equipment which it is most advisable to install. The load that a magnet will lift depends largely upon the nature of the material to be handled. With a solid mass of iron or steel affording a surface of good magnetic contact, a 62-inch magnet of the type built by the Cutler-Hammer Clutch Co., Milwaukee, Wis., will lift as much as 60,000 pounds, while under very adverse conditions the lifting capacity of the same magnet may drop to 2000 pounds. An idea of the service obtained from a magnet will be gathered from the fact that at an ore dock of the Inland Steel Co., Indiana Harbor, Ind., about 4,000,000 pounds of machine-cast pig iron was unloaded in 10½ hours by two 62-inch old-style Cutler-Hammer magnets, the average lift per magnet being 3427 pounds. Later one of the new style high-duty 62-inch magnets handled 6000 pounds per trip at the same plant.

Types of Equipment Used for Lifting Materials

Hoists, hand-operated; capacity, ¼ to 40 tons.
Hoists, air, cylinder type; capacity, ½ to 10 tons.
Hoists, pneumatic-motor type; capacity, ½ to 10 tons.
Hoists, electric-motor type; capacity, ¼ to 10 tons.
Cranes, portable; capacity, 1 to 4 tons.
Cranes, jib; capacity, 1 to 10 tons.
Cranes, traveling, hand-operated; capacity, ¼ to 10 tons.
Cranes, traveling, air-operated; capacity, ¼ to 4 tons.
Cranes, traveling, electric; capacity, 5 to 200 tons.
Cranes, traveling, wall type; capacity, 5 to 10 tons.
Elevators, portable; capacity, 4/10 to 1¼ ton.
Elevators, freight; capacity, to suit existing requirements.

TABLE 1. DATA ON PNEUMATIC MOTOR HOISTS

Capacity, Pounds	Feet Lift per Minute, 80 Pounds Pressure	Maximum Lift, Feet	Cubic Feet Free Air per Minute, 80 Pounds
1,000	32	20	45
2,000	16	20	45
4,000	8	20	45
7,000	8	20	80
10,000	7	20	80

Machinery

Means for Transporting Work

Trucks, two-wheeled, hand-operated; capacity, 1/8 to 3/8 ton.
Trucks, hand-operated, elevating type; capacity, 1/2 to 2 1/2 tons.
Trucks, power-driven; capacity, 1 to 1 1/2 ton.
Trucks, power-driven, elevating type; capacity, 1 to 2 tons.
Trolley system; capacity, 1 to 10 tons.
Conveyor system, gravity type.
Conveyor system, belt type.
Conveyor system, bucket type.
Cranes, jib, hand-operated; capacity, 1 to 10 tons.
Cranes, jib, air-operated; capacity, 1 to 10 tons.
Cranes, traveling, hand-operated; capacity, 1/4 to 10 tons.
Cranes, traveling, air-operated; capacity, 1/2 to 10 tons.
Cranes, traveling, electric; capacity, 5 to 200 tons.
Cranes, locomotive on industrial tracks; capacity, 10 to 20 tons.
Cranes, gantry.
Industrial railways.

In connection with the preceding list of equipments used for lifting and transporting materials, it will be of interest to review briefly those classes of service for which each equipment is particularly adapted. First giving attention to devices used for lifting, the general statement may be made that all types of hoists, portable cranes, portable elevators and jib cranes find application in lifting heavy pieces of work into position on machine tools and for a variety of similar classes of service. The choice of a hand-operated hoist or a power hoist will depend largely upon the magnitude of loads which have to be handled and the frequency of handling. Where heavy loads are the general rule and where such loads have to be raised or lowered through a considerable distance and at frequent intervals, it will be desirable to employ a power hoist to eliminate the fatigue factor, with the resulting reduction in production rates toward the end of the day. When the decision has been reached to use a power hoist, further selection is possible between air cylinder, pneumatic and electric hoists, and here it may be stated that if there is sufficient head room, the cylinder type of hoist will be found more economical than the pneumatic motor hoist, due to its lower consumption of air for a given lifting capacity. The choice between an electric and pneumatic hoist is dependent upon various factors, which may be of greater or less importance in different cases. As a general rule, the question will be decided by the number of hoists to be used, the cost at which electric power can be bought from a generating station, and the relative cost at which electric power or compressed air can be generated in the plant. Each problem has its own peculiar conditions, and in some cases electric hoists will seem preferable, while at other times the use of air-operated hoists will seem advisable. Before leaving this subject it should be stated that where only a few hoists are used or where an air line is not required in the shop for operating pneumatic tools, etc., electric hoists will always be preferable, because it is cheaper to provide connections with an electric power circuit than it is to install air compressors and pipe lines through the shop. Cylinder type air hoists are commonly used where there is plenty of head room, so that the vertical cylinder will not interfere with obtaining the required lift, but where the head room is limited, either a pneumatic motor or an electric motor hoist is more suitable. Another general application of the cylinder type of hoist is in connection with cantilever beams, jib cranes, etc., so that a cable can run from the hoist over an idler pulley; in this way the desired lift is obtained without interference from the cylinder. Of course it will be understood that the lift of a cylinder type of hoist is limited to the length of travel of the piston, unless some form of multiplying rigging is provided to carry the cable.

TABLE 2. DATA ON AIR HOISTS—VERTICAL CYLINDER

	Diameter, Inches	Capacity		Size of Hose Connection, Inches	Cubic Feet of Free Air for 4-foot Lift	
		At 80 Pounds	At 100 Pounds		At 80 Pounds	At 100 Pounds
Brass	4	920	1,150	1/2	1.83	2.29
Brass	5	1,430	1,790	1/2	2.84	3.56
Brass	6	2,010	2,510	1/2	3.25	4.05
Cast Iron	7	2,840	3,550	1/2	5.97	7.47
Cast Iron	8	3,720	4,650	1/2	7.81	9.77
Cast Iron	9	4,700	5,875	3/4	9.88	12.36
Cast Iron	10	5,700	7,150	3/4	11.96	15.00
Cast Iron	12	8,250	10,300	3/4	17.31	21.68
Cast Iron	14	11,250	14,050	3/4	23.61	29.55
Cast Iron	16	14,600	18,200	1	30.58	38.28
Cast Iron	18	18,500	23,100	1	38.80	48.50
Cast Iron	20	22,800	28,500	1	47.88	60.00

Machinery

Portable cranes find extensive application in lifting heavy castings and other pieces of work from trucks or trolleys and placing them in position on machine tools, etc. The peculiar advantage of portable cranes is that they afford means of adjusting the work vertically to exactly the right height, and of transporting it short distances between trucks or trolleys and machine tools on which operations are to be performed. They reach into cramped spaces where traveling cranes cannot go, and make it unnecessary for a man to get help when setting up a heavy piece of work on his machine.

Jib cranes are used for much the same class of service as portable cranes, and where proper care is taken in the lay-

TABLE 3. DATA ON AIR HOISTS—HORIZONTAL CYLINDER

	Diameter of Hoist, Inches	Capacities: Straight		Capacities: One Sheave, 2 to 1		Capacities: Two Sheaves, 4 to 1		Size of Hose Connection, Inches	Cubic Feet Free Air for 4-foot Stroke	
		At 80 Pounds	At 100 Pounds	At 80 Pounds	At 100 Pounds	At 80 Pounds	At 100 Pounds		At 80 Pounds	At 100 Pounds
Brass	4	920	1,150	450	565	215	270	1/2	1.83	2.29
Brass	5	1,430	1,790	700	880	335	420	1/2	2.84	3.56
Brass	6	2,010	2,510	980	1,225	470	590	1/2	3.25	4.05
Cast Iron	7	2,840	3,550	1,390	1,740	670	835	1/2	5.97	7.47
Cast Iron	8	3,720	4,650	1,820	2,280	825	1,090	1/2	7.81	9.77
Cast Iron	9	4,700	5,875	2,300	2,880	1,100	1,380	3/4	9.88	12.36
Cast Iron	10	5,700	7,150	2,800	3,500	1,340	1,680	3/4	11.96	15.00
Cast Iron	12	8,250	10,300	4,040	5,050	1,940	2,420	3/4	17.31	21.68
Cast Iron	14	11,250	14,050	5,550	6,900	2,620	3,300	3/4	23.61	29.55
Cast Iron	16	14,600	18,200	7,150	8,925	3,430	4,275	1	30.58	38.28
Cast Iron	18	18,500	23,100	9,050	11,100	4,350	5,425	1	38.80	48.50
Cast Iron	20	22,800	28,500	11,150	13,650	5,350	6,700	1	47.88	60.00

Machinery

Fig. 19. Bar stock, sheet metal and similar raw materials may be conveniently racked with the assistance of a "revolvator" which is a revolving portable elevator made by the New York Revolving Portable Elevator Co., Jersey City, N. J. Material may be deposited on the elevator platform, raised to the desired level, and turned to any position

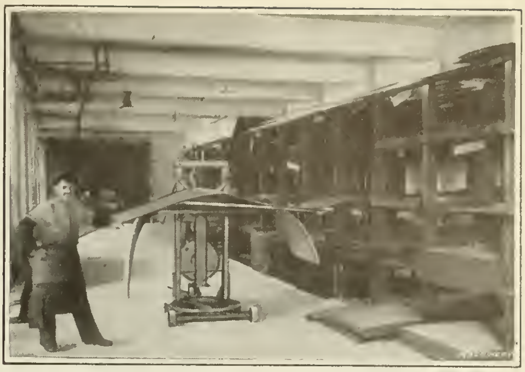


Fig. 20. In the preceding illustration, Fig. 19, the sheet metal has been taken from the wagon and placed on the revolvator platform, with the material running parallel to the length of the rack. Then the revolvator is turned through an angle of 90 degrees and raised the necessary amount, so that the end of the stock comes opposite the desired rack

Fig. 21. Worm drives for rear axle transmissions are made in large quantities at the plant of the Timken-Detroit Axle Co. Of course, these worms and the worm-shaft bearings, etc., are carefully machined and precautions must be taken to prevent damage through one worm striking another. This is accomplished by the use of special trucks with "cradles" in which the worms are held without danger of damage

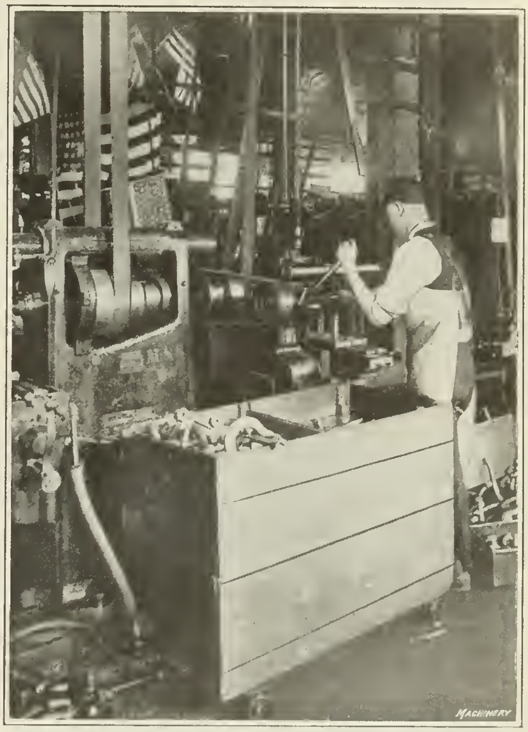


Fig. 22. Forgings, castings, etc., delivered to machines for a specified operation must be kept separate from those on which the operation has already been performed. One truck for blanks and one for machined work take up considerable space. A better method is to have one truck with a partition dividing the space into a compartment for blanks and a second compartment for finished work (Timken-Detroit Axle Co.)

Fig. 23. In order for trucking to be done efficiently, it is of absolute importance that all aisles in the factory be kept open. Instead of a paint line down each side of the aisle, the Timken-Detroit Axle Co. uses 2- by 4-inch timbers protected with angle-irons. These effectually prevent trucks running out of the aisles

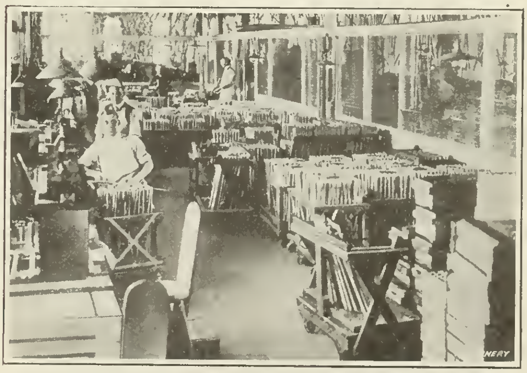


Fig. 24. In one of the United States government arsenals, 20,000 rifle barrels are inspected at one time. Obviously, this form of work calls for careful methods of handling. Not only is it necessary to provide means of transferring work to the inspection department, but the trucks must be so made that finished surfaces of the barrels will not be marred

TABLE 4. STANDARD SIZES OF CRANES SUITABLE FOR GENERAL SERVICE, WITH HOISTING AND TRAVELING SPEEDS[1]

Size in Tons of 2000 Lbs.	Standard Hoisting Speeds, Feet per Minute	Bridge Travel Speeds, Feet per Minute	Trolley Travel Speeds, Feet per Minute	Size of Aux. Hoist, Tons	Aux. Hoist Speeds, Feet per Minute
5	25– 60 30– 75 40–100	300–350 400–450	100–150		
10	20– 50 25– 60 30– 75	300–350 400–450	100–150	3	30– 75
15	17– 42 20– 50 24– 60	300–350 350–400	100–150	3 or 5	50–125 40–100
20	12– 30 15– 40 20– 50	250–300 300–350	100–150	3 or 5	50–125 40–100
25	10– 25 12– 30 16– 40	250–300 300–350	100–150	3 5 10	50–125 40–100 25– 60
30	10– 25 12– 30 14– 35	250–300 300–350	100–150	5 or 10	40–100 25– 60
40	9–22 10–25 12–30	250–300 300–350	100–150	5 or 10	40–100 25– 60
50	8–20 10–25 12–30	200–250 250–300	100–150	5 or 10	40–100 25– 60
60	8–20 10–25 12–30	200–250 250–300	100–150	10 or 15	25– 60 20– 50
75	6–15 8–20 10–25	200–250	100–150	15	20– 50
100	5–12 6–15 7½–18	200–250	100–150	20	20– 50
125	5–12 6–15	200–250	100–150	25	20– 50
150	5–12 6–15	200–250	100–150	25	20– 50

Machinery

[1] Practice of Pawling & Harnischfeger Co., Milwaukee, Wis., with Type A and Type C trolleys. Capacities can be doubled by using two standard trolleys on a single bridge.

out of equipment in a department, it is often possible to so locate a given jib crane that it provides for transferring work to several machines. For instance, in the plant of the Gisholt Machine Co., Madison, Wis., vertical turret lathes are so grouped that one jib crane carries work to and from five machines. Similarly, in the plant of the Griffin Wheel Co., Chicago, Ill., car-wheel molds are laid out on the foundry floor in a circle, at the center of which a jib crane is located. This crane takes a ladle of molten iron and swings it around into position over each mold so that the metal may be poured.

Portable elevators are used for somewhat the same classes of service as portable cranes, although the conditions under which they operate are rather different. Exceptionally good results may be obtained with portable elevators for such purposes as taking heavy dies out of storage racks and transferring them to drop-hammers or power presses, lifting heavy electric motors and countershafts into position to be bolted to their supports, raising barrels and boxes to the desired level to be rolled into freight cars or onto storage shelves, etc.

Freight elevators are used for lifting material from floor to floor in industrial plants. They may be of the familiar type in which material is carried onto the elevator by a truck or other means; or they may be of the self-loading type, *i. e.*, the load is placed on a platform so that it may be automatically taken off by bars which pass up between spaces in the loading platform and carry the work away.

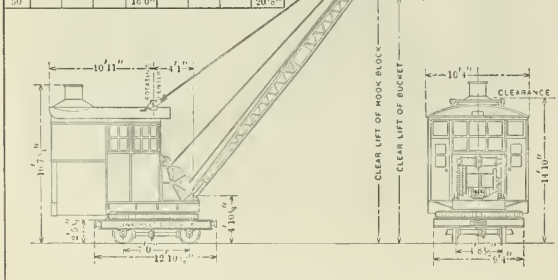
Methods of Transporting Work

Of the ten forms of equipment for transporting material and product, there are four general classes of service that must be fulfilled, which are given in the following:

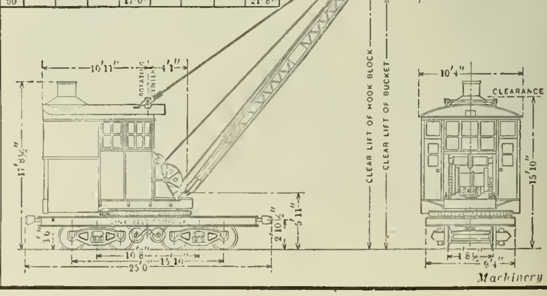
Hand-operated trucks or power trucks are used for the miscellaneous transfer of material from point to point in a factory, and their chief virtue lies in the fact that no fixed course

TABLE 5. CLEARANCE DIAGRAMS FOR STANDARD FOUR- AND EIGHT-WHEEL LOCOMOTIVE CRANES[1]

Radius Feet	Clear Lift of Bucket: Length of Boom 38'0"	42'0"	46'0"	50'0"	Clear Lift of Hook Block: Length of Boom 38'0"	42'0"	46'0"	50'0"
10					32'0"	35'0"	37'6"	40'9"
15	21'6"	23'0"	25'0"	26'6"	34'6"	38'6"	42'0"	45'6"
20	26'0"	28'6"	31'0"	34'6"	35'0"	38'9"	42'0"	46'0"
25	26'6"	30'6"	33'6"	36'6"	32'6"	36'6"	41'0"	45'0"
30	23'6"	28'6"	33'0"	36'6"	28'8"	33'8"	38'6"	43'4"
35	18'0"	24'0"	29'0"	34'6"	23'0"	29'0"	34'9"	40'0"
40	10'6"	18'0"	24'0"	30'0"	13'3"	22'8"	29'5"	35'6"
45		8'0"	16'6"	24'0"		11'0"	21'9"	29'9"
50				16'0"				20'8"



Radius Feet	Clear Lift of Bucket: Length of Boom 38'0"	42'0"	46'0"	50'0"	Clear Lift of Hook Block: Length of Boom 38'0"	42'0"	46'0"	50'0"
10					33'0"	36'0"	38'6"	41'8"
15	22'6"	24'6"	26'0"	27'6"	35'6"	39'6"	43'6"	46'6"
20	27'0"	29'8"	32'0"	35'0"	36'0"	39'8"	43'0"	47'0"
25	27'6"	31'0"	34'6"	37'6"	33'6"	37'6"	42'0"	46'0"
30	24'8"	29'8"	34'0"	37'6"	29'0"	34'8"	39'6"	44'4"
35	19'0"	25'0"	30'0"	35'6"	24'0"	30'0"	35'9"	41'0"
40	11'0"	19'0"	25'0"	31'0"	14'3"	23'8"	30'4"	36'6"
45		9'0"	17'6"	25'0"		12'0"	22'9"	30'8"
50				17'0"				21'8"



Machinery

[1] Practice of Link-Belt Co., Chicago, Ill.

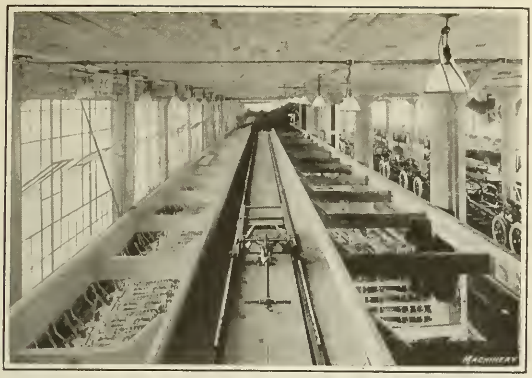


Fig. 25. The Palmer-Bee Co., of Detroit, Mich., installed conveyors and other equipment for handling work at the plant of the Paige-Detroit Motor Car Co. A rack was designed for storing automobile bodies, over which they are carried by a special elevating truck

Fig. 26. The Cowan elevating truck is used in the plant of the De Laval Separator Co., Poughkeepsie, N. Y., for handling work. Platform racks hold finished parts and prevent them from striking each other. Note how racks overlap to provide clearance for work

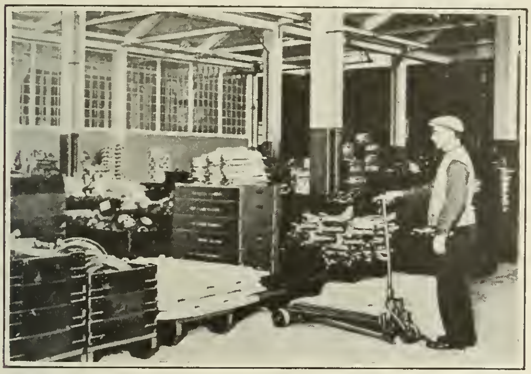


Fig. 27. Telescopic boxes on platforms are used by the Pierce-Arrow Motor Car Co., Buffalo, N. Y., in connection with Cowan elevating trucks. Box sections are of standard size and can be built up as required. Note saving of floor space made possible

Fig. 28. It is often a good plan to make tables which can be handled on elevating trucks. This illustration shows a table loaded with work being handled on an elevating truck built by the Barrett-Cravens Co., Chicago, Ill.

Fig. 29. Where a number of cores have to be handled in a foundry, it is well to have racks for moving them. This illustration shows a power-driven elevating truck built by the Automatic Transportation Co., Buffalo, N. Y., carrying a rackful of cores to a baking oven

Fig. 30. Power-driven trucks handle loads at greater speed than is possible by hand. In the National Cash Register Co.'s factory, illustrated, where the output is large, power-driven trucks made by the General Vehicle Co., Long Island City, N. Y., are used in the shipping room

Fig. 31. For handling material of compact form, so that a full truck load can be stacked on a single platform, satisfactory results may be obtained by the use of power-driven elevating trucks. The additional speed of operation saves considerable time and labor

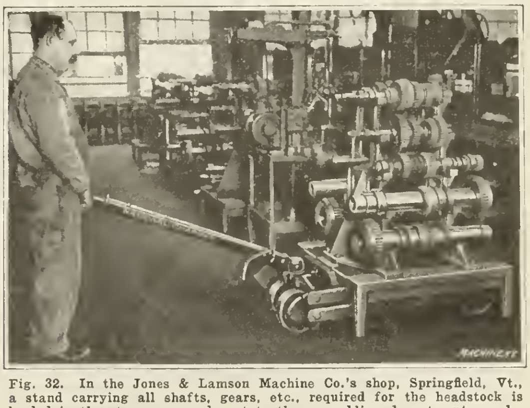


Fig. 32. In the Jones & Lamson Machine Co.'s shop, Springfield, Vt., a stand carrying all shafts, gears, etc., required for the headstock is loaded in the store-room and sent to the assembling department on elevating trucks built by the National Scale Co., Chicopee Falls, Mass.

need be followed. Hand-operated trucks of the plain or platform type may be either pushed or pulled, and when they are pushed it is desirable to have some form of buffer at the front to provide for opening swinging doors without delay. This buffer should be of a curved shape, so that if the truck gets into a jam, the buffer will assist in guiding the front through a narrow passage. A curved buffer also prevents damaging swinging doors in the shop, which are often pushed open by bumping the truck against them. For short hauls, hand-operated trucks are most satisfactory because of their lower cost and small upkeep charge; but in case heavy loads have to be hauled considerable distances, it is better to use power trucks, and these are ordinarily made of the storage battery type. In the plant of the Timken-Detroit Axle Co. and elsewhere, an alternative for power trucks is provided by having platform trucks arranged with couplings, so that they may be connected in trains and pulled by an "engine" which is equipped with the motor of a discarded Ford automobile. Such trains of cars are pulled from the forge shop to the first machine shop—a distance of about one-eighth mile—and enable material to be handled much more rapidly than it could be with hand-operated trucks.

Where it is desired to transfer work along a well defined route of no great width, use may be made of a track equipped with trolley hoists of the hand-operated type or furnished with electric or pneumatic motors. For the same class of service, use may be made of conveyor systems of various types, but as a general thing conveyors are not employed unless there is a large volume of work to be handled. Industrial railroads on which trains of cars are pulled by steam or electric engines are not commonly employed unless it is required to carry very heavy loads, and in order to be a paying proposition there should be enough work to be done to enable the industrial railroad to earn a satisfactory return upon a somewhat heavy investment.

Jib cranes are more properly used for lifting work and material, but in a limited sense they may be discussed under the heading of transportation, because cranes of this type are employed for swinging heavy loads a short distance between trucks and machine tools on which work is to be done, and for similar classes of service. Jib cranes may be equipped with hand-operated hoists or with electric, pneumatic or air hoists, the air cylinder type being one of the most common.

Locomotive cranes, although generally used for swinging a load through relatively short distances, are supported so that the load may be picked up and carried any desired distance. Some fairly small factories make good use of locomotive cranes, although at first thought it may appear as though they have not enough work to keep such an equipment busy. A locomotive crane, when not in use for the purpose of lifting, may be satisfactorily employed as a switch engine, and it is this "fill in" work that has led to a considerable increase in the application of this type of crane. A smaller form of crane combining the same general features of design as a locomotive crane is made with a swinging arm of relatively short reach, which is supported on an electric motor-driven truck.

The chief distinction between the classes of service for which some form of trolley system is suitable and those for which a traveling crane is required is that provision is made for carrying work along a definite course in the trolley systems, while an entire area may be served by cranes, as, for instance, the whole floor of a shop. Traveling cranes are of numerous types and may be equipped with electric or air motors; in addition, they may be hand-operated or of the one-, two or three-motor types, according to whether the hoist, trolley and trucks that support the bridge are motor-driven. There are two general types of equipment used for this purpose, *viz.*, the traveling crane supported on runways carried by the structure of the building, and the gantry crane on which the hoist and trolley are carried by a structure which runs on truck wheels carried by rails placed on the ground. The distinction in use between these equipments is that traveling cranes are used inside buildings, while gantry cranes are used in railroad yards and similar places out of doors. In such cases it will be found economical to build a structure to carry a traveling crane, if the probable saving in power will be sufficient to warrant such an expenditure. In operating a gantry crane, additional power is consumed in traversing the structure that supports the bridge, and if a lot of service is required of the crane, this increase in power consumption may more than offset the lower first cost of the gantry crane.

Handling Work of Assembling Department

In plants engaged in the manufacture of complete products, that is, in machining parts and assembling them ready for shipment to the user, there is probably no better method of handling than sending completed parts to what is generally known as the "finished stores" department, from which they are drawn on requisition by the assembling department as fast as they are required. The introduction of various profit-sharing plans in industrial plants has been extremely valuable through its tendency to unify the interests of employer and employe, as both classes benefit through any increase of production which is made possible. To facilitate the handling of materials and the performance of machining operations as far as possible, and to make a corresponding increase in the earnings of men and the profits of employers, most large manufacturing plants have established what are known as planning departments, which employ engineers whose duty it is to devise time- and labor-saving methods.

Much has been accomplished in this way, but there is probably no one step which has effected greater savings in the cost of production than the development of what is known as the progressive method of assembling. This was first employed in the assembling of parts to form complete motor cars, and as practiced in automobile factories, it consists of putting the automobile frame on a traveling conveyor which runs the entire length of the assembling shop. This conveyor carries the frame along, and stationed at intervals along the track are gangs of men who perform specified parts of the work of assembling. These men are kept constantly supplied with parts, which they put in place on each car as it passes their station; thus the conveyor constitutes a pacemaker which stimulates activity on the part of the men and keeps them working at top speed.

Practice varies in the method of handling progressive assembling in different automobile plants. In some cases the automobiles which are constantly getting nearer the completed condition are moved along the track by a power-driven conveyor, as previously mentioned, while in other cases each frame supported by the axles and wheels of the automobile is run along the track as fast as the different groups of men are through with their task. The former is usually the better method, as when the work is moved along by hand the personal equation becomes the determining factor in establishing rates of production, so that much of the possible benefit of the plan is lost.

An alternative method is employed in assembling automobiles in the plant of the Studebaker Corporation, Detroit, Mich. Under this plan the cars are all connected to a conveyor, which, instead of running continuously, is moved intermittently by a man who is stationed on a bridge at the head end of the track and operates control levers to move the cars forward one station as soon as the assembling operation has been completed by all the men along the track. Each station is given a number, and a push-button is provided by which a signal is sent to the man on the bridge that the work of assembling at that station has been completed. These signals consist of electric lights which glow as soon as the push-button is pressed and show the numbers of the stations that have completed their work.

When all the lights are on, the man on the bridge immediately throws over his control lever and advances the automobiles on the assembling track to the next station. This man keeps a record of the order in which assembling operations are completed at the different stations and the number of men at each station is regulated according to the complexity of the work, the idea being to have all of the assembling operations completed at the same time. Should it happen that a given station is conspicuously behind time, an investigation is made to find whether the men at this station are taking an unnecessary amount of time or whether conditions of the work justify such an increase in the time required for assembling.

Fig. 33. Time is often lost through assemblers having to make trips to the store-room to obtain missing parts. The Cadillac Motor Car Co. has overcome this difficulty by constructing trucks with individual compartments for carrying a complete set of parts for a motor

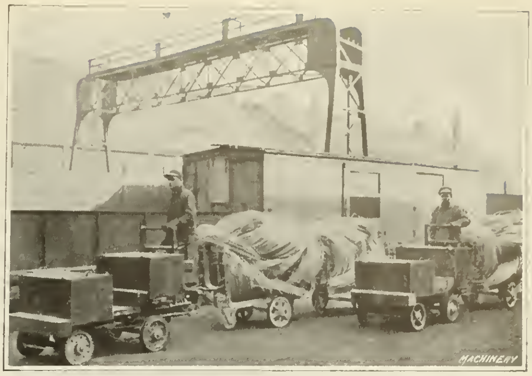


Fig. 34. Where material is bulky and requires considerable space on a truck, several trucks can be coupled together and pulled through the plant by a tractor. The illustration shows one of the mill type electric tractors built by the Automatic Transportation Co. pulling trucks

Fig. 35. In factories that have industrial railroad tracks trains need not always be pulled by an engine. Where the load is to be moved only a moderate distance, the cars can be pushed along with a motor-driven truck. An Automatic Transportation Co. tractor is shown in the illustration

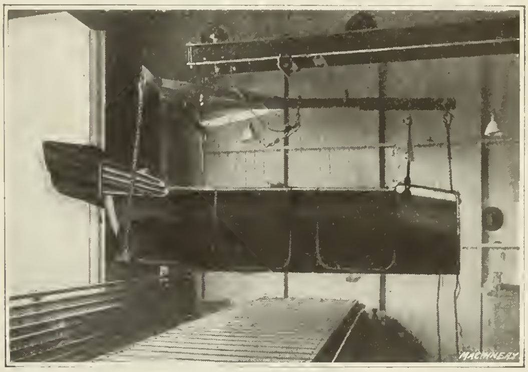


Fig. 36. In some cities municipal regulations prohibit extending a beam out over the roadway to support a trolley. The Palmer-Bee Co., of Detroit, Mich., made a movable trolley for the Paige-Detroit Motor Car Co., which can be run out over the road to pick up auto bodies

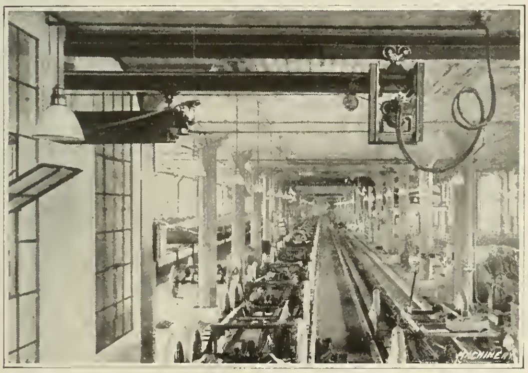


Fig. 37. In the trolley rail extension (Fig. 36), the air cylinder actuates the hoist and the pneumatic motor runs the extension out so that the hoist can pick up its load and carry it back into the shop, where the auto body is put on a conveyor and carried to the assembling department

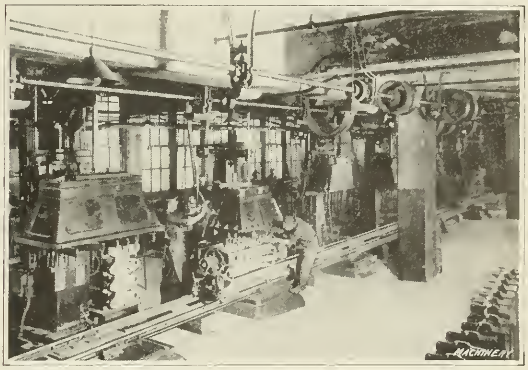


Fig. 38. At the Packard Motor Car Co.'s factory in Detroit, crankcases are drilled in jigs, which run on rails leading from machine to machine. These jigs are supported on trunnions and have index-pins to enable all surfaces to be brought into the drilling position

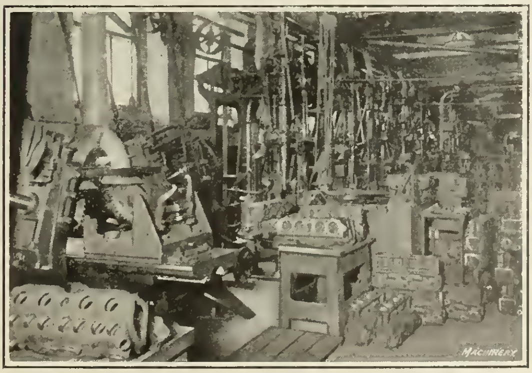


Fig. 39. In the cylinder department of the Cadillac Motor Car Co. there is a stand between each pair of machines, of the same height as the machine tables, so the operator does not have to stoop. Castings are swung from machine to stand and thence to next machine

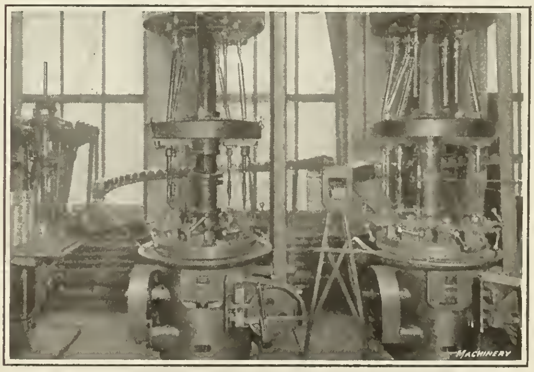


Fig. 40. In performing a sequence of operations on pistons, the Cadillac Motor Car Co. uses a trough in which the pistons are rolled from machine to machine. When an operation has been completed, the piston is removed from the machine and placed in the trough

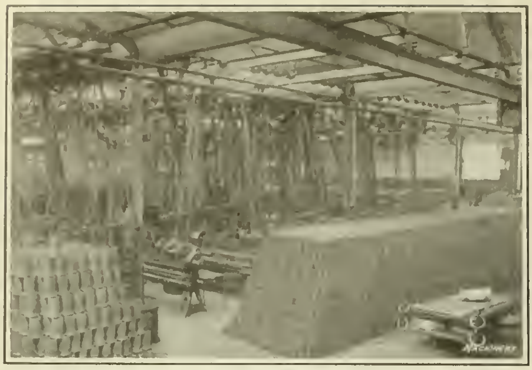


Fig. 41. Troughs are also used for carrying cylindrical work, such as pistons, from machine to machine in the plant of the Ford Motor Co. This illustration shows a somewhat different arrangement from that illustrated in the Cadillac factory. An idea of the enormous rate of production in the Ford shops will be gathered from the stack of pistons shown in the foreground of this illustration

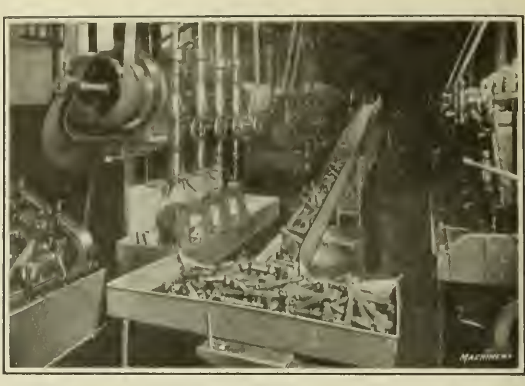


Fig. 42. In the Ford Motor Co.'s plant, application of work-carrying troughs is not limited to the handling of pieces of cylindrical form. Many small parts are carried in this way, but it is necessary to have a considerably greater pitch where the work must slide instead of roll in the trough. This idea is simple and could be used to excellent advantage in handling a great variety of work

Upon the result of this investigation a decision is reached either to supply one or more additional men to help with the work or to replace those men who are found to be taking too much time in the performance of their task.

Mention has already been made of the fact that the progressive method was developed for the assembling of complete automobiles, but its advantages have become so conspicuous that automobile manufacturers are now using it in many other kinds of work. For instance, motors, rear axles, clutches and many other parts are assembled by the progressive method, and illustrations showing the performance of this work are presented in this article.

The Palmer-Bee Co., Detroit, Mich., had installed a number of successful conveyor systems in the Packard factory, and suggested that it would be entirely feasible to apply the progressive method of assembling in handling the clutches. The result was that stands of the same type as those originally used, except that they are made lower on account of being supported on the conveyor, were placed on the power-driven conveyor, along which groups of men are stationed to perform the assembling operations. These men are constantly supplied with the parts they are required to put together, and as the conveyor sets the pace, the rate of production in handling this work has been greatly increased. Although progressive assembling was originally developed and is still generally used in automobile plants, the method is now finding application in other lines of work; in the second installment of this article illustrations will be shown of the progressive assembly of parts of gas ranges in the factory of the Detroit Stove Works, and of automobile cushion springs in the plant of the Detroit Wire Spring Co., Detroit, Mich.

Organization of Assembling Methods in Other Directions

Lack of organization in handling the work of the assembling department probably offers a better opportunity for unconscientious employes to waste time than is the case in any other department. This is due to the fact that in assembling, certain parts are likely to be missing, and this presents an opportunity for the assembler to go to the store-room for parts and take a lot of time in getting them. With the view of overcoming trouble from this cause, many manufacturers have organized their work of assembling in such a way that a complete set of parts for a given unit is carefully made up in the finished stores department and checked over to see that nothing is missing; this set of parts is then sent up to the assembling room and can be put together without delay. A case in point is seen in the motor assembling department of the Cadillac Motor Car Co., Detroit, Mich. This firm has refused to adopt the method of progressive assembly because its engineers hold the view that a forced rate of production must, of necessity, lead to turning out work which is likely to be found unsatisfactory in service. Every effort has been made to facilitate the work of assembling by keeping the men constantly supplied with the parts they need and by every other means that cannot exert a harmful effect upon the quality of the work produced. One important step in this direction consists of providing trucks that are furnished with trays divided up into compartments for all the parts of a motor. These trucks are sent empty to the finished stores department, where a complete set of parts for a motor is loaded into the truck. By having the trucks subdivided into trays and compartments, it is an easy matter for the men in the store-room to check up the parts to see that nothing is missing. Then when the truck goes up to the assembling room there is no chance of delay through lack of parts. Work is further facilitated by providing stands mounted on joints that permit the motor to be swiveled into any position that will be found most convenient for putting each part into place.

Application of Highly Systematized Methods of Automobile Factories in Machine Tool Work

The machine tool builder who is being shown through one of the large automobile factories is bound to be impressed by the results obtained from the highly systematized assembling methods employed in these plants. But he is likely to regard this merely as a case in which scientific management has produced gratifying results and fail to see the possibility of applying similar methods in his own shops. However, these methods are capable of wide application—after making suitable modifications to adapt them to existing conditions. It is the purpose of the present article to describe the way in which such highly systematized assembling methods were applied in the factory of the Jones & Lamson Machine Co., Springfield, Vt., and the conditions which led to their employment. Credit for the development of this plan is due to Ralph E. Flanders, general manager of the firm.

It is an axiom of factory administration that the greatest return will be obtained from labor by arranging working conditions in such a manner that the men will be required to move about the shop as little as possible. The method of assembling to be described is employed on all parts that go to make up the headstocks of Jones & Lamson flat turret lathes, including the shafts for the lathe headstocks. A study of the methods of assembling formerly employed in the factory revealed the fact that a large amount of time was spent by the men in going to the store-room for supplies, in delivering the work which they had completed to the next department, and in various wasteful ways which were fostered by the conditions existing in the shop.

With a view of overcoming these difficulties it was decided to develop a method which would provide for delivering the necessary parts to each man employed in the assembling department, so that he could carry on his work without the necessity of going to the stock-room. There are two obvious advantages in such a plan; the possible loss of parts is avoided and the time of the assembler is saved, as the delivery of parts from the stock-room can be looked after by a boy whose time is of little value. The assembling department was then laid out in such a way that the work would move in a continuous circuit and its transfer be simplified as far as possible.

Fig. 43. For handling pieces that are too heavy to slide in troughs, and where it is only required to transport the work a short distance, rails are set up in the Ford Motor Co.'s factory, along which the work can be slid from machine to machine. This saves lost production during late hours of the afternoon which would otherwise be caused by machine operators becoming unduly fatigued

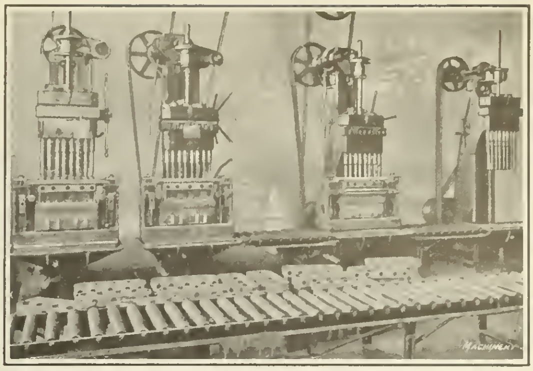


Fig. 44. Sometimes it is feasible to design jigs and fixtures in which work may be held for the performance of a number of machining operations. This illustration shows such jigs in use in the Maxwell Motor Co.'s shops in Detroit, Mich. The work and jig are pushed along from machine to machine on a roller conveyor, the operator following the jig right down the line of machines

In the department where the headstocks are assembled, each employe is assigned to a bench fitted with a vise, arbor press and the necessary tools. The parts are transferred from the stock-room to the assembling department in bins, each of which carries all the necessary gears and other parts required for one or more complete shafts or other unit assemblies. The bin in which these parts are contained is supported on a small truck carried on the stand, which is made so that it may be conveniently moved by an elevating truck. The truck carrying a bin full of supplies is backed up so that the tracks on the stand are in line with tracks located at the back of the assembling bench. The latch which holds the small truck in place on the stand is then released, and this "bench truck," as it is called, is then run onto the tracks on the bench and locked in place. At the time a bin full of parts is delivered to the assembling bench, a truck and empty bin is run off at the opposite end of the bench and returned to the stock-room, where it is filled with parts ready for delivery. Each bin full of parts is delivered from the stock-room against a signed order from the foreman of the assembling department.

Construction of Assembling Benches and Bench Trucks

The tracks for the bench trucks are located slightly below the working surface of the bench for the purpose of bringing the lowest compartments of the stock bins level with the bench and placing all compartments within easy reach of the operator. It will be evident that some provision must be made for securing each of the bench trucks in place. This is effected by latches which engage each side of a lug cast on the bottom of the truck body. When a truck is run into place on the bench or moved from one station to another, these latches are released by turning suitably arranged handles which cause the latches to drop to a horizontal position and release the lug on the truck.

The front corners of the bench are beveled off, the purpose being to enlarge the opening between adjacent benches so that it is an easy matter to back the elevating trucks into place. Cleats are provided on the floor at the end of each bench which engage the legs of the stands on which the bins are brought out from the stock-room, thus locating them in such a position that the tracks are in line with the tracks on the assembling bench. These stands are to be arranged with wheels so that the elevating truck can be dispensed with.

Taking Machine to Work

The idea of making it unnecessary for the workmen to leave their places in the factory has been carried a step further by providing portable drilling machines for use in the assembling department. The equipment consists of an "Avey" bench drilling machine, made by the Cincinnati Pulley Machinery Co., which is mounted on a stand used in connection with an elevating truck. It will be evident that the individual motor drive makes it possible to connect with the electric circuit in any part of the shop where the machine is to be used. The drilling machine is used for drilling pin-holes in the shafts at the time the assembling is done in order to get exactly the required relation between the different parts for the machines. It has been mentioned that the stands on which these drilling machines are mounted are so designed that an elevating truck may be used for moving the machine about the factory; but as in the case of the stands for the stock bins, it is intended to apply wheels so that the use of a truck will be unnecessary.

The method by which the parts are delivered from the stock-room has already been referred to, and there is little more to be said about the work of assembling the shafts beyond the fact that special stands are provided on which the complete shafts are stacked pending their delivery to the men who assemble them in the headstocks. On these stands brackets are provided for holding the shafts, the former being faced with soft brass to prevent scoring the bearings. Each rack has a capacity for holding the shafts required for two complete headstocks, and represents a normal day's work of one assembler. As the factory is at present turning out four single-spindle lathes a day, it will be obvious that it is necessary to have two men employed in assembling shafts. The output of these two men is passed along to the two head assemblers, where the bearing linings are fitted into the headstock castings and the shaft is assembled in place. Special assembling stands are used to support the work, and electric hoists are provided on each side of the assembling department to assist the men in lifting heavy parts. These hoists are arranged on I-beam trolleys which extend the whole length of the bay directly over the space in which the assembling stands and shaft racks are located, so that the hoists may be used if necessary at any bench. It should be noted, however, that they are in general use only at those benches where the headstock castings themselves are handled, inasmuch as every item of the equipment, with the exception of the assembling benches, is arranged to be moved by elevating trucks.

Criticisms of scientific management are often made on the grounds that the cost of installation is high, that it complicates the routine work of the factory, and that the benefits obtained do not justify the trouble and expense that have been involved. In some cases these contentions are undeniably true, but in the present instance it will be evident that the cost of installing the method was relatively low and the work of assembling has been greatly simplified rather than complicated. A concrete idea of the actual benefits resulting will be gathered from the fact that four men are now able to do the work for which ten were formerly required.

Importance of Advance Information

There are few apparently unimportant items of expense that are likely to assume more serious proportions than the wasting of time by men who are sent to stock-rooms to obtain materials and parts required in the assembly of machines and other manufactured products. In some shops where little system is followed, men regard a trip to the store-room as the equivalent of a half-hour's vacation. At the door they meet several acquaintances, and unless means are taken to check this form

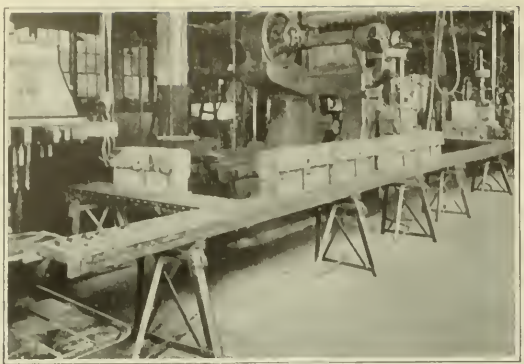


Fig. 45. The equipment shown in this illustration is somewhat similar to that illustrated in Fig. 44. A conveyor built by the Mathews Gravity Carrier Co., Elwood City, Pa., provides for easy transportation of work from machine to machine, but in this case the jig or fixture does not go with the work. Attention is called to branch lines running off to different machines

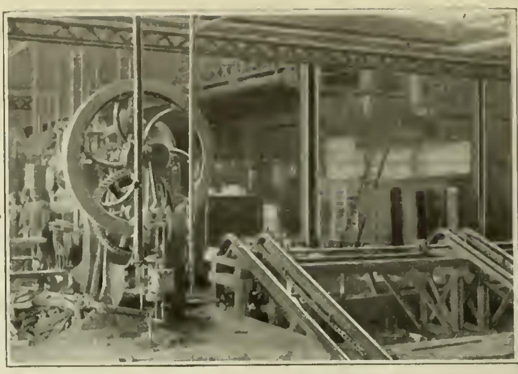


Fig. 46. A special conveyor is built by the Chain Belt Co., Milwaukee, Wis., for the rapid handling of bars in the Milwaukee works of the Illinois Steel Co. The chain conveyors carry the work up inclined rails, where it is in position to be fed into power shears, which are used for trimming the ends. Such an arrangement avoids handling the work by manual labor

of soldiering, there is likely to be a knot of workmen standing around the door of the store-room having a friendly chat. One of the reasons for the existence of such a condition is that men are often sent down to the store-room with a requisition slip calling for the parts or materials which are required, and as the attendant in the supply-room has a number of men to look after, each order must be attended to in turn. Such practice involves delay to the man who has handed in a requisition slip, and since a delay is more or less expected, even conscientious workers may unconsciously form the habit of wasting time when sent after supplies.

One way of overcoming this difficulty is to make a practice of having the foreman who sends for supplies telephone his order to the supply-room at the time he hands the requisition to the workman who is to be sent after the material. Such a practice involves little loss of time, and as the store-room attendant has received advance information of the requirements, he has had an opportunity to get the order assembled ready for immediate delivery to the messenger who hands him the foreman's signed requisition slip. In this way wasting time by both the messenger and the store-room attendant is avoided, because the attendant can utilize time when he would be otherwise unemployed in making up orders which have been telephoned him, and this avoids delay on the part of the messenger when he arrives at the store-room. Standard telephones may be used for this purpose or one of the automatic inter-department telephone systems may be employed to advantage. The "Select-o-phone" manufactured by the Screw Machine Products Corporation, Providence, R. I., is a suitable form of apparatus for this purpose. As it is the practice in many moderate sized shops to allow experienced mechanics drawing from forty to fifty cents an hour to go after supplies, it is important to adopt some method of preventing these men from wasting their time.

Assembling Machines with Bed Castings Bolted onto Elevating Truck Skids

In assembling machine tools and other machinery of moderate size, some manufacturers have found it advisable to bolt the bed casting down to an elevating truck skid as soon as the planing operations on the casting have been completed. After placing on the skid, it is an easy matter to move the casting around with an elevating truck, so that it may be carried to the inspection department and then be sent on to the assembling room where small parts are put in place. After assembling, the machine may be taken to the painting and shipping room and easily placed in a freight car. Elevating trucks are now so generally used that the chances are in favor of the purchaser of the machine having a truck which he can run under the skid and easily pull the machine out of the car and haul it to any desired position in the factory. Should it happen, however, that his plant is not equipped with elevating trucks, making it necessary to use the slow method of rolling the machine into place on rollers, the fact that the machine is mounted on a skid is a benefit rather than a drawback, because the skid forms a good smooth bearing for the rollers.

Taking Tools to Work

In handling heavy work, considerable time is often required for transferring the pieces to a machine and setting them up. Such a practice means a heavy expense both for labor and for equipment which must be provided for handling parts of this kind. In many cases this is unavoidable, but there are instances where much of the trouble can be overcome by the use of portable tools which are taken to the work instead of carrying the work to the machines. Drilling, reaming and grinding operations are often performed by portable tools driven by either electric or pneumatic motors, and such work as snagging castings, etc., is conveniently done by portable

Fig. 47. For carrying work through a series of pickling and rinsing baths to remove grease, the Chain Belt Co. built the special conveyor system illustrated herewith. This is shown carrying brass cartridge cases through the pickling baths. The conveyor consists of two strands of this company's "Griplock" roller chain belt with cradles for supporting the cartridge cases

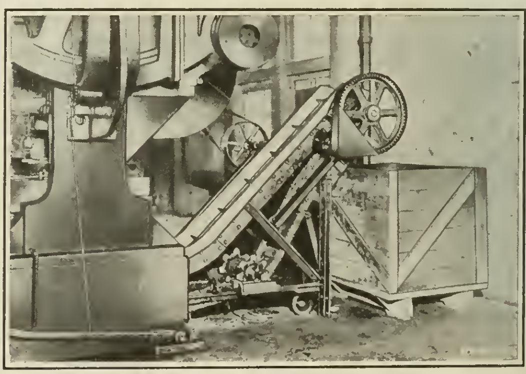


Fig. 48. Presses running on repetition work are often seriously slowed down to permit the operator to remove the work by hand. Here we show a special conveyor built by the Chain Belt Co. for handling product of a blanking press. Work is carried away by the conveyor and dropped into a box, which is hauled away on an elevating truck after it has been filled

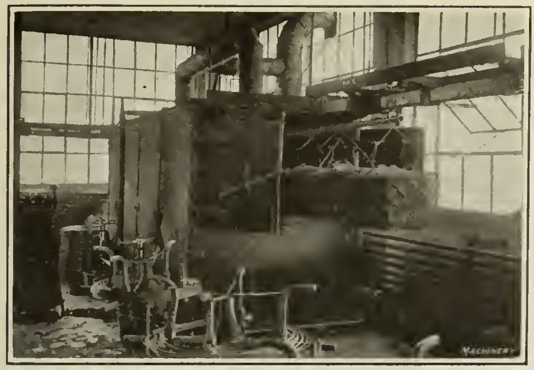


Fig. 49. Usually it will be found desirable to employ standard forms of elevating and transporting equipment whenever this is possible. In many cases standard equipments can be adapted for special conditions by the addition of auxiliary apparatus. A case in point is seen in this illustration, which shows baskets for carrying wire springs to a japan baking oven in the plant of the Detroit Wire Spring Co.

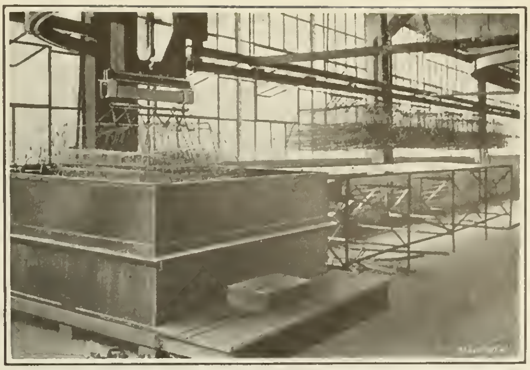


Fig. 50. To provide for dipping assembled cushion springs into a japanning tank, the Detroit Wire Spring Co. arranged a section of trolley rail on a hoist so that the trolley could be run onto this section of the rail to enable the work held by it to be immersed in the japan. After dipping, the rail is raised so that the trolley can run off onto the main line

chipping hammers driven by compressed air which actuates a reciprocating piston in a cylinder. Other examples of the obvious saving which may be effected through the use of portable tools are found in such operations as reboring locomotive cylinders. Here the saving is two-fold: not only is it unnecessary to take the work to a machine tool, but the expense incident to removing the cylinder from the engine and replacing it is also avoided, as the portable cylinder boring machine is so designed that it will operate with the cylinder in place on the engine. The only work required is to remove the cylinder head, piston and piston-rod, and replace them after the boring has been done. Other familiar examples of this kind are portable lathes and milling machines which are mounted on trucks so that they may be drawn about the works. Machines of this type are driven by electric motors, which make it an easy matter to form connection with a power circuit in the shop. In addition, there are portable turning, milling and keyseating machines which may be secured to a shaft or other cylindrical part in the position that it occupies in the shop, instead of requiring the shaft to be removed from its bearings and set up on the machine.

Use of Tote Boxes

There are a great variety of machine shop products that can be conveniently handled in tote boxes. Where the quantity of material to be passed along from machine to machine is small, it will usually be found satisfactory to handle single boxes by means of hooks; but where a large quantity of product has to be transferred, greater efficiency will result from handling a load of filled boxes on some form of shop truck. The New Britain Machine Co., New Britain, Conn., makes these tote boxes of steel, and they are designed in such a way that they may be stacked up to economize in floor space or to pile more boxes on a truck. The sides are folded over onto the ends, which are formed by the upturned extensions of the bottom; and the top edges of the stock at the sides and ends are turned over to form a hem, which precludes the possibility of injury to the operator. Near the corners where the strain is greatest, the stock is of quadruple thickness. A hole is punched in the handle for convenience in dragging with a hook, and the raised ends allow somewhat greater piling capacity in each box. Also the steel construction makes these boxes practically indestructible. Fig. B (first page) shows the use of these tote boxes in the plant of the New Departure Mfg. Co., Bristol, Conn., where they are used for carrying steel balls. The electric storage battery truck on which the load is being transferred is built by the Elwell-Parker Electric Co., Cleveland, Ohio.

Design of Auxiliary Equipment for Use in Connection with Elevating Trucks

Selection of a suitable type of auxiliary equipment for use in connection with elevating trucks will, of necessity, depend largely upon the nature of the work to be handled. Some classes of material may be stacked directly upon skids, while others will require some form of box or rack, this being particularly the case with large numbers of small castings, etc., which cannot be stacked up so that the different parts afford mutual support. Still another condition arises in the case of completely machined parts which must be held in racks to prevent finished surfaces from becoming bruised or marred. In some cases boxes are placed upon the familiar form of skids, while in other cases the boxes are constructed with skids on them. These boxes may be made of wood or sheet metal, according to the service required. In handling small parts that are delivered to a machine in large quantities, there is one requirement of considerable importance that is frequently overlooked. This is that the box should not be of

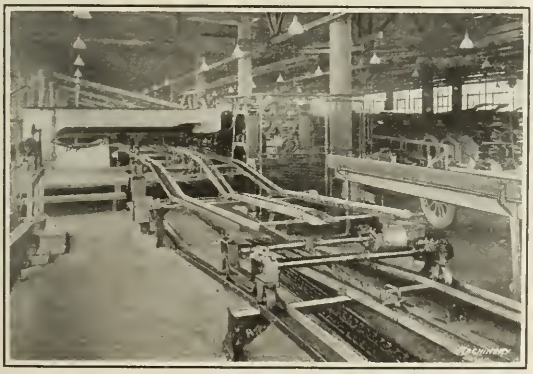


Fig. 51. Here we show a conveyor system installed by Palmer-Bee Co., of Detroit, Mich., for handling automobile frames in Paige-Detroit Motor Car Co.'s plant. Empty trucks return through tunnel and are caught by a hook on the conveyor. They run back over hinged section of track and receive frames from trolley system. One truck is coming up the incline, and another is on upper level of track with a frame on it

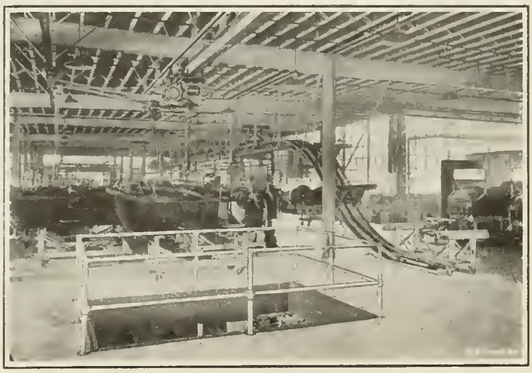


Fig. 52. Economy of space is a point of vital importance in plants handling a large volume of product. This illustration shows how automobile bodies are handled in the Willys-Overland Co.'s plant in Toledo, Ohio. The assembled bodies are picked up and carried away on a trolley hoist, and empty trucks are carried back to the beginning of the assembling line on the overhead track

Fig. 53. The Willys-Overland Co. has a motor storage department on the opposite side of a roadway from the building containing the motor assembling department. Motors are carried over into this storage department on an apron-type conveyor which runs through a tunnel under the road. This conveyor was built and installed by the Link-Belt Co., of Chicago, Ill.

Fig. 54. In large plants, such as that of the Willys-Overland Co., a visitor is bound to be impressed by the variety of equipments employed for handling raw materials and product. For instance, the preceding illustration shows an apron-type conveyor for carrying assembled motors, and in this view the same class of work is being done by a trolley system installed by the Link-Belt Co.

such depth that, as the supply of work becomes exhausted, the operator has to dive head and shoulders into the box in order to reach pieces near the bottom.

In many plants a "false" bottom is put in the box at a height of about two feet from the floor. The box can still be made two feet deep, so that it has ample capacity, but when the supply is nearly exhausted the operator has no difficulty in taking out parts. Another good plan is to have boxes divided into two sections and delivered to machines with one of these sections full of parts upon which an operation is to be performed. As fast as each part is machined it is thrown into the other half of the box, and when all the parts have been taken care of they are sent on to the next department. Reference has just been made to the trouble that arises from having boxes made of such depth that it is difficult to remove pieces as the supply becomes exhausted. In the plant of the Packard Motor Car Co. this trouble has been overcome in another way. The boxes are made in sections which telescope together, so that, as the supply of parts becomes exhausted, the upper sections of the box may be lifted off, so that they do not hinder the operator in removing work. In this type of box also it is a good plan to have the bottom located at some distance from the floor, so that the operator does not have to stoop to reach his work.

Features that Add to Efficiency in Operation of Elevating Trucks

Arguments in favor of the use of elevating trucks are based on time studies that show that it takes four times as long to load and unload a truck as it does to move the load through an average length of haul in an industrial plant. With the elevating type of truck this loss of time is avoided, because machine operators are furnished with boxes adapted for use in connection with elevating trucks, so that raw material or finished product is taken from or placed on a carrier, on which it is hauled away by the truck. Another claim made for elevating trucks is that they often save time which would otherwise be lost in removing the load from a plain truck in order to release the truck for use in handling another load. Granting the accuracy of the claim that it takes four times as long to load or unload a truck as it does to move the load an average distance in a plant, it follows that each elevating truck saves the wages of four truckmen operating plain trucks. At this time, when labor is so scarce, the use of a truck that enables one man to do the work of five and save needless loading and unloading is especially desirable.

Usually from fifty to one hundred wooden platforms or boxes are used in connection with each truck, and these platforms or boxes are mounted on skids so that the truck may be pushed under them with the platform down, and the platform raised by pulling the truck handle forward, in order to lift the load from the floor so that it may be hauled through the shop. A lock on the lifting mechanism holds the load up, and when this lock is tripped with the foot-pedal, a check allows the load to descend slowly, so that there is no danger of damaging the load or causing trouble in other ways. In plants where floor space is at a premium, an important feature of these trucks is that when not in use the platforms may be stacked one on top of the other, and in this way they take up very little space, while in the case of plain trucks each truck occupies its full amount of space, no matter whether it is idle or in use.

The conditions under which elevating trucks are used will naturally vary considerably, according to the requirements of different industries. The following, however, is about typical of the efficient conditions of operation which are made possible through proper application of elevating trucks. At one side of a machine operator, within easy reach of his position at the front of the machine, an elevating truck sets down a platform, rack or box loaded with pieces on which a machining operation is to be performed. At the other side of the machine, also within easy reach of the operator, the truck places a similar empty carrier. It is then possible for the machine operator to take pieces from one container, perform the required machining operation, and deposit them in the container at the opposite side of the machine. When the latter is filled with finished pieces, the elevating truck carries it away to the next machine; and similarly, when the supply of pieces to be machined has been exhausted, a fresh lot is brought. In this way the non-productive time of the operator and machine is reduced to a minimum. In addition to handling materials and work in course of production, elevating trucks may be used to advantage in handling many other heavy loads, such as large dies, etc. In no case, however, can it be hoped to obtain maximum efficiency in the operation of these trucks unless a point is made of having them carry approximately their maximum load at each trip.

Special Electric Truck for Loading and Unloading Lumber

Investigations made by the Covel Mfg. Co., Benton Harbor, Mich., show that it costs between twenty and thirty cents per thousand board feet to handle lumber with a horse-drawn wagon. This company has developed what is known as the Ross electric lumber carrier, and with this truck it is claimed that the cost of handling lumber has been reduced to six cents per thousand feet. This estimate is based on operation of the trucks over a period of eighteen months. The Ross carrier runs over a load of lumber and picks it up by lifting two simple bolsters upon which the load is built, it being only necessary for the load to be kept within a certain height and width. The operator drives the machine over the load which is engaged by means of two hooks on each side that are lowered and raised by power from the motor. This can be accomplished in about ten seconds. The normal speed of the truck is eight miles an hour when carrying a full load, or about three times the speed of horse-drawn trucks.

The second and concluding installment of "Factory Transportation" will appear in the August number.—Editor.

METAL EXTRUSION[1]

BY F. G. SCHRANZ[2]

The art of extruding metal has been known approximately fifty years. About seventeen years ago, the American Brass Co. purchased the patent rights of Alexander Dick, an Englishman, who had made some experiments with extruding metal under high pressure and high temperatures. The first machines and extruding methods, compared with those of today, were crude and the operation was very slow. It was then the practice to heat the billet container during the extrusion process; a press with such a heating arrangement is shown in Fig. 1. In the later processes, annealing is unnecessary, as the extrusion is completed in a single operation; pickling, also, is unnecessary except when a special finish is desired. Considerable trouble was experienced in getting material for the container cylinder and the extrusion ram that had sufficient tensile strength to withstand the exorbitant pressure required to extrude metal. Today, where a pressure of 100,000 pounds per square inch is exerted on the heated billet, only the best alloy steel is employed in the construction of the dies. In some presses, the dies are held in the head, which takes the pressure during the extruding process.

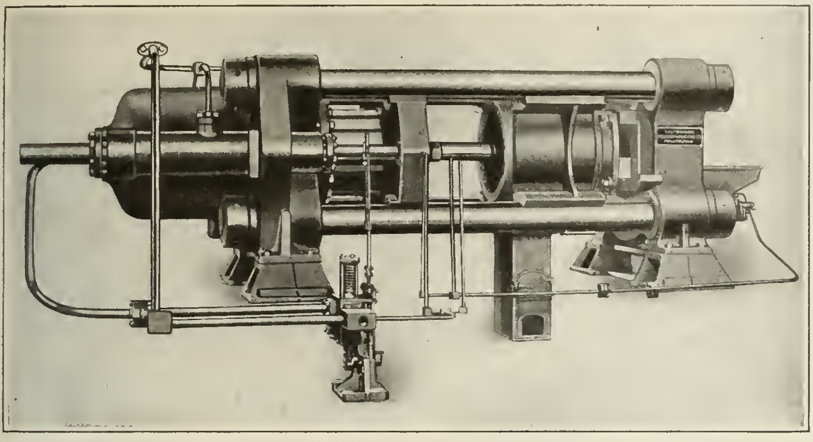


Fig. 1. Hydraulic Extrusion Press (1000 Tons Capacity) with Heater for Billet Container

The extrusion machines generally used in this country are of the three- or four-rod horizontal type, with capacities of 1000, 1500, and 2000 tons, and a production of from 50,000 to 80,000 pounds of extruded rods daily. A 2000-ton press, like that shown in Fig. 2, has extruded sixty billets per hour. These billets were 8 inches in diameter, 30 inches long, weighed 450 pounds, and the production was 20,000 pounds of finished rods per hour. The entire machine is constructed of open-hearth steel castings. The pressure in the main cylinder is 6000 pounds per square inch. A special valve is used for distributing the high-pressure water to the main cylinder. In many cases, this press is operated from a high-pressure hydraulic pump only, but if an accumulator is employed the output can be increased considerably. A hydraulically operated shifter inserts the billet into the container, and quickly removes the die-holder after the thrust block is withdrawn, bringing the billet stump under a cutting-off shear.

One of the greatest difficulties encountered in machines of this type is the removal of metal waste remaining in the pressure chamber after the extrusion operation has been completed. Metal forced between the joints by the high pressure solidifies and becomes difficult to remove. In the Southwark press, at the end of the extrusion, an auxiliary cylinder operates the pressure chamber in the reverse direction, opening the space between the pressure chamber and the die so that the surplus metal can be easily removed from the top of the die. The pressure chamber moves on four guide rods between the head and the hydraulic cylinder. A tapered hole in the head end of the pressure chamber exactly fits the correspondingly tapered dies. This hole and the tapered end of the die form a close-fitting joint, which prevents the metal from being squeezed out between the two surfaces. The piston of the auxiliary cylinder is connected with the pressure chamber; at the beginning of the extrusion the auxiliary cylinder forces the pressure chamber against the die.

The billets are prepared in the brass foundry and contain from 55 to 63 per cent copper and not more than 3 per cent lead. This mixture is heated in crucibles which contain from 200 to 300 pounds of metal in pit furnaces that are fired with coke and anthracite, using natural draft. The molten mixture is turned into cast-iron cannon molds, which are supported vertically on trunnions at the center and provided with a metal plug on the bottom. The molds are generally dressed with a mixture of fish oil and powdered charcoal, before the metal is poured. In many cases, a mixing ladle that holds the contents of two or three crucibles is used. The billets shrink in cooling, and when the mold is tilted they easily fall out. They are then taken to a cutting-off machine where from 8 to 10 per cent of the length is cut off, thus removing any pipe or blow-holes from the top.

Before extruding, these billets are reheated to from 1500 to 1800 degrees F., depending on the copper content, in a continuous reheating furnace, the hearth of which is inclined $1\frac{1}{2}$ inch per foot. If the billets are suddenly cooled, the surface of the metal loses plasticity and makes satisfactory work impossible, besides delaying the extrusion process. A cast-iron table 50 feet long supports the extruded rods, and between this table and the back edge of the machine there is a 30-ton cutting-off press, which severs the ram stump of the billet from the die block. From seven to ten men are required for operating the extrusion-press equipment and furnace.

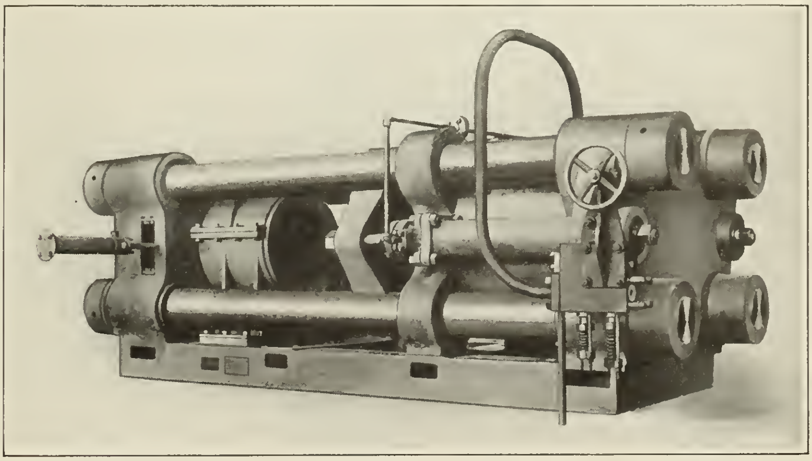


Fig. 2. Hydraulic Extrusion Press of 2000 Tons Capacity

[1] See also MACHINERY, August, 1906, "Extruded Metal Sections;" October, 1911, "The Extrusion Process;" November, 1911, "The Extrusion of Shells and Tubes;" December, 1911, "Making Collapsible Tubes by the Extrusion Process;" June, 1912, "An Experiment in Extrusion;" July, 1912, "The Extrusion of Plastic Metals."

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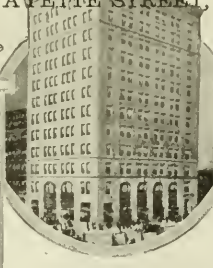

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FACTORY TRANSPORTATION

A study of manufacturing leads to the conclusion that the important factors of production are the workmen, the machines and tools provided for machining, the methods employed and the means installed for conveying work expeditiously from machine to machine, department to department, and thence to the assembling floor. The plant as a whole is most efficient when it functions like a machine, all its elements being coordinated to effect the desired end with the least internal friction and lost work. In an automatic machine the matter of holding the work and passing it on to the next work-holding fixture or bringing other tools into action must be carefully worked out on the drafting-board to the most minute detail. All its functions have to be planned before building the machine. But, unfortunately, it is not uncommon to find manufacturing concerns equipped with high-grade machine tools, housed in modern buildings provided with all sanitary conveniences, modern ventilating and heating systems and other modern features, yet without the means and methods of carrying the work through with a minimum of labor cost. And it should be borne in mind that the loss incurred by employing labor inefficiently in transporting materials is but a small part of the total loss caused by highly paid workmen being short of parts or hampered by piles of finished and unfinished work standing about their machines. The machine shop that is always in a congested condition because of inadequate work-handling trucks and other means of transporting parts is not only inefficient but dangerous to the workmen. Decreasing the congestion permits machines to be more closely grouped, and that may make unnecessary the addition of new buildings where now contemplated.

The manufacture of shells and similar munitions affords an excellent study of routing and transportation. The product is comparatively simple and lends itself to several means of movement; the large quantity produced has led to the development of unique methods, but the general principle of movement applies to all kinds of manufacturing. The volume of duplicate parts made and the need of producing them rapidly and at low cost have forced managers to recognize certain obvious principles of efficient manufacture.

The article in this number of MACHINERY on factory transportation is a review of existing methods of moving work from machine to machine and from one department to another, and was written with the object of pointing out the need of close coordination between the machining methods and the work-handling methods. The shop in which all these elements of production exist is one that should be capable of turning out a satisfactory product at the lowest cost.

* * *

BANISHING SECRECY

One beneficent result that may come out of the war is the breaking down of the reserve or secrecy that too often has been maintained in regard to methods and means of production, and securing greater cooperation among manufacturers in kindred lines. The Canadian manufacturers, under the influence of the Imperial Munitions Board and their patriotic ardor to serve their country, have thrown their plants open to all legitimately interested in the making of shells, guns, cartridges and other munitions. This has resulted in pooling data and information, so that each interested concern can draw therefrom to improve its practice. Each contributes in order that he may receive, and the beneficent results are so pronounced as to suggest the extension of the idea to all classes of industrial activity. More cooperative effort is needed instead of keener competition. Competition of a destructive nature is war; and this is no time for war within the nation itself. We must pool our resources and knowledge for the common good in order that all may benefit, and thus be able to present the strongest front to the common enemy.

* * *

MACHINISTS' APPRENTICESHIPS

Apprenticeships and the need of trained machinists has been written about until the subject is worn threadbare, but at the risk of discussing a stale subject we call the reader's attention again to the article in the February number dealing with the apprenticeship system in the plant of the Pratt & Whitney Co. It seems that Mr. Hanson has taken the bull by the horns and developed a system for the express purpose of training young men to be machinists. Mr. Hanson holds that the trade of a machinist is an honorable occupation. He points out that all the leaders in the Pratt & Whitney organization were machinists to begin with, and that the very nature of the business requires that the leaders shall have had first-class mechanical training. Hence, while the avowed purpose of the apprenticeship system is to train men to be machinists, they are shown that if they cultivate intelligence, industry and research they may aspire to higher positions in the company's organization.

The fault with apprenticeship systems in many plants is that they were wrongly conceived and are poorly carried out. The education bestowed on the apprentices tended to make them something else besides machinists. Another trouble with apprenticeship systems in general is that the employers have not dealt honestly with their young men, nor have the young men been fair and honest with their employers. We believe that if a concern gains a reputation for dealing fairly and generously with its apprentices, much of the trouble experienced by young men leaving before their indentures are completed will be avoided. Apprenticeships should not be conducted for the purpose of training men to be virtually machine operators working at low pay. Apprenticeship instruction properly carried out is expensive, and the concern should not attempt to make the young man pay all the cost. It is better to be liberal in the matter of wage payments and secure the loyal service of the apprentices rather than to save a small percentage of their wages and lose them in the second or third year.

American manufacturers are beginning to realize something of the appalling cost of hiring and firing employes. A loyal, efficient organization is above price and one of the surest ways of creating an organization that will work for the common interest is to train young men in the elements of the trades and to pay them as much as they can obtain in other plants. They should be worth more to the employer who has trained them than to anyone else.

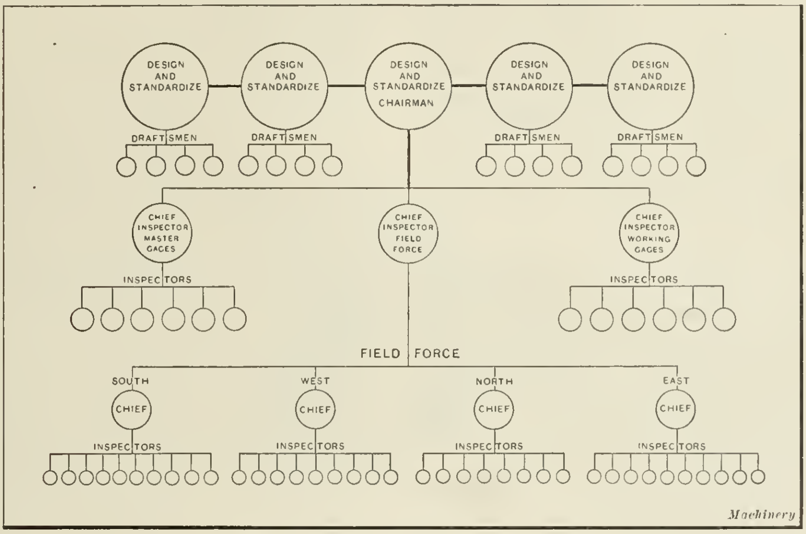
NATIONAL SUPERVISION OF GAGES

BY WILLIAM T. ILER, JR.[1]

There are many lessons in the standardization of munition manufacture that the heads of the Federal government may learn from the experiences of the American shops manufacturing tools and gages for our allies. When a Canadian shop obtains a contract for munitions, it receives from the Imperial Munitions Board a set of blueprints of the parts to be made and of the master gages. If the men in charge of the shop taking the contract know their business, they immediately organize a first-class tool-room, in which are made all the flat and simple gages. The thread gages and the more complicated gages are made in the United States, as the manufacture of these requires an experienced organization and expert men.

The Imperial Munitions Board requires each firm making munitions to send it two sets of master gages. These gages are inspected and, if passed, one set is retained by the board for the use of its inspectors and the other set is used as master gages by the manufacturer. The munitions manufacturer then has as many sets of working gages made as he deems necessary to take care of the inspection of the daily product.

In every contract that the Imperial Munitions Board makes with munitions manufacturers there is a clause that demands a predetermined daily production, and for each day that this production is not reached, a total equal to the predetermined daily production is subtracted from the total of the contract. This clause puts a premium on knowing what to do and how to do it in the least possible time. One of the largest and most successful munitions manufacturers in Canada realized the great importance of gages from the beginning; it therefore secured the best man possible for the head of its inspection department, paying him as large a salary as it paid the president of the company.



Proposed Gage Department of U. S. Munitions Board

Another Canadian company that had taken an order for 750,000 80MK-VII fuses, the delivery of which was to begin in two weeks from the receipt of the order at the rate of 1500 fuses a day, did not establish a tool-room or hire a toolmaker; but it ordered from an American company two sets of master gages and six sets of working gages, specifying that all these were to be delivered in two weeks from receipt of order. As each set comprised seventy gages, some of which took 200 hours to make, this company was immediately notified that deliveries could not be made as called for on the order, so it asked the gage-making company to do the best that it could. By working overtime and Sundays, the latter was able to deliver about one-half the gages in the first two weeks. These gages were sent by the Canadian firm to the Imperial Munitions Board, as it had no facilities for checking the working gages. The Imperial Munitions Board passed all the master gages with the exception of the graduation gages, which checked correctly on the first and last graduation but were out about forty seconds at the center graduation; forty seconds on this size gage is about one-half a hair breadth. These rejected gages were returned to the American company for correction. To make them right, it was necessary to attach a special indexing plate to a dividing head that was used on a very accurate milling machine. The difficulty of making these gages will be appreciated from the statement of the chief inspector of the Imperial Munitions Board that these were the first American graduation gages that had been passed.

When, however, the Imperial Munitions Board returned to the Canadian manufacturer the working gages, the trouble began. According to its custom, the gage company had made all working plug gages to the maximum limits and all working ring gages to the minimum limits. The tolerances on the parts of the fuse to be gaged were given on the official Munitions Board blueprint as $\pm$ 0.0003 inch; the blueprints of the master gages did not give any tolerance, so they were made within $\pm$ 0.0001 inch. The Imperial Munitions Board had attached to each working gage a tag on which was written the dimensions of the gage. On receipt of the working gages from the Imperial Munitions Board the Canadian firm immediately wired the American company that it had rejected all the working gages, as the plug gages differed + 0.0002 to + 0.00025 inch and the ring gages were — 0.0002 inch from the blueprints. Other sets were then made to the exact dimensions, which were accepted by the manufacturer. The folly of his method was forcibly brought to the manufacturer's attention shortly afterward, by the government rejecting 90,000 fuses. The gage company, however, did not lose anything, as it shipped the gages to another manufacturer, whose inspector said they were the best working gages that he had received.

The story of the Russian shells made in this country that were filled with sawdust and brickdust and accepted by the Russian government is well known. A story on a par with this is the experience of an American manufacturer who made fuse parts for a Canadian firm. This company could only see the profits and thought the less it spent for gages the greater would be its profits; so it purchased its thread gages, both plug and ring, from the lowest bidder and did not inspect them before using them on the work. The company was disagreeably surprised when the Canadian firm rejected its entire first shipment. The blueprints were immediately checked, and as these proved right, the gages were sent to a well-known gage-making firm for inspection. A short examination showed that they had been cut with a collapsible tap and die. The cost to the manufacturer of these so-called "gages," when the spoiled parts were taken into consideration, was many times the amount asked by the highest bidder.

In the fall of 1915, a foreign government gave a contract for fuses to an American watch-making company which was ideally equipped and organized for interchangeable manufacturing. The government supplied the manufacturer with a set of master gages it had O.K.'d, but sent no blueprints of either the fuse or gages. The master gages were given to a gage-making company with a request to duplicate them. By the time the gages were completed, the watch manufacturer received an official blueprint of the fuse and found that the master gages the gage company had delivered did not check up with the blueprint. As the makers claimed that the master gages were

[1]Address: 90 W. 164th St., New York City.

duplicates of the set furnished by the government, the original set was checked and found to be 0.0005 to 0.0025 inch off, so the government promptly paid for the gages.

The foregoing are only a few examples of the various difficulties that confront the munitions manufacturers as well as the tool- and gage-makers. The Federal government can avoid most of the errors made by our allies if it will follow a plan based on that of the Canadian Imperial Munitions Board.

Graphic Organization Chart

A condensed organization chart is shown herewith that, if followed, will accelerate the manufacture of munitions considerably. First, five men should be appointed to design and standardize the master and working gages. For this purpose they should have a well-equipped drafting department, which should prepare sets of blueprints of all gages and make all changes and keep the manufacturers informed of these changes. These men should be practical toolmakers who have risen to executive positions. They can be obtained by asking the large munitions manufacturers and tool- and gage-making shops to recommend, from their organization, a man who is qualified to hold this position. If followed, this will result in the nomination of probably thirty-five to fifty men.

This board should also have three inspection departments, one of which should pass on all master gages. Each company manufacturing munitions should be required to submit two sets of master gages for approval. One of these sets will later be used as the shop's masters and the other by the board's resident inspector. Another department should inspect all the working gages, because of the scarcity of toolmakers, which would make it impossible for the munitions manufacturer to establish a complete tool-room or inspect the gages rapidly and correctly; also, because of the scarcity of testing apparatus, such as micrometers, test blocks, height gages, sine bars, etc., that are absolutely correct, that is, not more than 0.00005 inch out.

It might be advisable here to caution all munitions manufacturers to test all micrometers, sine bars, test blocks, etc., before using them, as the writer has found that the only good instruments are those that were made before the war. Out of ten sine bars ordered from a firm that, before the war, had a reputation for very fine work, all but one had to be rejected, as they were out at least 0.0003 inch in each case. The manufacturers said that they could not guarantee their product with greater accuracy than $\pm$ 0.0005 inch, whereas before the war their guarantee covered an accuracy of $\pm$ 0.0001 inch.

This munitions board should also have a force of inspectors who would be stationed at the various plants making munitions. It should be the duty of these men to inspect all the finished product as well as to check working gages. These gages should be inspected for wear three times a week, and the final inspection gages at least twice a week. The inspector should also report each week the condition of the gages used in the shop and recommend the renewal of any or all of them. He should have the power to stop any operation if the gages are not up to size. All these inspectors should be practical toolmakers or men having had long experience in gages and their use.

The chart does not show a complete organization by any means, but will serve as a foundation for a highly efficient force that will lift about one-half the burden from the munitions manufacturer's back.

* * *

GROUP INSURANCE

BY J. D. WHITNEY [1]

Group insurance, a development of recent years, is based on the fact that large groups of people can be insured without medical examination and at a much lower cost. The reason that the medical examination can be dispensed with is that group insurance is applied simply to workmen already in the employ of men who have presumably chosen them because they are in good health and a good state of mind. The insurance company assumes that a factory owner, for instance, will not hire a man to do hard work in his factory if that man is on the point of death. It is claimed by manufacturers that it costs from $50 to $100 to break in a new man, and naturally an employer is not willing to make that expenditure on a man who is likely to drop off within a few months.

The reason that group insurance can be written at a reduced rate is that it is wholesale in its nature, and the insurance company saves a great deal on commissions and overhead expenses. The cost of group insurance is indeed so low that most employers find themselves able to pay the entire premium, though in some cases the employers feel that the men will be more interested in the insurance if they are required to contribute part of the premium. One progressive machine tool concern allows each employe to decide whether he will take a low-cost life policy at a minimum cost or a form of policy that will require more thrift and self-denial. But employers are encouraged to adopt the plan of paying the entire premium for the men, as the effect on the men is remarkable. Many business men claim that they get their money back in increased efficiency and loyalty in their employes.

Of the many hundred group risks, ranging from one hundred employes, which is the minimum, up to many thousands, that have been written by one company in the five years in which group insurance has been extensively cultivated, only one group contract has been discontinued, and that one for temporary reasons. This is in spite of the fact that group insurance is written on the one-year term plan and can be easily dropped at every anniversary.

Group insurance can be written on a great many plans. Indeed, a plan may be adapted to any particular case, but, generally speaking, the idea is this: After an employe has been with a concern for three or six months, or whatever length of time the employer thinks necessary to establish the presumption that the workman is going to stay, the workman receives a policy of insurance of a sufficient face value to enable his family to take care of itself for a period, in case the workman loses his life or is disabled. Some concerns provide $500, some $1000 or more, and some give each workman a policy valued at the amount of his annual salary. The most common kind of policy is life insurance with a disability clause, but health and accident insurance are also written on the group plan.

Among the companies that have taken out group insurance are many concerns that have always taken a paternal interest in their employes, and have been spending several thousand dollars a year providing burials for pensioners and taking care of their families for a few months, at least, after the death of their bread winner. These concerns have been glad to substitute the group plan and rid themselves entirely of the responsibility of taking care of dependent families. The general satisfaction of the workmen at being given their own resources in this respect is noticeable, and wherever the intelligence of the workmen is sufficiently high to enable them to comprehend the idea fully, the men receive the group plan with the utmost enthusiasm. It has decided advantages over the giving of bonuses at Christmas or on other occasions.

One of the earliest purchasers of group insurance was a large manufacturing concern in Michigan. When the plan was announced, a number of employes took a belligerent attitude and declared that they would not have anything to do with the scheme and would not even accept their certificates (each workman is provided with an individual certificate). Nevertheless, the company placed the insurance on all its workmen alike. The first one to die was the ring leader of the belligerent element. The wife was left without money enough to pay the funeral expenses and was in despair until somebody told her that $1200 was coming to her from the insurance company. Not long afterward the belligerents marched to the office in a body and asked for their certificates.

The New York legislature thought so well of group insurance, at its 1916 session, that it took group insurance out from under the limitation which it imposes on life insurance companies as to the amount of business they are allowed to write. Group insurance, of course, runs into the millions rapidly. There is about a quarter of a billion dollars worth of it in effect in this country at present, but the surface has not been more than scratched.

[1] Publicity Manager, Travelers Insurance Co., Hartford, Conn.

SNAPSHOTS ON THE ROAD

HOW MACHINE TOOLS ARE SOMETIMES BOUGHT—ONE WAY TO GET A MACHINIST'S JOB—HOW STEVE OILED THE PULLEYS—WHEN GOOD STEEL WAS POOR STEEL—MAKING THE SCRAP PILE PAY—COURTEOUS TREATMENT OF TRAVELING MEN—MACHINERY FOR THE SWEAT-SHOP

BY THE FIELD EDITORS

"—it was found to stick as close to the plane as though it were glued there"

THE pure theorist will ever be the laughing stock of the so-called "practical" man, but here is a case where both of them were fooled. It happened in a New England shop, where the elderly proprietor was a theorist and a young toolmaker the practical man. Mr. Theorist came in to George, the toolmaker, one day and with a burst of enthusiasm said:

"Look here, George, I want you to drop that job you're on and make a file-testing apparatus for me. I've just been down through the shop where all those kids are filing, and I find any number of files lying around which they claim are worn out. Now what I want is a device for measuring accurately how much these files are actually worn. You see, it's a simple matter; all we need is a tilting, graduated, inclined plane, made of cast iron, finished to a specified degree of smoothness. We will determine the angle at which a new file of any coarseness will slide down the incline and the angle at which a used file must slide to be considered worn out. You see, for a new No. 1 it might be 45 degrees, while the angle for the used No. 1 might be 28 degrees. Now, George, get right to work on this, and make it right, because it's an instrument of precision and there is no doubt in the world about the underlying principle."

George set to work and, according to the sketch furnished him by the boss, turned out, in a little less than a week, a specimen of his handiwork that was a joy to look upon, accurately graduated, and in every sense an instrument of precision. The boss was highly elated over the appearance of his pet device, and as the time approached for giving it the initial test, his enthusiasm grew. The first thing he did was to determine the sliding angle of a new file of a certain coarseness, which was found to be in the vicinity of 38 degrees. But when he came to try the same file very much worn, it was found to stick as close to the plane as though it were glued there, although tilted at the same angle.

This was a complete reversal of his calculations. Further experiment proved conclusively that the more the file was worn, the less tendency there was for it to slide. After close examination of the worn files, and a long consultation, in which George, the practical man, participated freely, the real cause was arrived at. It was found that a so-called "worn" file was indeed worn smooth on a large part of its surface, but at the heel and point a few scattered teeth protruded. These few teeth, of course, prevented the file from sliding much more than a whole bank of sharp teeth.

Mr. Theorist was sick at heart, not so much because of the failure of his theory, but because of the expenditure tied up in the file tester. George came to his rescue, however, by suggesting that it could easily be converted into an adjustable angle-plate such as he had been wanting for several years. Perhaps George had this in mind when he was making it, which may account for the accuracy with which it was made.

How Machine Tools are Sometimes Bought

We often run into men who want to buy machine tools. In nine cases out of ten, they know just what they want and the buying is done intelligently, based on sound, practical experience, but occasionally, and especially during these busy times, machine tools are bought with a woeful lack of mechanical knowledge. For instance, a newcomer in the machine business, fresh from an exporting office, was asking us for advice on what kind of milling machine he should purchase for one of his clients. He wasn't sure whether he wanted a universal, plain or special manufacturing machine, but, as he expressed himself, "You will probably know what kind of machine my customer wants, because he has to mill all sorts of curious shaped pieces."

And he went away disgusted because we could not recommend exactly the type of machine best suited for milling "curious shaped pieces."

One Way to get a Machinist's Job

Force is a good thing to have, especially when it comes to getting a new job. How this quality stood one young man in good stead is best told in his own words:

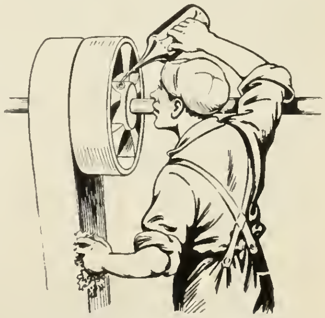
"I landed in Boston, fresh from Liverpool, with a wife and just $12, and no idea where to go to get a job in my line—the machinist's trade. I had been used to mill machinery repairing, so it was only natural that I should inquire as to what city had the most textile mills. The answer was 'Fall River,' so to Fall River I went. After we had put up at a cheap hotel and paid for the night's lodging, I had just $1.75 left.

"A watchman saw me jumping the fence and came after me, which simply made me move faster"

"The next day was Sunday, but I was up bright and early, determined to start the hunt for a job, because that $1.75 wouldn't last long. It was during rush times, and as I went by one of the mills I could hear the machinery of the repair shop at work. A ten-foot board fence surrounded the mill, but it didn't take me long to climb over and start in the direction in which I heard the machinery running. A watchman saw me jumping the fence and came after me, which simply made me move faster. I soon got inside of the repair shop and the foreman greeted me with, 'Where in blazes did you come from and what do you want in here?' I told him that I came over the fence and wanted a job, and I wanted it bad, too. 'Don't you know you can't get a job here on a Sunday?' the foreman answered. But I could see that he was anxious to get a man, so I told him I would be there bright and early Monday morning if he'd hire me — and he did."

Today that fellow is equipment superintendent of a plant employing thousands of men—and he has prospects for a promotion that his "force" is going to land for him.

How Steve Oiled the Pulleys



"—he had his oil-can industriously at work—putting the oil into the hole of the safety set-screw"

The manufacturers of safety set-screws are do-

"Don't I tole you never to buy any steel but Sheffield?"

ing a great work, but there is one man in the country who, until a few days ago, did not appreciate this. He was the oiler at one of the big machine tool manufacturing plants, and, although he was not strong on the whys and wherefores of the machine shop, he certainly could swing a twenty-foot ladder efficiently for ten hours a day. But he had not been working long before squeaking was heard all over the shop from the loose pulleys on the countershafts. This is the story the boss millwright told us:

"We couldn't imagine what made the loose pulleys squeak, because the oiler was going his rounds regularly and seemed industrious. One day it occurred to me to watch Steve and see just how much oil he used and where he put it. He climbed up his ladder, threw the belt onto the loose pulley, stopping the machine, and commenced looking all over the tight pulley; pretty soon he had his oil-can industriously at work—putting the oil into the hole of the safety set-screw that was used to hold the pulley on the countershaft. He didn't touch the loose pulley at all—simply shifted the ladder and went through the performance on the next countershaft. He was a green Polack, and meant well enough, and after he had been given a lesson in oiling loose pulleys, he made one of the best oilers we have ever had."

When Good Steel was Poor Steel

When it comes to the last analysis, most of the troubles in the machine shop, as well as elsewhere, come from the ever-present human element. So it was with the new manager's troubles at the old Johnson plant that for a few years previously had been run by a young fellow with plenty of money but no brains, mechanical or otherwise. One of his tales has a good moral.

"There was one old Dutchman when I came here who had the whole plant buffaloed by his arbitrary methods. He was the boss diemaker, and a mighty good one, too. Like most men of his type, he was not in the least open-minded, and especially was he prejudiced on matters relating to steel. He swore by Sheffield steel and didn't even want to consider any other brand. One day the non-mechanical manager bought a bar of perfectly good American steel and, grudgingly, Dutchy consented to try it out. It seemed that the old chap had a young German friend whom he had brought in to learn the business, and it was to him that the first die from the new steel was given to be made. The die was made and hardened perfectly, but in fitting the punch, the inexperienced diemaker left too much stock to be sheared, and during the shearing-in operation the die cracked, as any other die would have done under the same conditions. In consternation, the young man went to his old boss, who, telling him not to worry, took the die and went to the manager, saying, as he exhibited the broken halves: 'Don't I tole you never to buy any steel but Sheffield? Now you buy some of this no good American steel, and here's what you get!'"

And the sorrowful part of the incident is that "Old Dutchy" got away with it!

Making the Scrap Pile Pay

The superintendent leaned back in his chair and soliloquized as he gazed out through the shop. "There are lots of things in this world that it's all right to mix, but that doesn't apply when it comes to chips from brass, copper, aluminum and steel; we must keep them separate, because the price of scrap is now quite an item."

"See that old fellow out there sweeping up chips?" said the superintendent, as he pointed out through the office window into the shop. "He's the shop sweeper, and up to six months ago we sure did have all kinds of trouble from the mixing of chips. We couldn't seem to keep them separate, and so they brought very little from the junk man. Finally I hit on the idea of paying a piece-work price for sweeping up chips. I offered the sweeper a bonus of $2 a ton for mixed chips, but for clean aluminum, copper and brass chips from other metals the bonus was $8 a ton, and now you'd be surprised to see the way that old chap hustles to keep the chips from getting mixed. He's the first man to put up a holler if one of the workmen doesn't clean up his lathe before he starts on a job of turning different metal from the one he's been working on. The stunt works fine; we save many times the bonus that we pay him for the chips, and, of course, he's happy, too, for he's making more money."

We departed more than ever impressed with the fact that if you want to make money, you must give somebody else a chance to make some, too.

Courteous Treatment of Traveling Men

We recently called at a Connecticut factory, and upon entering the office our heart was gladdened by the sight of a placard, placed in a conspicuous position near the telephone operator's desk, which is reproduced herewith.

What is of greater interest is the fact that we actually did receive treatment in accordance with the sentiment of the placard. It is not necessary that all manufacturers adopt a placard of this nature, but it would be desirable if some of their employes whose business it is to meet the traveling men would act on the suggestion contained therein.

CALLERS WILL PLEASE APPLY TO OPERATOR.
INSIST ON AN ANSWER IN A REASONABLE
TIME OR A REASON FOR THE DELAY.

"—a placard placed in a conspicuous position near the telephone operator's desk"

Machinery for the Sweat-shop

We were visiting one of the big contract shops of New York City when our eye happened to catch a lot of twenty-five or thirty light foot presses that were on the floor ready to be assembled. This sight would not have been uncommon in Providence, but in New York it's different, so we buttonholed the superintendent.

"What's the idea on the foot presses—are you making these for the Providence market?"

The shop man smiled as he turned one of the castings over with his foot.

"Would you believe it if I told you those presses are all going to be used in tenement houses over on the East Side?"

"On the East Side? We didn't suppose there was a manufacturing shop in the tenement section of the East Side."

"Nevertheless, there's a good market over on the East Side for these presses," continued the superintendent. "If you should go down through this district any day, you'd find whole families, ranging from little girls of ten to grandfathers of seventy-five, kicking away at these foot presses, set up on kitchen tables, covering buttons by the gross."

On almost every trip we learn of new markets for machinery, but it would be better, it seems, if this market did not exist.

"—it would be better if this market did not exist"

A FOUNDATION FOR MACHINE TOOL DESIGN AND CONSTRUCTION[1]

NECESSITY FOR MORE COMPLETE KNOWLEDGE OF ACTION OF METAL-CUTTING TOOLS AND WORK DONE BY CUTTING LUBRICANT

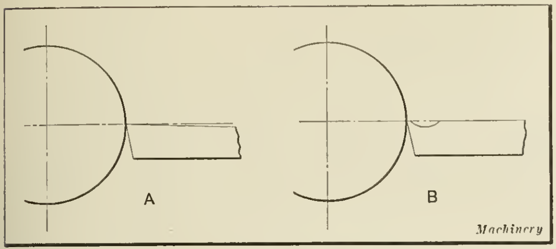


Fig. 1. Cutting with Lathe Tools

THE rapidity of progress of the various branches of engineering may be said to be in proportion to the ease with which their principles can be reduced to mathematics. This was, perhaps, never so clearly shown as in the case of the development of alternating-current apparatus. The mathematics of this branch was waiting for somebody to apply it; as a result, alternating-current apparatus has known no period of experimentation—of stumbling, fumbling progress. Compare this with the slow, hesitating development of the steam engine in its first stages. Nothing was known except that steam would exert pressure, and no knowledge existed of the properties of steam, of thermodynamics, nor of the mathematics of engineering materials.

As soon as the laws of thermodynamics were understood and reduced to mathematics, it became possible to imagine an ideal steam engine, which is another term for a 100 per cent efficient steam engine, and to show what is the maximum obtainable efficiency in any steam engine. It is therefore possible to express the efficiency of existing or contemplated steam engines in percentages of the ideal engine. In other words, the ideal steam engine has become the standard, or unit, of measurement, and it is no longer possible for any designer or builder to think that he has produced a steam engine of the highest possible efficiency merely because his steam engine is twice as efficient as some other existing engine. Mathematical analysis will soon show that his engine is far from the ideal, and a test will show how closely he has approached the product he had intended to build; in other words, he can use his theory to check up his practice. The fact that the inefficiency of the engine is known leaves the door open for further improvement.

Is it possible to develop a theory of the ideal machine tool, such as has been developed for the steam engine? If the only function of a machine tool were the removal of metal, our best machine tool would be found to have an efficiency of from 0.12 to 0.22, which is very low as compared with the efficiency of other machines. If chips could be removed from a piece of work by a straight pull, the ideal machine tool would be one that would remove material with the same expenditure of power as is required by a testing machine. However, the question is whether material is removed by a straight pull. The author does not know what the exact nature of the cutting of metal is, and he believes that he is not alone in his ignorance. To his knowledge, no experiments have been made that establish the true nature of the cutting of metals with a reasonable certainty.

Among the questions that should be answered before machine tools can be designed in a thoroughly scientific manner are the following:

When we turn up a narrow disk by means of a square-nosed turning tool of which the width is greater than the width of the disk, is the action of removing the chips purely a matter of tension? If not, what is it?

Does the front end of the tool have any function at all?

How far from the edge of the tool is the point where the chip strikes the tool?

If the action is purely a matter of pull, and the chip does not strike the top of the tool at the cutting point, but some distance farther back, is it necessary that the cutting edge of the tool be sharp?

What is the nature of the lamination of the chip?

How much power is required for the actual removal of the chip, for the friction between chip and tool, and for laminating the chip?

What would be the best shape for such a turning tool for this particular turning operation?

How does the amount of power vary with the various angles of the tool?

If the turning operation is not as simple as assumed in the first question, if, for instance, there is a side feed, as in ordinary shaft-turning operations, how is the cutting action modified by this side feed?

If the chip is removed by the action of the top of the tool, that is, if the front of the tool has no function, what determines the nature of the finish of a cut?

In what relation does the power required for the side feed stand to the power required for the actual removal of the chip?

Action of a Cutting Lubricant

As dark a subject as the action of the tool itself is the action of a cutting lubricant. It is well known that the use and the nature of a lubricant affect both the finish and the size. If the chip is separated by tension, that is, if the point where the chip begins to separate from the work is some distance ahead of the point of the cutting tool, how can the cutting lubricant affect either the size or the nature of the finish? Another equally puzzling question is: If one of the functions of the cutting lubricant is to reduce the friction between chip and tool, why not use a heavy lubricating oil instead of a light lard oil that has practically no lubricating qualities? Also, if, as facts seem to show, the best results are obtained with a cutting lubricant that has little viscosity and therefore can readily rise between the chip and the work by capillary action, what is the action of the oil on the separation of the chip, seeing that the oil only gets to the point of separation after the chip is separated?

Even more puzzling is the effect a cutting lubricant seems to have on the size of the work. We do not see how it is possible for the lubricant to influence the size, yet that it does has been observed many times. For instance, when twenty-four screws were made on an automatic screw machine, using a mineral oil with 15 per cent lard oil, the screws came true to size within the limit of 0.0005 inch. But when the oil was removed, the machine and tools cleaned, and another cutting compound substituted, not only were all the screws made larger than those cut with the regular oil, but they also varied from 0.0025 to 0.005 inch over size. The machine was once more cleaned and the original oil put back; the screws again came uniform and to size, showing that the cutting of the first twenty-four screws had not dulled the tool nor caused any other disturbing element to enter into the equation. The fact that the cutting compound caused the screws to be over size might possibly be explained by a difference in the heating or cooling effect of the different lubricants; but how can the difference in the size of screws made with the same lubricant be explained when there was no difference in the oil that was employed when the screws were being made?

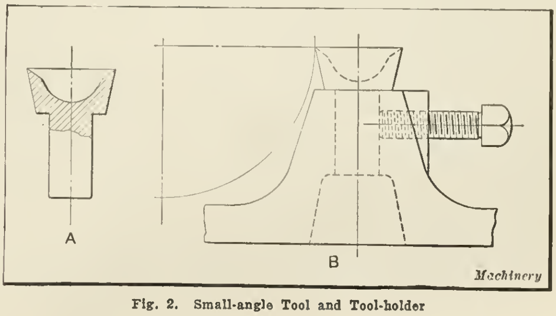


Fig. 2. Small-angle Tool and Tool-holder

[1]Abstract of a paper by A. L. De Leeuw read before the American Society of Mechanical Engineers, at Cincinnati, Ohio, May, 1917.

Proper Angles and Forms of Cutting Tools

The results of an investigation should lie in the direction of saving of power, diminished wastage of tools, and less strain on the machine; or in the direction of increased output with or without the other advantages. That such advantages may be reached seems clear, and the following isolated experiments, though not complete in themselves, point to interesting possibilities.

Forged spindles of sixty-point carbon steel were roughed by a tool like that shown at *A*, Fig. 1, which was able to rough three spindles before a breakdown. In its broken-down condition, the tool appeared as shown at *B*. A hollow had been ground out by the chip, but a land a little more than 1/64 inch wide had been left at the front end, showing that the extreme front of the tool had not been in action. The broken-down tools were carefully measured and new tools of just that shape made, and the hollow was carefully polished. A tool thus prepared would rough from nine to thirteen spindles. Examination showed that the hollow in the tool would remain smooth almost to the last, and that a complete breakdown followed soon after the surface of the hollow began to show scratches. No tests of power consumption were made, but it may be assumed that the power required with the old tool was more than with the new tool, as the chip did not have to

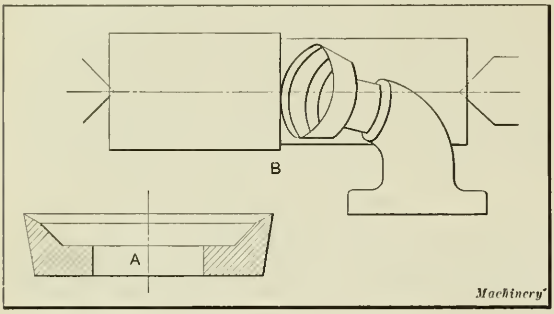


Fig. 3. Rotary Lathe Tool

bend so sharply and the work required for hollowing out the tool was omitted. Another interesting point about this tool was that the actual contained angle between the front of the tool and the front of the hollow was much less than we would have dared to make between the front and top of an ordinary lathe tool, especially if it were to be used for roughing. Nevertheless, under the conditions given, this tool with the small front angle stood up better than the original tool with the large angle.

In his paper "On the Art of Cutting Metals," Mr. Taylor states that his experiments showed no perceptible difference in power consumption for various contained angles of the cutting tool. The author thought that this conclusion would probably be correct only for the range of cutting angles tried by Mr. Taylor. Realizing that an ordinary lathe tool would not stand up with much smaller angles than those used in present-day practice, he devised the tool shown at *A*, Fig. 2, which was held in a rigid block of metal and directly over the lathe carriage, as shown at *B*. The tool was used for turning, preparatory to grinding, milling machine over-arms, about 4½ inches in diameter and 5 feet long. When the tool gave out, it was turned in the tool-holder so as to present a new piece of the edge to the work. In this manner, from twelve to sixteen settings could be made with one sharpening of the tool. The sharpening itself was a matter of circular grinding. The tool would make a very smooth cut, and without a steadyrest would turn half the length of the bar with a variation in diameter of less than 0.003 inch. The surface of the work was unusually smooth, and the amount required for grinding was much less than usual. This matter of the relation of the contained angle to the power consumption for a given cut led to the introduction of the helical cutter, where the actual angle of the tool is not small, but where the tool is presented to the work in such a manner as to have the same effect as a small angle.

Another experiment was an attempt to use a rotary lathe tool, such as is shown at *A*, Fig. 3. The edge of this tool bears up against the work as shown, and there is a very slight difference in speed between the work and the tool. It was set in such a way as to make the virtual cutting angle very small. High cutting speeds had no apparent effect on the tool and the cutting speed was limited only by the machine. With a reduction of 3/16 inch in diameter and a feed of 1½ inch, a cutting speed of 650 feet was used for both cast iron and steel. All cutting was done dry. No attempt was made to get accurate data as to power consumption, as it was realized that the lathe in its present form is not well adapted for this kind of cutting tool. The chips made by this tool were not broken up and were practically solid steel bars; moreover, as they came off the lathe they were cold enough to be caught in the hand.

Suggested Lines of Experimentation

The author believes that interesting results may be obtained by following a line of experimentation such as the following: An instrument should be built, somewhat along the lines of a microtome, in which a soft material is to be cut by a razor-like blade or tool. This tool should be arranged so that it can present various angles to the work, and tools of various contained angles should be experimented with. The angles presented to the work should vary as to clearance, rake and shear. A dynamometer, which should be part of the instrument, should register the pull required for the cut. The material to be cut should be standardized, and it is suggested that paraffin may fill all requirements; by selecting a paraffin of standard melting point, we would also get a material of standard hardness. In this manner, the relation between cutting angles and power required can be established over a wide part of the curve. Though the actual figures obtained will not be immediately applicable to metal cutting, it may be possible to find the controlling law, after which the cutting of harder materials over a small portion of the curve may be studied. The same instrument could possibly be used for tests on such materials as lead, soft white metal, etc.

Another line of experimentation would be to arrange some machine tool, such as a lathe, for running at very low speed, say, one inch per hour; mount a steel disk on this lathe, and take a cut at the circumference of this disk. In this manner the cutting action will be of the simplest kind, as the tool used can be a square-nosed tool of greater width than the thickness of the disk, so that there will be no side cut. A moving picture taken at a high rate of speed can then be reeled off at a low speed, and thus visualize what actually takes place in cutting metal. It will readily show whether cutting is merely the result of tension, whether shear plays a role, or whether both are responsible. It will probably show whether the chip leaves the work ahead of the tool point and whether or not the front end of the tool is in contact with the work. It will show many other things besides, and might be made the foundation for a number of lines of experimentation.

* * *

UTILIZATION OF WASTE

High prices and economies enforced by war conditions have brought about some surprising changes in manufacturing practice, especially as regards the utilization of waste. A shoe manufacturer had for years disposed of small scraps of leather at a low price, as they were considered worthless for any purpose except for making charred leather used in case-hardening. The high cost of leather led him to consider other possible markets for the leather scraps, and, as a result, he is today converting the scraps into straps for slippers and realizes approximately $3500 yearly from material that brought less than one-tenth as much before. The Ford Motor Co. utilizes the waste textiles, pantasote and other materials used in making tops to make spark coil boxes. The material is ground fine and then is fed to a machine having a screw or worm somewhat like a sausage machine, which is capable of forcing the material under heavy pressure into separable dies. The output of the department in which this scrap material is converted into spark coil boxes is more than 3000 boxes a day.

GAGING SYSTEMS FOR SCREWS AND TAPS

DEVICES FOR MEASURING VARIATIONS IN LEAD AND DIAMETER

IN the accompanying illustrations are shown the gaging devices being considered by the subcommittee on gaging systems of the American Society of Mechanical Engineers, in its effort to find a gage that will quickly measure variations in both lead and diameter. The devices shown in Figs. 1, 2 and 5 are suitable for a wide range of diameters and pitches; the other gages are limited to one size of screw or tap.

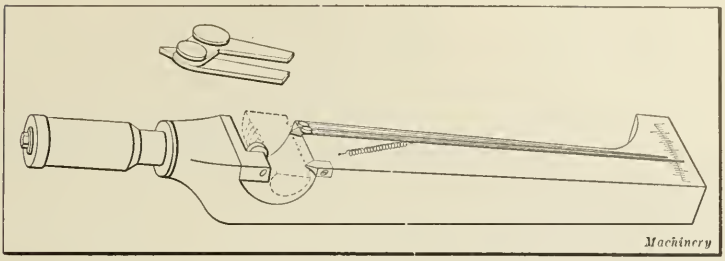


Fig. 1. Gage for measuring Variations in Diameter and Lead of Screws and Taps

The gage shown in Fig. 1 measures the variation from standard of both the pitch diameter and the lead of screws and taps. It is constructed with the fixed V-point, a micrometer adjusted grooved roll, and a floating point. The grooved roll fits over the thread and is free to move sideways to allow for variation in lead. The roll is set to the standard pitch diameter of the work to be tested by the micrometer thimble. A floating point is so connected that the longer lever shows variations in lead, and the shorter, variations in pitch diameter. Work is placed between the points, as shown in dotted lines, and the variations from standard pitch diameter and lead are read directly in thousandths of an inch.

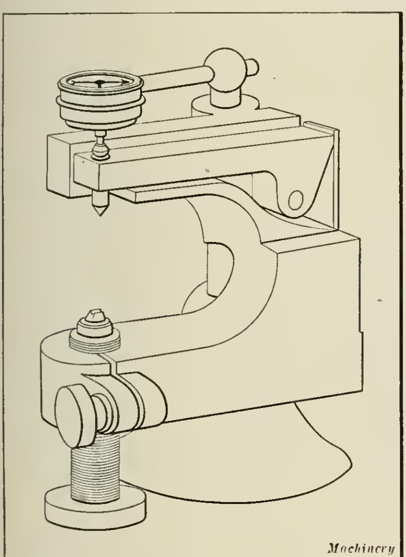


Fig. 2. Gage for measuring Variation in Pitch Diameter

The gages shown in Figs. 2 and 3 are to be used together. That shown in Fig. 2 measures variations in pitch diameter only. The V-shaped anvil is adjustable through a wide range of diameters and can be locked in position by a clamping screw. The gaging arm is pivoted, and the gaging point is held in contact with the work at a constant pressure by a spring at the rear. A dial indicator is in contact with the arm. The gage is set to a standard, and as the work is passed between the points, variations in diameter are transmitted through the arm to the dial indicator, where the amount of variation may be read directly in thousandths of an inch.

The gage shown in Fig. 3 is for testing the lead only. The positive point may be used in any of four positions to allow for different lengths of thread. The floating point is part of the bellcrank lever, which is mounted to act on the dial indicator as the distance between the measuring points varies. After the indicator is set to a standard, the work is positioned on the two points. Any variation from the standard in the lead can be read directly, in thousandths of an inch, on the dial.

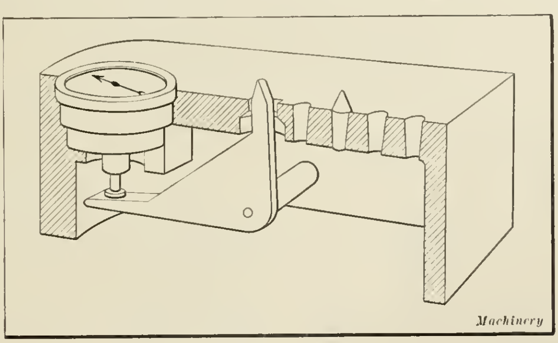


Fig. 3. Gage for measuring Variation in Lead

In Fig. 4 is shown a gage that can be used for pitch diameters only. It is made slightly tapering and is split and furnished with screws for adjusting and locking. It is adjusted so that the setting standard *A* will screw into the gage until a line on the standard matches a line on the gage. The other lines on the gage indicate 0.001 inch variation from the standard in pitch diameter.

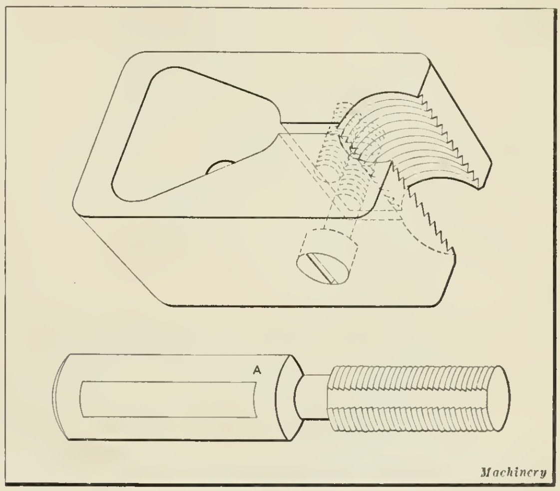


Fig. 4. Split Gage for measuring Pitch Diameters

A combination gage for pitch diameter and lead is shown in Fig. 5. In this gage there is a fixed point and two adjustable points, one for variations in pitch diameter and the other for variations in lead. The errors, in both cases, are read in thousandths of an inch on the dial indicators. The indicators must be set to a standard before testing work. An adjustable block may be set by a vernier so that work resting on it will have its center line in line with the gaging points.

The gage shown in Fig. 6 has three fixed points, located correctly for lead and having a set relation to a flat pin between which and the screw being tested a pin gage is used. This pin gage is of such a diameter that it will "not go" when the work passes inspection as to combined errors of diameter and lead. The work being tested is shown in dotted lines. In Fig. 8 is shown a gage with

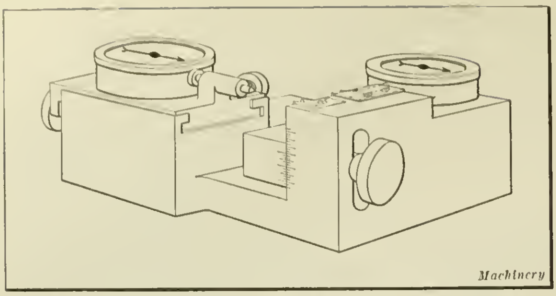


Fig. 5. Combination Gage for measuring Pitch Diameter and Lead

two fixed points, located correctly. Guiding grooves serve to align the work, which is placed in the gage as shown by the dotted lines. The amount of variation from the standard can only be estimated.

A gage fitted with a hinge *F* and spring *G*, like that on a spring caliper, is shown in Fig. 7. The jaws are opened when the screw to be measured is inserted, and are brought together by the fingers. The hole *B* is the "Go" gage. It has a standard thread, and when the flat surfaces between this hole and

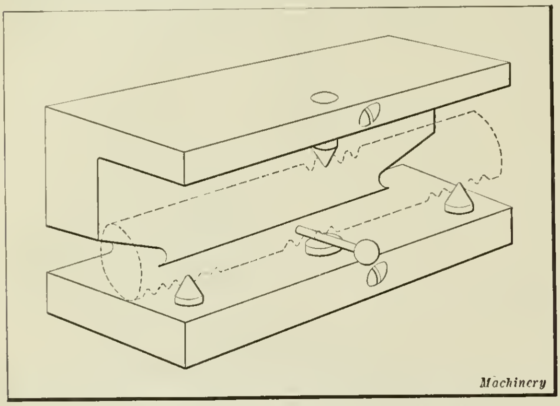


Fig. 6. Gage having Three Fixed Points and Measuring Pin

the end are in contact, any screw that goes in will enter the tapped hole, regardless of the lead error. The other three holes *C*, *D* and *E* are "Not Go" gages and test the root diameter, pitch diameter, and outside diameter, respectively. In order to eliminate the question of lead, in both *C* and *D*, only a single turn of thread of special form, as shown by the enlarged views, is used. The last hole *E* is plain, to gage the minimum outside diameter. The "Not Go" gage *D*, in combination with the "Go" gage *B*, limits errors of pitch diameter and lead also.

The gage shown in Fig. 9 is similar in principle to that shown in Fig. 8. It has four fixed points located in the correct relation to one another. Screws locate the work so that its center line is on the line of the gage points. Work is placed in position and variations in lead and pitch diameter may be estimated.

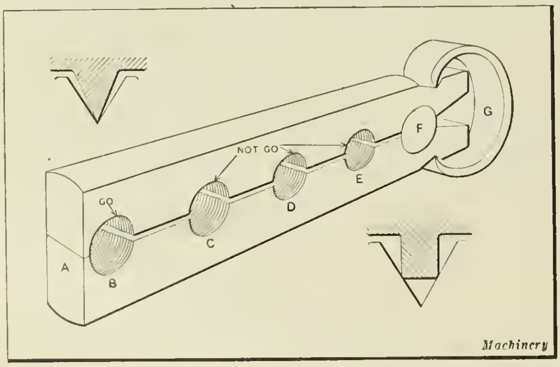


Fig. 7. Combination Gage with Hinged Joint

SUBSTITUTES FOR TIN CANS

The Department of Commerce, in cooperation with the Department of Agriculture, has been conducting an investigation to determine to what extent substitutes can be used in place of tin for packing products. Tin plate is 98 per cent steel and 2 per cent tin. Steel is the backbone of war, and the mills have not been able to keep all their customers fully supplied at all times. It is therefore imperative that substitutes be used for products that can be preserved in containers other than tins. The price of glass has risen so steadily that its use for food containers is impracticable, but fiber or paper containers have been used for many materials with satisfactory results. The fiber containers are made in various shapes and

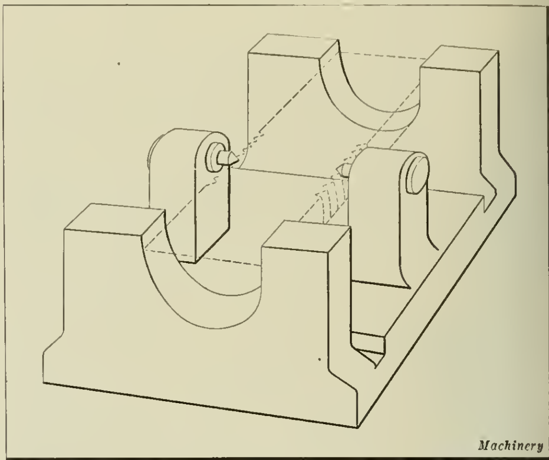


Fig. 8. Gage having Two Fixed Points

sizes adapted for different purposes, and may or may not be coated with paraffin, which is chemically inert and is sometimes baked into the paper material. Some of these containers are claimed to be air-tight, proof against leakage and protected from contamination by the paraffin. Fiber containers are recommended for the distribution by the retailer of many foodstuffs, including milk, cream, buttermilk, ice cream, ices, dried fruits, jellies, mustard and salads. It is also claimed that dried food products, such as coffee, tea, alum, baking powder, prunes, etc., may be successfully packed by producers and manufacturers in paper or fiber containers. Other commodities usually packed in tin could be marketed as well in paper or fiber with the advantage of lower cost. Chief among these is tobacco, and other articles are lye cleansers, soap powders, shoe polishes, toilet articles, such as talcum powder and various dry drugs and chemicals.

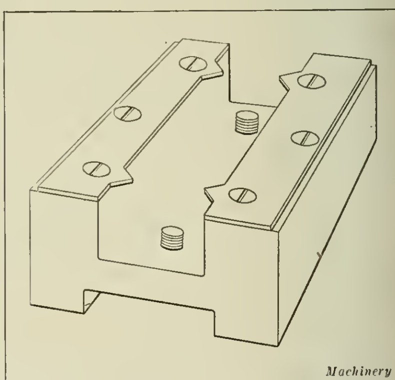


Fig. 9. Combination Gage with Four Fixed Points

* * *

John Younger states in an article on "Retardation," published in the proceedings of the Engineers' Club of Philadelphia, that experience has shown an acceleration or deceleration of six feet per second per second is about all that can be borne in comfort by passengers, and that ten feet per second per second is the maximum. This is equivalent to an applied horizontal pressure on the passenger of about one-third his weight.

TESTING SPRINGS FOR MILITARY RIFLES

FIRING, VIBRATING AND WEIGHT TESTS

BY S. N. BACON

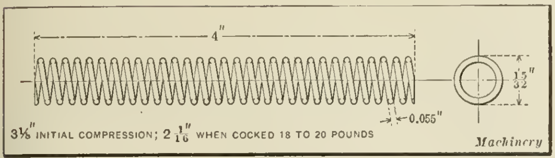


Fig. 1. Firing-pin Spring

A TYPE of firing-pin spring that, with slight variations in dimensions, is used in many foreign military rifles now being manufactured in this country is illustrated in Fig. 1. The specifications require that the spring be subjected to a compression test of forty-eight hours and shall not exceed four inches in length after the test. Each spring is then tested by firing it one hundred times.

The fixture for the firing test, shown in Fig. 4, is mounted in a standard form of punch press having an adjustable stroke. Ten of the springs are loaded into the U-shaped block *A*, which has a handle *B* and is slid against a stop-pin *C* in a groove in the base *E*. The springs are compressed by plungers *F* carried by a plate *G;* a bushing *H* pressed into this plate slides on the center post *I*, which is mounted in the base *E* of the fixture. This plate *G* is lowered by a punch *K* until the spring

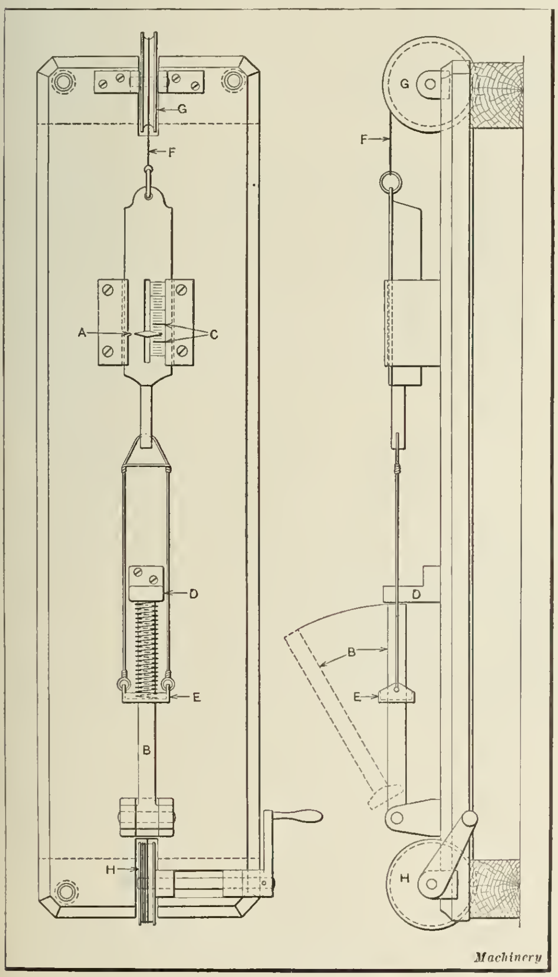


Fig. 2. Weighing Pressure of Firing-pin Spring

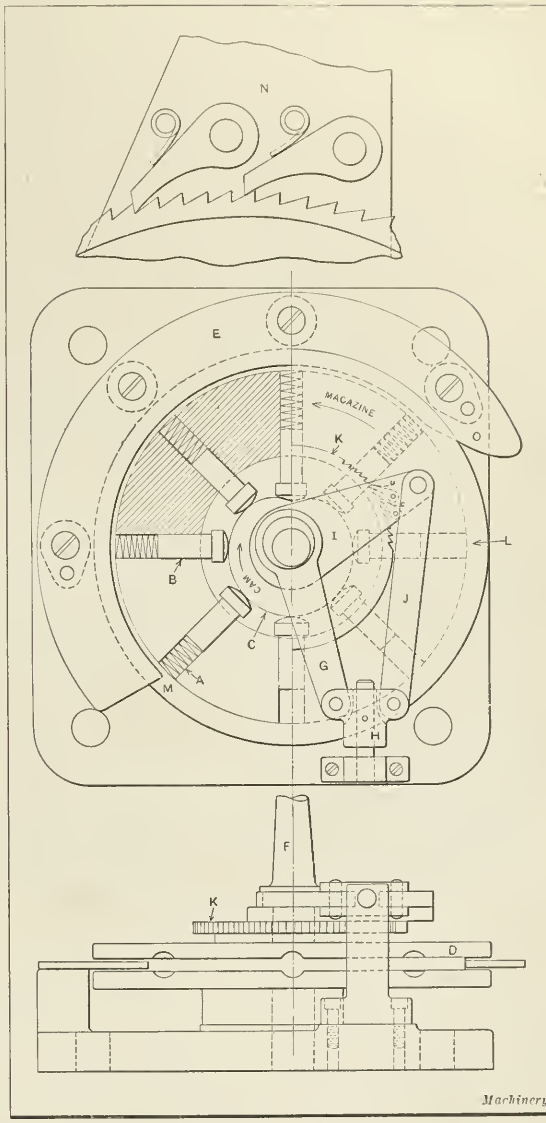


Fig. 3. Making Vibrating Test on Coil Springs

L forces the sear *M* into a pin *N* in the center post. When the adjustable pin *O* descends, it causes the trigger *P* to withdraw the sear, and the plate *G* is shot upward by the springs until it strikes the descending punch *K*, which is protected by a hard paper-fiber pad *Q* that is fastened to the punch as shown. The plate *G* is at once carried downward until the sear *M* locks it in the firing position. The springs, four inches in length, are put into the testing fixture and are compressed to 2 1/16 inches, as shown at *S*, which is equivalent to the amount of compression that the spring is subjected to when the rifle is cocked; the firing is so timed that the springs are released to a length *T* equal to their initial compression length when the rifle is not cocked for firing.

The impact is taken by the punch *K* while on the down-stroke, and on the up-stroke the trigger allows the rod *O* to pass it, and is returned to position by the flat spring *J*. The trigger is carried by plate *U*, which is screwed to plate *G*.

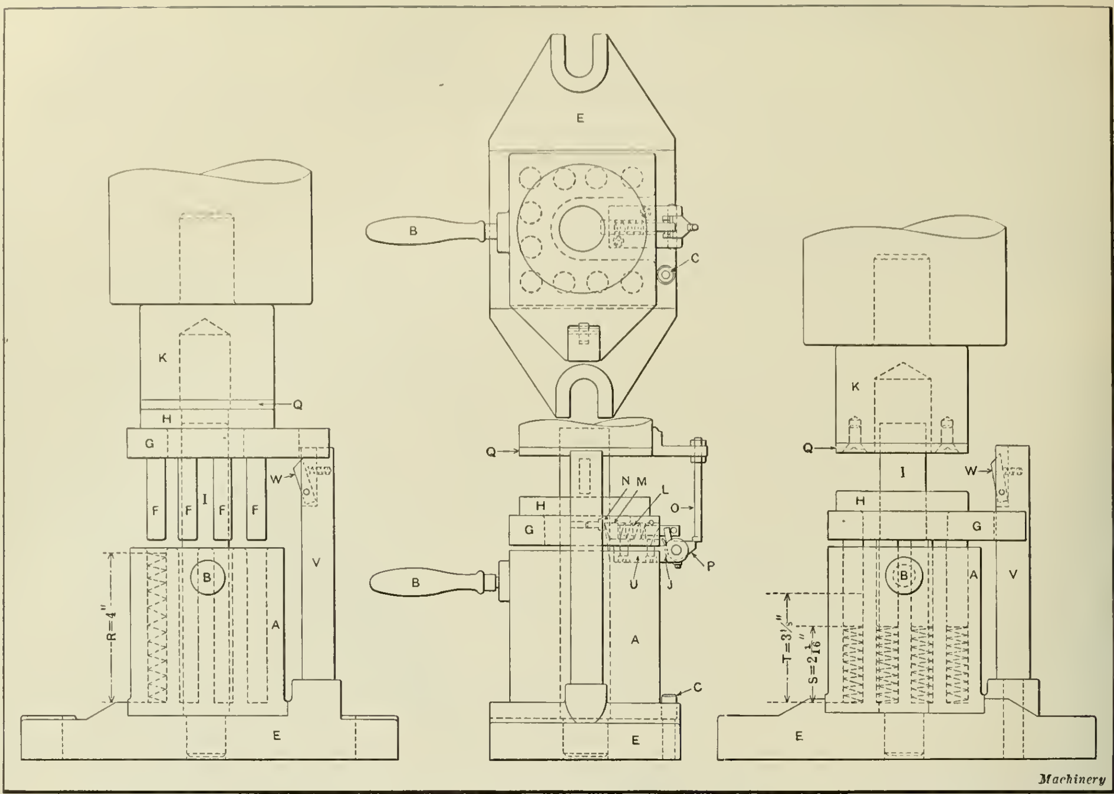


Fig. 4. Fixture for performing Firing Test on Springs

The post V keys the plate G in position and carries the spring-operated retainer W that keeps the plate G and plungers in the upper position when loading, thus allowing clearance for removing the loading block. Two loading blocks are furnished with each fixture to enable the machine to be continuously operated. After the loading block with ten springs is in position, the first stroke of the punch causes the plate G to escape the retainer W and compresses the springs to the length S; they are retained in this position by the sear M until the punch has returned to the upper position and is again lowered sufficiently for the pin O to pull the trigger P. An annunciator attachment rings a bell after the springs have been fired one hundred times. The bell-hammer is operated by dry cells, and the electric contact is made after one revolution of a ratchet wheel rotated by a pawl mounted on the ram of the punch press.

Weighing Pressure of Firing-pin Spring

In Fig. 2 is shown a vertical weighing fixture that is mounted on the wall. This fixture is designed to weigh the pounds pressure of the firing-pin spring at a given length. When the special pointer on the scale coincides with the pointer A, the firing-pin spring (which is loaded on the swinging pin B) has been compressed to its initial compression of 3⅛ inches. The graduations C on the standard scale that represent the specified weight of the spring (minimum 18 pounds, maximum 20 pounds) are cut deeper than the others and filled with red wax, so as to be readily distinguished. The spring is compressed against the stop D by the swing E, which is hung from the scale beam. Its light construction balances the weight of the usual ring and hook, which have been removed. The scale is hung from the pulley line F, which runs over the pulley G and then down the back of the frame to the drum H, operated by the crank shown. This crank affords a sensitive control over the scale beam, as the leverage of the crank allows the spring to be easily compressed. The swing E is lowered until the spring attains its free length before the pin B is swung out for reloading with another firing-pin.

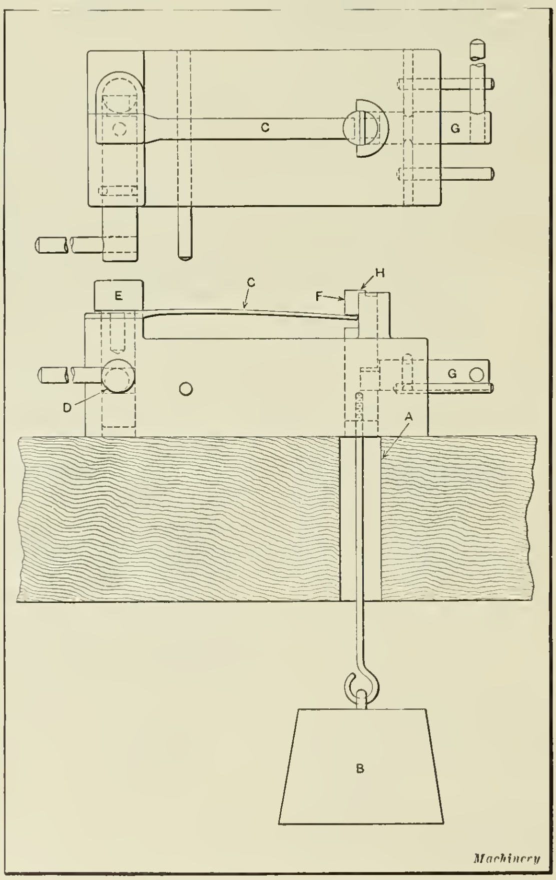


Fig. 5. Testing Temper of Flat Springs

Vibrating Test

The other coiled springs used in military rifles do not require the shock test described for the firing-pin spring, but they do require a vibrating test of one hundred strokes each. A fixture for making this test in a drill press is shown in Fig. 3. The springs *A* are compressed by the plungers *B*, which are operated by a heart-shaped cam *C* fastened to the spindle *F*. The springs and plungers are carried in the rotating magazine *D*, which has a bearing in the base of the fixture to which is fastened the semicircular guide *E*. Spindle *F* has a No. 2 Morse taper shank to fit the spindle of the drill press. An eccentric mounted on spindle *F* transmits motion to the arm *G* and the slider *H* that rotates arm *I* by means of connecting link *J*. Two pawls mounted on arm *I* rotate ratchet wheel *K* and magazine *D* independently of the spindle.

In operation, the drill-press spindle and cam *C* are revolved at about 120 revolutions per minute, and the cam compresses the springs once each revolution; it will be seen by referring to the illustration that a spring is loaded at *L* and travels 180 degrees within the guide *E* before being ejected at *M*. Hence, since the spring must be compressed 100 times before being ejected (or while passing through a distance of 180 degrees), the speed ratio of the cam to the carrier must be 200 to 1. For this reason a ratchet of 100 teeth is operated by the double pawl action shown at *N*, which indexes the ratchet wheel one-half tooth at a stroke; this is equivalent to using a ratchet wheel of 200 teeth, so during one hundred revolutions of the cam the carrier makes one-half turn, thus compressing each spring one hundred times, as required for the test. The guide *E* (which compresses the springs at *O* to the length required when assembled) fits into the circular slot in the carrier *D*, thus keeping the springs inside the rim of the carrier to prevent them from dragging. A tin chute at *M* conveys the springs into a container from which they are ejected. When loading, the operator keeps his finger on the spring until it passes under the guide *E*, so that it will not be pushed out of the fixture by the cam.

Testing Temper of Flat Springs

Flat springs for military rifles must be tested to determine the proper temper for resisting a specified weight. A convenient method of making this test is shown in Fig. 5. The fixture is fastened to the work-bench, in which a hole *A* is bored to allow the weight *B* to be suspended. The spring *C* is clamped by the eccentric clamp *D* operating the hook-bolt *E*; the other end of the spring is located in the notch of the gage plunger *F*. After the spring is clamped in position, the weight and plunger are lowered by means of the eccentric *G*, and the resistance of the spring is noted at the stepped gaging point *H*.

* * *

AIDING MANUFACTURERS TO LOCATE IN NEW YORK CITY OR VICINITY

The Merchants' Association of New York offers the manufacturers about to locate in New York City or vicinity services entirely without charge to aid in securing a desirable location. The problem of finding a good location is an intricate and puzzling one. This is not strange in view of the fact that the industrial district of metropolitan New York contains twenty important cities and many smaller communities, in addition to the five great boroughs of Greater New York. For several years the association has performed a valuable service to such manufacturers in aiding them to select the particular location best suited to their requirements and furnishing them with information relating to the many industrial factors with which they may be concerned. All manufacturers thinking of locating in New York City or vicinity are urged to communicate with Alfred S. Smith, manager of the Industrial Bureau of the Merchants' Association of New York, 233 Broadway, New York City.

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PROGRESSIVE FRACTION ADDER

Fred J. Perry, Nashua, N. H., the maker of the progressive fraction adder shown in the March number of MACHINERY, has received a number of requests for the adder, but he is not making it for sale, and therefore is unable to supply it.

WORKMEN'S COMPENSATION ACTS

BY CHESLA C. SHERLOCK[1]

In a consideration of the compensation acts the question naturally arises, Who are employers and who are employes within the meaning of the law? Section 13 of the British act defines an employer as including any body of persons, "corporate or unincorporate, and the legal representative of a deceased employer; and where the services of a workman are temporarily lent or let on hire to another person by the person with whom the workman has entered into a contract of service or apprenticeship, the latter shall, for the purposes of this act, be deemed to continue to be the employer of the workman while he is working for that other person."

To many business men it may seem a little beside the question to discuss who are employers. Such a question is easily determined in most cases, but the real importance attaches to the exceptions and not to the general rule in discussions of this nature. If a firm employs a workman and he receives an injury for which he is entitled to compensation under the compensation acts, it may be an easy matter to say that the firm is the employer and is liable. But suppose that the firm is a partnership, one partner of which is insolvent, and that he is the one employing the injured workman. Naturally, the workman wishes to hold the responsible partner for compensation. Then, again, a serious question or doubt may be raised as to whether one is an employer at law, even though he has actually engaged a workman to perform certain duties for him. For instance, is the owner of a threshing machine the employer of a man known as a "trusser" who accompanies a machine from place to place but who receives his wages from each farmer? It was shown, in a given case, that a trusser rendered incidental services to the owner of a threshing machine in going from farm to farm, by riding ahead of the machine and clearing the way for it. Although there was absolutely no pecuniary relation whatever between the owner of the machine and the workman, the court held that the workman, if injured, was able to collect compensation from the owner of the threshing machine on the theory that such owner was the workman's employer. In a Scottish case the court said:

> A coal trimmer, although employed by an agent of the harbor commissioners, is in the employment of a firm of shipping agents who act as managers of a vessel being loaded with coal for third persons, where the trimmers are directly under the control of the agents and are paid from the freight, the balance of which, less charges, is sent by the agents to the owners of the vessel.

In another case, it appeared that the owner of a ship, being in a hurry, gave some money to a stevedore and asked him to employ a workman to assist in mooring the ship. In endeavoring to do this the workman was injured. The court held that the owner of the vessel was the employer, although the stevedore had actually employed the workman. Other questions arise where there is more than one employer and where the workman is admittedly the employe of one of them. The courts have, of course, decided cases on this point, but they have not decided them by virtue of the compensation acts, but by rules of law entirely independent of these acts.

There can be no recovery for injuries under the English act unless there is a contract of service between the employer and the employe. This is a question that is fruitful of litigation, but one that is determined, not upon the compensation acts, but upon rules of law entirely independent of the acts.

The section of the British act defining workmen reads:

> "Workman" does not include anyone employed otherwise than by way of manual labor whose remuneration exceeds £250 a year, or a person whose employment is of a casual nature and who is employed otherwise than for the purposes of the employer's trade or business, or a member of the police force, or an outworker, or a member of the employer's family dwelling in his house, but, save as aforesaid, means any person who has entered into or works under a contract of service or apprenticeship with an employer, whether by way of manual labor, clerical work, or otherwise, and whether the contract is express or implied, is oral or in writing.

[1]Address: Box 253, Des Moines, Iowa.

In one of the leading cases on this question, the court said:

> The popular meaning must be given to a definition where we are confronted with such an expression as "wages," and we must interpret the act as applying to persons whom, *ex hypothesi*, the legislature regards as not being in a position to protect themselves. None of these considerations apply in the case of a person holding the position of a certificated manager of a colliery, who comes within a very different category from that of an ordinary workman. I do not say that a person in the position of the deceased is absolutely excluded from the possibility of coming within the act, for it is possible that such a man might in fact work as a workman, though I do not know that such a contingency is at all probable; there might, however, be facts in a particular case from which the conclusion might be drawn that, although the man was a certificated manager, he was also a workman.

In another important case, the Master of the Rolls said: "The root of the matter is that each case must be decided in view of that which the person whom it is sought to treat as a workman was employed to do." These rules for classifying workmen may seem to be the essence of simplicity, but in most cases the status of an employe can be brought into question. The law cannot be an exact science, even though it is oftentimes so charged by ill-informed persons. The law can only hope to establish guide posts along the way, and each case, under the direction of the court, must find its own way. Partners are not workmen within the meaning of the acts, nor are servants employed in the master's house. A Scottish court even went so far as to say that a son, twenty-six years of age, who was employed as other workmen, but who lived in his father's house and paid his own board and rent, was, nevertheless, a member of the employer's family and could not recover compensation, as he was not a workman within the meaning of the law.

The question of who are workmen is one that is often technical and involved, but in the vast majority of cases it is either defined by the state laws or can be determined by good, sound sense. The majority of our compensation laws are based upon those of England, so it will not be amiss to take into consideration the English interpretation. A spirited question has confronted the courts in whether or not an independent contractor is a workman within the acts. The English courts early found that this question would have to be settled by general principles and could not be considered under the acts, inasmuch as the law did not define an independent contractor. They have held, however, that the mere fact that a workman contracts to do a job by the piece should not dispossess him of compensation. Under this principle, a workman employed in a quarry at so much per ton of stone that he got out, was allowed to recover compensation; also a coal miner under similar conditions was permitted compensation.

It should be kept in mind that the original theory of the compensation acts was that if a workman had, by the product of his skill or labor, enriched society through his added contribution to production, society should bear any losses that he sustained in working for its advancement; in other words, industrial injuries were a part of the cost of production and should be borne by the consumer just as other costs of production are borne. The proposition that confronted the legislators in the first instance of compensation acts was what would be done if a workman had been employed only a short time prior to his injury. Would it be consistent with justice to force society to pay for something that society had not received? A workman employed only a day or so before injury has not had an opportunity to contribute anything to society. The legislators then and there wisely settled a question that might have caused serious disputes between capital and labor. They provided that there could be no compensation for a mere temporary or casual employe.

The question of what is meant by "casual employe" is one that has been bitterly fought in the courts, but has been settled according to common sense and fairness. The rule is this: That irregular intervals of employment are not the proper criterion, but that if an employe is employed at intervals more or less regular, he is held to be a workman under the act. Perhaps the word "casual" is ill chosen; it seems that the word "incidental" or "temporary" would come nearer expressing the light in which the courts regard the meaning of this term than the term itself. If a man is working at something incidental to his main duties, he is a casual employe. If he is for the time being sawing wood, waiting for his plow to be repaired, he is a casual employe. If he is milking a cow when he was employed to build fences, he is a casual employe. If he is wandering past a mill and applies for work and is injured the next day, he is a casual employe. This class of workers is justly ruled out from the benefits of compensation. Of course this does not mean that where a man intends to follow his employment indefinitely and his employers are of the same mind, he cannot recover compensation if he is so unfortunate as to be injured within a short time after entering upon his duties. This is a fact that will be taken into consideration by the court in arriving at the rights of the respective parties.

* * *

EDITORIAL CONFERENCE

A conference of more than ordinary interest and importance was held at the New Willard Hotel, Washington, D. C., May 25, between the editors of the trade and technical press and the Cabinet heads and special representatives of the government engaged in mobilizing the vast and varied resources of the nation for war purposes. The meeting was initiated and organized by the Editorial Conference, which is the name of the society of trade and technical press editors, with headquarters in New York City.

The purpose of the conference was to bring about closer cooperation between governmental activities and the industrial press of the country, and all the leading trade, class and technical journals were represented at the meeting, which was addressed by Newton D. Baker, Secretary of War; Josephus Daniels, Secretary of the Navy; Franklin K. Lane, Secretary of the Interior; William C. Redfield, Secretary of Commerce; William B. Wilson, Secretary of Labor; Dr. Van H. Manning, Director of the Bureau of United States Bureau of Mines; Herbert C. Hoover, Food Administrator; Walter Gifford, Director of the Council of National Defense; Frank A. Scott, chairman Munitions Board, Council of National Defense; Frank A. Vanderlip, president of the National City Bank; Howard Elliott, member of the Executive Committee, Council of National Defense; Dr. Franklin H. Martin, in charge of Red Cross work, medicine and sanitation, Council of National Defense; George Creel, chairman, Committee of Public Information; Dr. Pearson, president of the Iowa State College, now affiliated with the Department of Agriculture; and Lewis B. Franklin, in charge of the distribution of the Liberty Loan bonds. These men are grappling with problems of great magnitude, which, as Secretary Baker said, are the "mobilization of the industry and resources of the United States. . . . War has become a thing of industry and commerce and business. It is no longer Sampson with his shield and spear and sword and Goliath with his sling; it is no longer selected parties representing the nations as champions in physical conflict one with the other; it is the conflict of smokestacks now; it is the combat of the driving-wheel and of the engine, and the nation or group of nations in a modern war which is to prevail is the one which will best be able to coordinate and marshal its material, industrial and commercial strength against the combination which may be opposed to it."

These are the basic truths which the industrial press of the country must bring home to the men who operate the industries of production and distribution. As Secretary of Labor Wilson said, "Under warfare as it is now conducted, more people are required in the industries in the rear for the support of an army than are required in the trenches at the front." We must be united, each must do his part, and each is of prime importance. This is true whether your business is the managing of an enterprise or a department, or operating a lathe, planer or any other machine. Whatever your employment, the great thing is to keep busy—to keep the wheels of industry turning. That way lies the earliest and surest peace.

This was the lesson of the Editorial Conference at Washington, which, in all respects, was a decided success.

GRIDLEY MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINES—2

DESIGN, CONSTRUCTION, OPERATION, TOOL EQUIPMENT AND ATTACHMENTS

BY DOUGLAS T. HAMILTON[1]

THE change-gear mechanism on the Gridley multiple-spindle automatic is of such interest that further description may be desirable. In the first place, with this type of machine it is not necessary to start with a machine operating at its maximum efficiency. As a general rule, when an operator is setting up a new job, the first thing he considers is the speed at which he can run the work. Then, if necessary, the change-gears are replaced by those giving the desired spindle speed. He then proceeds to set the various cutting tools, paying no attention to the feed of the turret slide or forming and cutting-off slides. After every tool has been properly set, he then speeds up the machine by changing the levers on the speed gear-box until he obtains a speed as great as the limiting tool will stand. The feed given the tool is then determined in relation to the spindle speed. For instance, on the change-gear box the series of feeds obtainable are 75 to 200 in the following ratios: 75, 100, 125, 150, 175 and 200. This means that the work-spindle makes this number of revolutions to one-inch travel of the tool-slide. With this arrangement, of course, it can be easily seen that it is a comparatively easy matter to obtain a suitable feed, and this can be done while the machine is in operation. It also helps an operator to run the machine more economically, especially when the stock varies considerably in hardness. The change-gear box lever is adjusted with reference to the cams on the drum for operating the turret slide, and each of the three positions for the lever is marked according to the throws of the cams used. For instance, on the ¾-inch size, the positions would be marked 1 1/2, 3 and 4 9/16, respectively. The lever is then put in the hole that is marked to

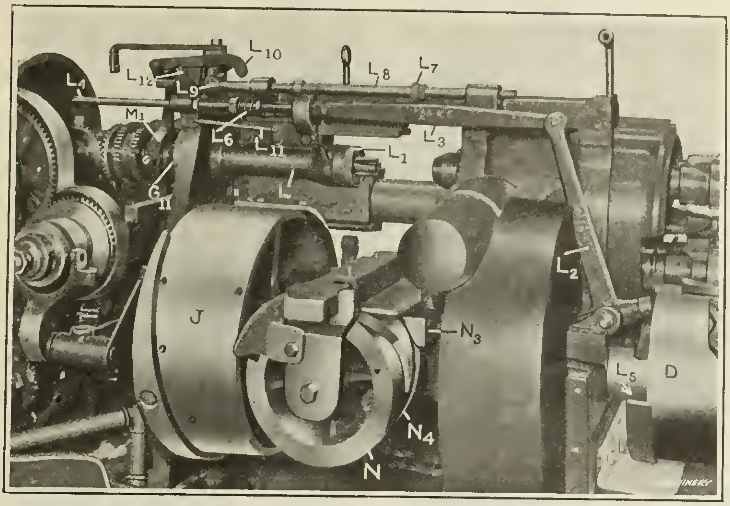

Fig. 21. Arrangement of Die Mechanism for Right-hand Threading on Gridley Automatic

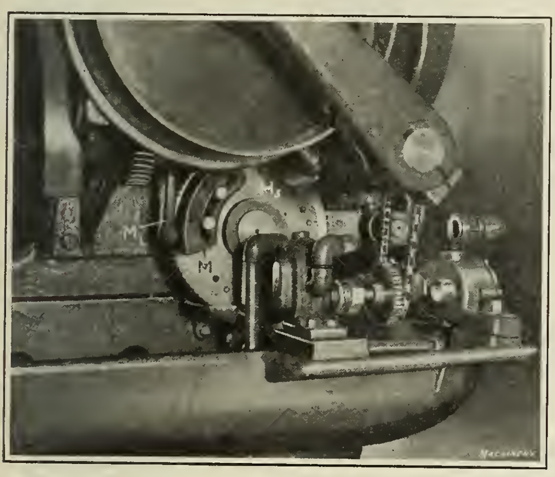

Fig. 22. Cam Position for operating Clutch for Right-hand Threading

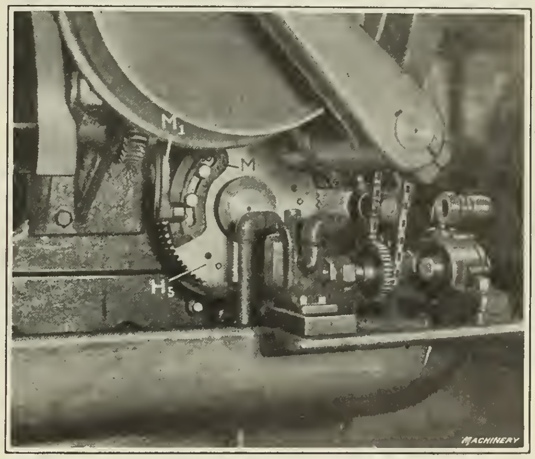

Fig. 23. Cam Position for operating Clutch for Left-hand Threading

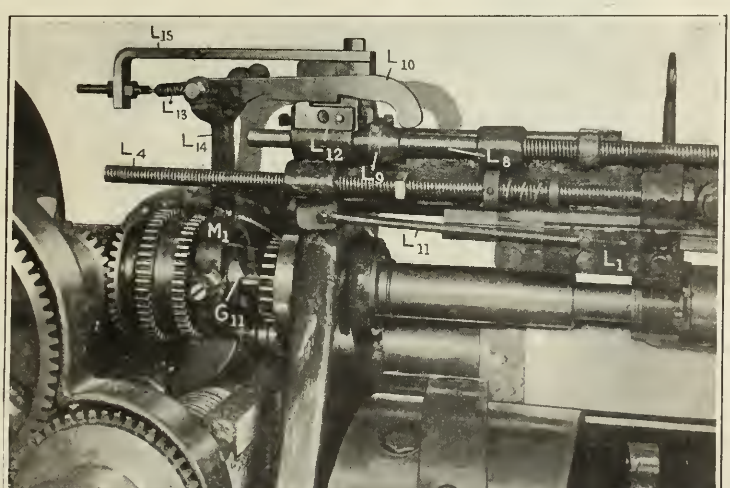

Fig. 24. Arrangement of Die Mechanism for Left-hand Threading on Gridley Automatic Screw Machine

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correspond with the throw of the cam used on the turret drum.

The threading mechanism on the Gridley multiple-spindle automatic screw machines comprises a separate and independently driven die-spindle L, as shown in Fig. 21. The gear end of this mechanism is clearly illustrated in Fig. 18 in the June installment of this article. The die-spindle extends through the main frame of the machine and carries the loose gear K_2, the loose combination gear G_9, G_{10}, and the sliding clutch G_{11}, which engages with clutch teeth on the loose gears K_2 and G_{10}. The loose gears G_9, G_{10} and K_2 are driven by gears K and K_1 fastened to the central driving shaft, which drives the spindles.

When right-hand threads are being cut clutch G_{11} is engaged with gear G_{10}, and when the die is being run off from the thread the clutch is engaged with gear K_2. When left-hand threads are being cut, clutch G_{11} engages with gear K_2, and when the die is being run off from a left-hand thread, the clutch is engaged with gear G_{10}.

The method of operating the threading mechanism for right-hand threading is shown in Fig. 21. The threading spindle L is supported on a bracket L_1 that is guided by a slide on the bracket connecting the feed and spindle end of the machine. Bracket L_1 is drawn forward through the action of a bellcrank lever L_2, connecting-link L_3 and screw L_4. The die is started by means of cam L_5 on drum D, contacting with the roll on bellcrank lever L_2. When this cam comes into play, it draws screw L_4 to the right and compresses the spring L_6 located between the adjusting nut and washer shown.

In operation, the cam L_5 advances the die toward the work and when the roll reaches the high point of the cam, the spring L_6 is compressed, the spring action assisting the die in starting. The die-slide is then carried forward by the lead of the thread until the boss on the slide reaches the adjustable stop L_7 on screw L_8, when the latter is pulled along with the slide until spool L_9 trips lever L_{10}. This lever, in turn, through the action of a spring, operates clutch G_{11}, throwing it into engagement with the other gear so that the die runs off the work. The slide is then returned to its rear position through the tension of spring L_{11}. This spring, which is put under tension when the slide advances, prevents the die or tap from dwelling on the work and "chewing up" the thread. Just prior to the indexing of the spindle carrier, the return cam throws the die-slide back to the rear position. The clutch is reengaged to drive the die-

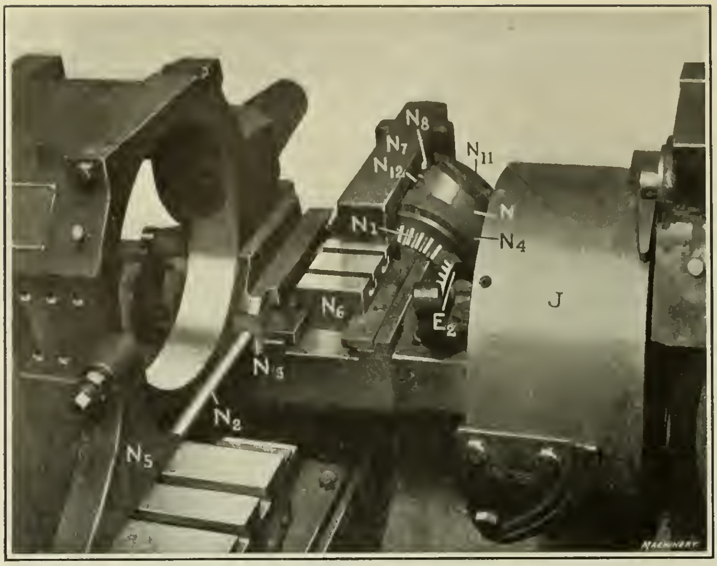


Fig. 25. View of Machine showing Method of operating Forming and Cutting-off Slides

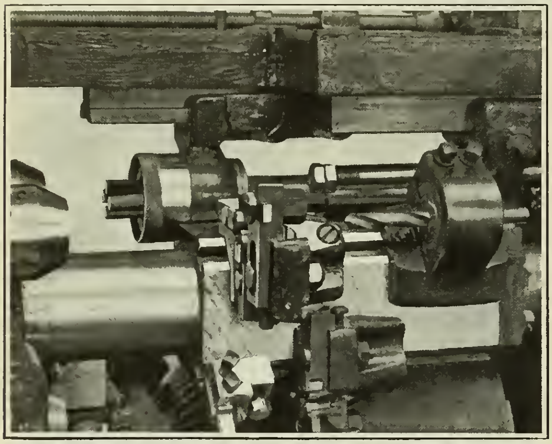


Fig. 26. Method of locating One Turret Tool behind Another

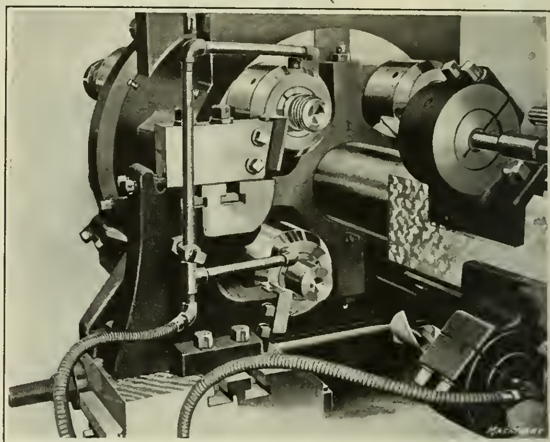


Fig. 27. Rough- and Finish-forming Tools in First and Second Positions

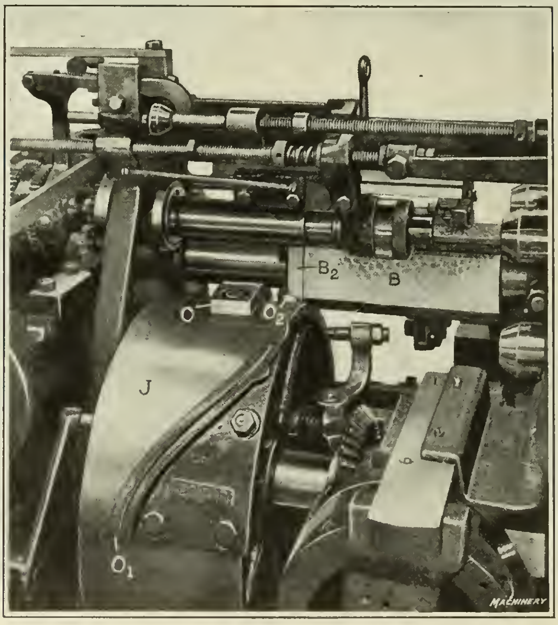


Fig. 28. Detailed View showing Cam for operating Turret Slide

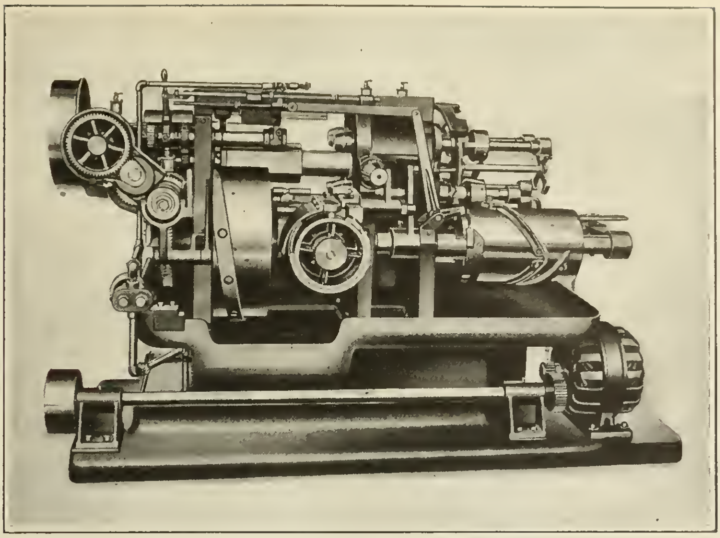


Fig. 29. 1¼-inch Gridley Multiple-spindle Automatic Screw Machine with Motor Drive

spindle at the proper speed after the die backs off the work by a cam *M* held on worm-wheel H_5, as shown in Fig. 22. This cam comes into contact with the lower end of clutch lever M_1. Cam *M* also resets lever L_{10} on cam L_{12}, Fig. 21. With this arrangement it is possible for the die to thread a piece and immediately run off without waiting for the turret slide to return to the rear position. It is impossible, except in extreme cases, for the threading operation to be the longest single operation—or, in other words, the operation that controls the time required to produce one complete piece.

For cutting a left-hand thread, it is simply necessary to make a few changes in the arrangement of the tripping cam and springs, as shown in Fig. 24. Here it will be noticed that cam L_{12} is reversed so that it catches the rear instead of the front notch in lever L_{10}. The position of spring L_{13} is also changed, being attached to the clutch lever L_{14} and to the bracket L_{15}. The spring tends to keep the clutch in mesh with the high-speed driving gear on the pulley shaft and thus rotates the die at a faster speed than the spindle, so that it advances on the work; when the die advances to the point desired, spool L_9 trips lever L_{10} and throws the clutch into the slow-speed gear, causing the die to back off the work.

The trip is reset by a cam *M* on worm-wheel H_5 as shown in Fig. 23, which operates clutch lever M_1 in the opposite direction to that in which it moves for right-hand threading.

Operation of Forming and Cutting-off Slides

As has been previously mentioned, the forming and cutting-off slides are operated from a separate cam drum *N* as shown in Fig. 25, which is held on a shaft that is located at right angles to the main cam drum. The forming and cutting-off cam drum is driven from the main shaft through bevel gears E_2 and N_1. The drum *N* carries the cams for operating the forming and cutting-off slides. The forming slide is operated through a rod N_2, which is held in slide N_3 supported in a slot in the bed of the machine and also by a bracket located on top of it. This slide carries the roll which runs in contact with cam N_4 on the cam drum, as shown in Fig. 21. The rod N_2 is connected to the forming slide as mentioned, and has an adjusting collar for depth at its forward end, which is graduated in thousandths of an inch, as shown in Fig. 32. The top face of the forming slide has two T-slots in it for clamping the forming-tool holder in position. It also carries a bracket N_5, holding an adjustable stop that comes in contact with stops B_4 in the arms of

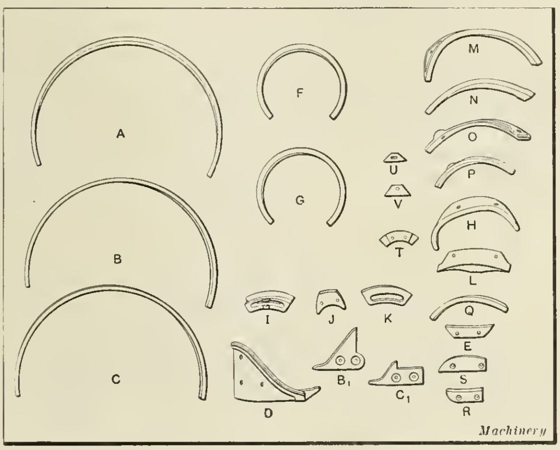


Fig. 30. Various Cams, Dogs, etc., used on Gridley Automatic

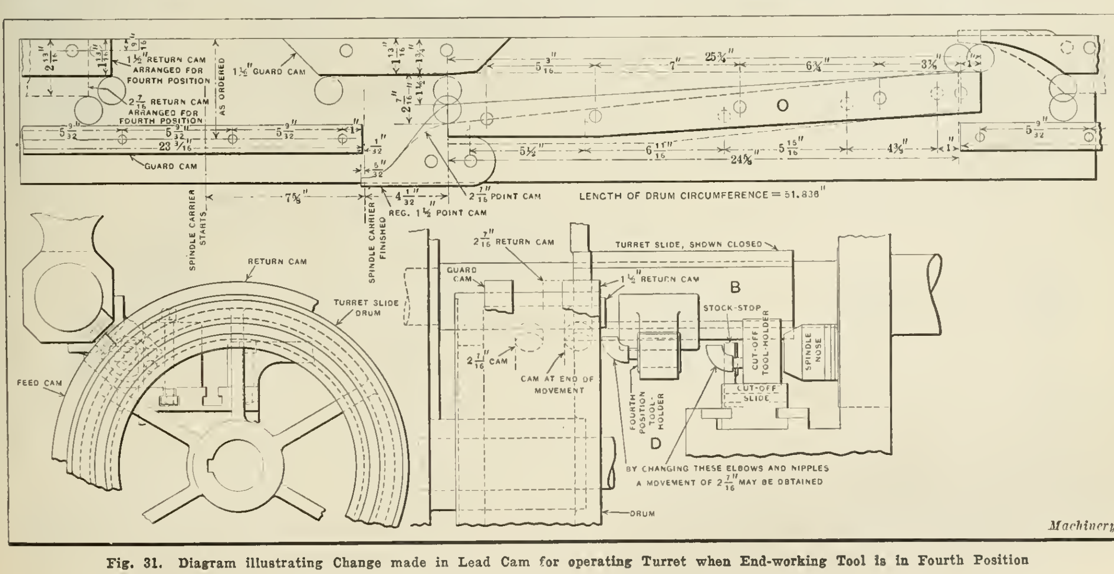


Fig. 31. Diagram illustrating Change made in Lead Cam for operating Turret when End-working Tool is in Fourth Position

the forming ring B_3 on the spindle carrier.

The cutting-off slide N_6 operates in a groove cut in the bed and is held down by gibs as shown. It is operated from cam drum N through a connecting-bar N_7 that has a roll N_8 attached to its lower face. The adjustment of the cutting-off slide is accomplished by changing the position of the roll, which is adjusted by set-screw N_9 and locked by screw N_{10}. The roll is operated upon to advance the slide by cam N_{11} and returned by cam N_{12}, Fig. 25. Both cutting-off and forming slides can be adjusted vertically to compensate for wear by means of taper gibs, as shown in Fig. 32, upon which the slide moves. These gibs are moved in to raise the slides when they have become worn down below the correct center distance by means of a collar screw as illustrated.

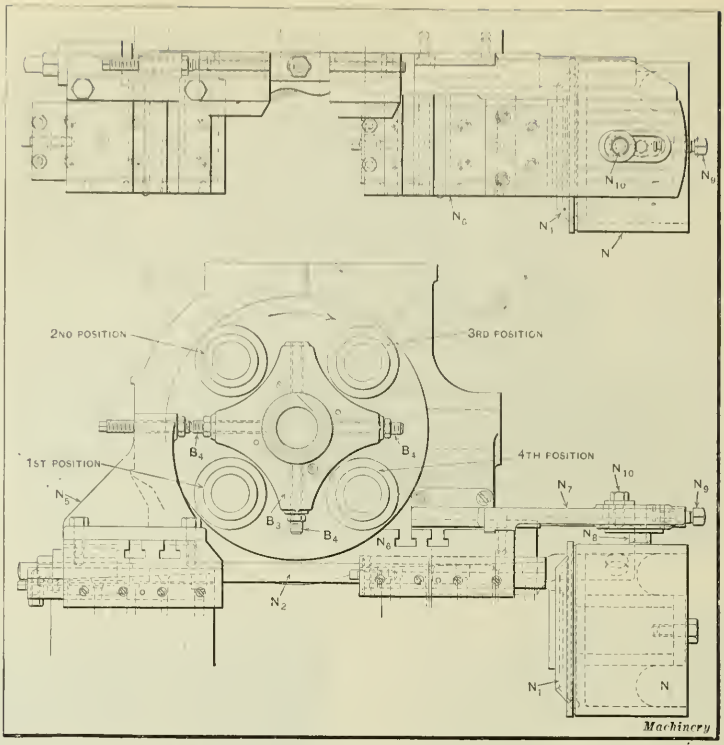
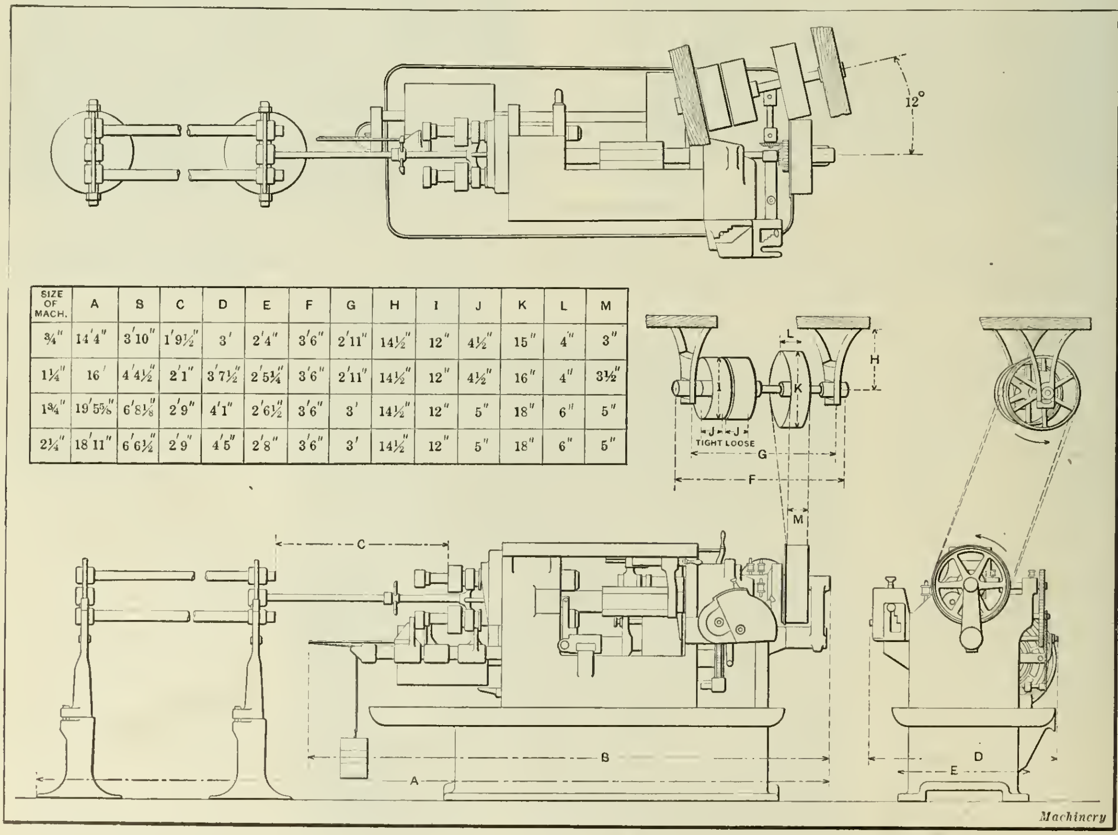


Fig. 32. Diagram illustrating Operation of Forming and Cutting-off Slides

Operating Positions

The Gridley multiple-spindle automatic screw machine has four operating or work-spindle positions as shown in Fig. 32. By arranging the tools on the turret slide, however, as shown in Fig. 26, it is possible to locate one tool-holder back of another so that turning and drilling operations, spotting, centering, etc., can be accomplished from the same tool position, which greatly increases the productive capacity of the machine, as well as its range of work. The turret slide B, as shown in Fig. 28, is advanced by cam O on drum J and is returned by cam O_1, these cams contacting with roll O_2 held on bracket B_2 attached to slide B. With regard to the operations performed in the various positions, the fourth position is the stock-feeding as well as the cutting-off position. Operations, such as drilling, spot-



SIZE OF MACH.	A	B	C	D	E	F	G	H	I	J	K	L	M
3/4"	14'4"	3'10"	1'9 1/2"	3'	2'4"	3'6"	2'11"	14 1/2"	12"	4 1/2"	15"	4"	3"
1 1/4"	16'	4'4 1/2"	2'1"	3'7 1/2"	2'5 1/4"	3'6"	2'11"	14 1/2"	12"	4 1/2"	16"	4"	3 1/2"
1 3/4"	19'5 5/8"	6'8 1/8"	2'9"	4'1"	2'6 1/2"	3'6"	3'	14 1/2"	12"	5"	18"	6"	5"
2 1/4"	18'11"	6'6 1/2"	2'9"	4'5"	2'8"	3'6"	3'	14 1/2"	12"	5"	18"	6"	5"

Fig. 33. Setting-up Plan and Overhead Works for Gridley Multiple-spindle Automatic Screw Machine

ting, turning, forming, etc., can be performed in the first position; the second position is similar; whereas the third position is always for threading, the operation here being handled by the die-slide; if the work does not require threading other tools can, of course, be used in this position, the same as in the other positions. As shown in Fig. 27, the forming slide can be provided with a double tool-holder, so that forming can be accomplished either in the first or second position. This arrangement is especially advantageous when there is considerable heavy forming to be done, and roughing and finishing cuts are necessary.

TABLE 1. DATA ON TURRET SLIDE, STOCK FEEDING, FORMING AND CUTTING-OFF SLIDE CAMS

Size of Machine	Throw of Turret Operating Cam, Inches	Turning Cut of Turret Slide, Inches	Stock Feed, Inches	Throw of Forming Cam, Inches	Throw of Cut-off Cam, Inches
3/4	1 1/2 3 4 9/16	...... 4 1/4	...... 5 1/2	...... 3/8	...... 7/16 ......
1 1/4	2 4 6	...... 5 1/2	...... 6 1/2	...... 0.727	...... 0.809 ......
1 3/4	2 1/2 5 7 1/2	...... 7	...... 8	...... 3/4	...... 15/16 ......
2 1/4	2 1/2 5 7 1/2	...... 7	...... 8	...... 1	...... 1 1/8 ......

Machinery

Camming for Turret Drum for Fourth Position

It is sometimes necessary to use the fourth position for operating the end-working tool, and in this case a special stop is required, as previously described, as well as a special arrangement of the cams on drum J, Fig. 28; this arrangement is shown diagrammatically in Fig. 31. The necessary changes in the cams consist in cutting off the lead cam O and setting forward the return cam O_1, so as to return the turret slide B, before the piece in the fourth-position work-spindle is cut off. For the 3/4-inch machine, the travel of the turret slide is 2 7/16 inches as shown at D. As has been previously mentioned, the stop E_4 shown in Figs. 11 and 12 in the June number is used. The slot in this stop is made to clear the tool used in the fourth position, and to allow the cutting-off slide to recede the required amount. This stop then acts as a stripper in case the lead cam is made so as to have the work cut off while the drill is still in it. When the turret slide recedes, the stop acts as a stripper to remove the work from the tool. When the cutting-off slide is returned, the end of the special stop acts as a stop for the stock.

Application of Motor Drive to Gridley Multiple-spindle Automatic Screw Machine

As the Gridley multiple-spindle automatic screw machines are provided with a single driving pulley that runs at a constant speed, the additions necessary to attach a motor drive are few and simple. Fig. 29 shows a rear view of the Gridley 1¼-inch multiple-spindle automatic, and illustrates the changes made to convert it from belt to motor drive. It will be seen that this consists of the addition of two brackets, which are fastened to the base of the machine and carry a shaft geared to the constant-speed motor shown. The other end of the

TABLE 2. WORK-SPINDLE SPEEDS, DRIVING GEARS, AND SURFACE SPEED OF STOCK FOR GRIDLEY 3/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle R.P.M.	Pulley Gear Number of Teeth	Pulley Gear Outside Diameter	Driving Gear Number of Teeth	Driving Gear Outside Diameter	Diameter of Stock, Inches: 1/4 — Surface Speed, Feet per Minute	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
181	20	2¾	44	5¾	11.8	14.8	17.7	20.7	23.7	26.6	29.6	32.5	35.5
209	22	3	42	5½	13.7	17.0	20.5	23.9	27.3	30.7	34.0	37.6	41.0
240	24	3¼	40	5¼	15.7	19.6	23.5	27.5	31.4	35.3	39.2	43.2	47.1
291	27	3⅝	37	4⅞	19.0	23.8	28.5	33.2	38.0	42.8	47.6	52.3	57.1
331	29	3⅞	35	4⅝	21.6	27.0	32.5	37.9	43.2	48.7	54.1	59.5	65.0
375	31	4⅛	33	4⅜	24.5	30.7	36.8	42.9	49.0	55.2	61.3	67.5	73.6
425	33	4⅜	31	4⅛	27.8	34.7	41.7	48.7	55.6	62.6	69.5	76.5	83.4
482	35	4⅝	29	3⅞	31.5	39.4	47.3	55.2	63.0	70.8	78.8	86.7	94.6
548	37	4⅞	27	3⅝	35.8	44.8	53.8	62.7	71.7	80.7	89.6	98.6	107.6
666	40	5¼	24	3¼	43.6	54.5	65.4	76.3	87.1	98.0	108.9	119.8	130.7
763	42	5½	22	3	49.9	62.4	74.9	87.4	99.8	112.4	124.8	137.3	149.8
880	44	5¾	20	2¾	57.6	72.0	86.4	100.8	115.2	129.6	144.0	158.3	172.8

Machinery

Speed of driving pulley, 400 R.P.M. Speed of countershaft, 390 R.P.M. Threading speed, fast, one-third spindle speed. Threading speed, slow, one-fifth spindle speed.

TABLE 3. WORK-SPINDLE SPEEDS, DRIVING GEARS AND SURFACE SPEED OF STOCK FOR GRIDLEY 1 1/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle R.P.M.	Pulley Gear Number of Teeth	Pulley Gear Outside Diam.	Driving Gear Number of Teeth	Driving Gear Outside Diam.	Diameter of Stock, Inches: 1/2 — Surface Speed, Feet per Minute	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4
207	30	4	58	7½	27.0	30.5	33.9	37.2	40.6	44.0	47.4	50.7	54.2	57.5	61.0	64.3	67.9
229	32	4¼	56	7¼	30.0	33.7	37.5	41.2	44.9	48.7	52.4	56.1	59.9	63.7	67.4	71.2	74.9
252	34	4½	54	7	33.0	37.1	41.2	45.3	49.4	53.6	57.7	61.8	66.0	70.1	74.2	78.3	82.4
276	36	4¾	52	6¾	36.1	40.6	45.1	49.6	54.2	58.7	63.2	67.8	72.2	76.7	81.3	85.8	90.3
304	38	5	50	6½	39.8	44.8	49.7	54.7	59.7	64.7	69.6	74.5	79.6	84.5	89.5	94.5	99.5
333	40	5¼	48	6¼	43.6	49.0	54.5	59.9	65.4	70.8	76.2	81.6	87.2	92.6	98.1	103.5	108.9
365	42	5½	46	6	47.8	53.7	59.7	65.7	71.6	77.6	83.6	89.5	95.5	101.5	107.5	113.5	119.4
400	44	5¾	44	5¾	52.3	58.9	65.4	71.9	78.5	85.1	91.6	98.1	104.7	111.2	117.8	124.3	130.8

Machinery

Speed of driving pulley and countershaft, 400 R.P.M. Threading speed, fast, one-third spindle speed. Threading speed, slow, one-fifth spindle speed.

TABLE 4. WORK-SPINDLE SPEEDS, DRIVING GEARS AND SURFACE SPEED OF STOCK FOR GRIDLEY 1 3/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle	Pulley Gear		Driving Gear		Diameter of Stock, Inches								
					3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4
R.P.M.	Number of Teeth	Outside Diameter	Number of Teeth	Outside Diameter	Surface Speed, Feet per Minute								
115.9	22	3	74	9½	22.76	26.55	30.34	34.16	37.93	41.72	45.51	49.31	53.10
130.0	24	3¼	72	9¼	25.53	29.78	34.03	38.29	42.54	46.80	51.05	55.31	59.56
144.85	26	3½	70	9	28.44	33.18	37.92	42.66	47.40	52.14	56.88	61.62	63.36
160.6	28	3¾	68	8¾	31.53	36.79	42.05	47.30	52.56	57.81	63.07	68.32	73.57
177.3	30	4	66	8½	34.81	40.61	46.42	52.22	58.02	63.82	69.63	75.43	81.23
195.0	32	4¼	64	8¼	38.29	44.67	51.05	57.43	63.81	70.20	76.58	82.96	89.34
213.8	34	4½	62	8	41.98	48.98	55.97	62.97	69.97	76.96	83.96	90.96	97.95
234.0	36	4¾	60	7¾	45.90	53.60	61.26	68.92	76.58	84.23	91.89	99.56	107.20
255.5	38	5	58	7½	50.20	58.53	66.89	75.25	83.61	91.97	100.33	108.7	117.06
278.57	40	5¼	56	7¼	54.70	63.81	72.93	82.05	91.16	100.28	109.39	118.51	127.63
303.33	42	5½	54	7	59.56	69.49	79.41	89.34	99.26	109.19	119.12	129.04	138.97
330.0	44	5¾	52	6¾	64.80	75.59	86.39	97.19	107.99	118.79	129.59	140.39	151.19

Machinery

Speed of driving pulley and countershaft, 390 R.P.M. Threading speed, fast, one-third spindle speed. Threading speed, slow, one-fifth spindle speed.

shaft carries a pulley that drives the constant-speed pulley on the machine by a belt.

Drums, Cams, Etc.

There are three cam drums on the Gridley multiple-spindle automatic screw machine; these have been described in detail in connection with the chuck-closing and stock-feeding mechansim, operation of the turret slide and forming and cutting-off slides. The various cams used are grouped in Fig. 30, in which A, B, B_1, C and C_1 are the five cams for advancing the turret slide; D is the turret slide return cam; E is the safety cam; F and G are for advancing the cut-off slide and forming slide, respectively; H is for returning the cut-off and forming slides; I is the right-hand threading cam; K is the left-hand threading cam; L is the threading advancing cam; J is the threading return cam; M is the chuck opening cam; Q is the chuck closing cam; R is the safety cam; M, N, O and P are for advancing and returning the pusher tube; S is the

TABLE 5. WORK-SPINDLE SPEEDS, DRIVING GEARS AND SURFACE SPEED OF STOCK FOR GRIDLEY 2 1/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle	Pulley Gear		Driving Gear		Diameter of Stock, Inches					
					1	1 1/4	1 1/2	1 3/4	2	2 1/4
R.P.M.	Number of Teeth	Outside Diameter	Number of Teeth	Outside Diameter	Surface Speed, Feet per Minute					
79	25	3⅜	81	10⅜	20.6	25.9	31.0	36.1	41.3	46.6
92	28	3¾	78	10	24.0	30.1	36.1	42.1	48.1	54.0
106	31	4⅛	75	9⅝	27.7	34.4	41.6	48.5	55.3	62.4
121	34	4½	72	9¼	31.6	40.6	50.6	55.3	63.1	71.0
137	37	4⅞	69	8⅞	34.8	44.8	54.0	62.6	70.3	80.3
155	40	5¼	66	8½	40.6	50.6	60.8	70.9	81.0	90.9
168	42	5½	64	8¼	43.9	54.8	65.8	76.8	87.4	98.8
188	45	5⅞	61	7⅞	49.4	61.7	73.8	86.4	99.0	111.0
211	48	6¼	58	7½	55.3	69.4	83.2	97.1	111.0	124.8
228	50	6½	56	7¼	59.6	75.0	89.9	104.8	119.5	134.0
246	52	6¾	54	7	64.4	80.9	97.3	113.2	129.2	144.9
265	54	7	52	6¾	69.2	87.0	104.5	121.4	139.4	156.1
287	56	7¼	50	6½	75.0	94.0	112.6	131.5	150.0	159.0
310	58	7½	48	6¼	80.8	101.4	121.2	141.9	161.6	182.6
347	61	7⅞	45	5⅞	90.8	113.6	136.2	158.9	181.6	204.4
390	64	8¼	42	5½	102.0	127.8	152.8	178.6	204.0	229.7

Machinery

TABLE 6. PRINCIPAL DIMENSIONS AND CAPACITIES OF GRIDLEY AUTOMATIC SCREW MACHINES

Standard Size Machine	3/4	1 1/4	1 3/4	2 1/4
Capacity of Chuck, Round Stock, Inches	3/4	1 1/4	1 3/4	2 1/4
Capacity of Chuck, Square Stock, Inches	0.530	0.8838	1.237	1.591
Capacity of Chuck, Hexagon Stock, Inches	0.649	1.082	1.515	1.948
Maximum Length of Feed, Inches	5 1/2	6 1/2	8	8
Maximum Length of Turning Operation, Inches	4 1/2	5 1/2	7	7
Speed of Countershaft, R.P.M.	390	400	390	390
Speed of Driving Pulley, R.P.M.	400	400	390	390
Diameter of Driving Pulley, Inches	14 1/2	16	18	18
Width of Belt for Countershaft, Inches	4	4	6	6
Width of Belt for Spindle Shaft, Inches	3	3 1/2	5	5
Threading Speed compared with Spindle Speed, Fast	1/3	1/3	1/3	1/3
Threading Speed compared with Spindle Speed, Slow	1/5	1/5	1/5	1/5
Size of Lead Cams, Inches	1/2, 3, 4, 9/16	2, 4, 6	2 1/2, 5, 7 1/2	2 1/2, 5, 7 1/2
Size of Forming Cam, Inches	3/8	0.727	3/4	1
Size of Cut-off Cam, Inches	7/16	0.809	15/16	1 1/8
Floor Space over all, including Reel Stand	14′, 4″, by 3′	16′ by 3′, 7 1/2″	19′ 6″, by 4′, 1″	18′, 11″ by 4′, 5″

Machinery

cam for withdrawing the locking pin; *T* is for advancing the stop; *U* and *V* are the cams for the fast and slow speeds.

As has been previously mentioned, the turret slide operating cams are supplied in three different throws with each size of machine, whereas the forming and cutting-off cams are supplied in one throw for each size of machine. The cam data on the various sizes of machines are given in Table 1. The cams listed are those furnished with the machine, and it is evident, of course, that it would be necessary in some cases to use special cams when the work to be accomplished is out of the ordinary line.

Change-gears, Spindle Speeds and Surface Speeds

Tables 2 to 5, inclusive, give the data regarding the change-gears used on the various sizes of machines for securing a suitable spindle speed for the work being machined. The right-hand section of these tables includes the surface speed of the stock within the capacity of the machines, obtainable with the change-gears supplied.

Principal Dimensions and Capacities

The table accompanying Fig. 33, and Table 6, include the principal dimensions such as chuck capacities, countershaft speeds, diameters of pulleys, over-all dimensions, etc.

* * *

CHUCK FOR HOLDING DRIVING-BOXES

BY M. K.

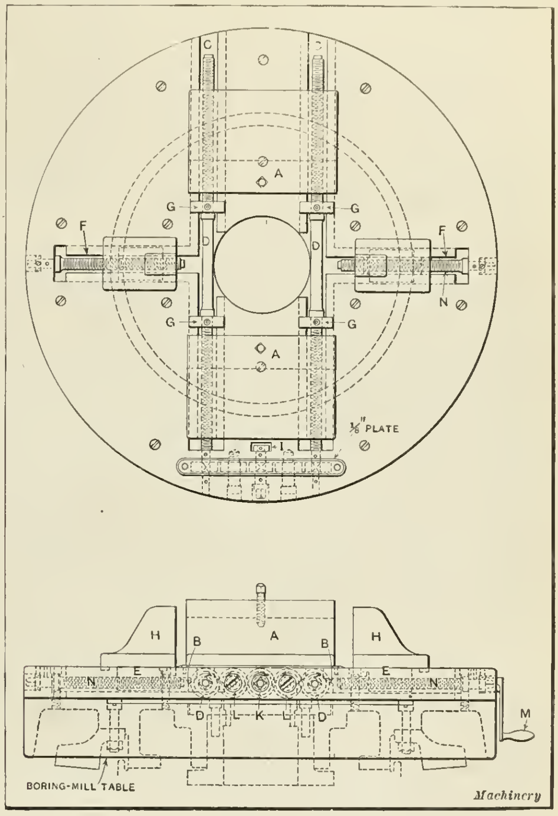
In the accompanying illustration is shown a specially designed chuck for holding driving-boxes while boring on a boring mill. The base is a solid cast-iron piece 3⅝ inches thick, with a ring protruding ½ inch. This ring, the width of which is 1½ inch and the outside diameter 35 inches, fits in a groove cut in the table of the boring mill. As the diameters of the boring mill table and the base of the chuck are the same—4½ feet—the chuck presents a neat and uniform appearance.

The chuck is fastened to the boring mill table by screws. The platen has an 11¼-inch hole in the center for the chips to drop into; this also allows the boring-bar and tool to clear. The two main sliding jaws *A* of the chuck are moved together, and hold the sides of the driving-box that go next to the driving-box shoes. These two jaws have projections *B* that fit corresponding slots *C* planed in the bed-plate. These projections are 4 inches wide and 1 inch high, and are beveled at a 30-degree angle to a width of 2 inches. One jaw is tapped right hand and the other left hand to suit the screws *D*. These screws have 2¼ inches more thread on one end than on the other, so care must be taken to see that just this much of each screw is screwed into the block having the right-hand threads before the block having the left-hand threads is brought up against the thread on the other end of the rod. As the screw is turned, both jaws are moved toward or away from each other. Before adjusting jaws *A*, two blocks *E* must be put in place in the slots *F* planed in the table at right angles to the slots *C*. One of these blocks is tapped right hand and the other left hand, and each may be moved independently of the other. After jaws *A* are put in place, four blocks *G* are inserted in small slots cut across slots *C*; these blocks hold screws *D* in place on the table. After the screws in slots *F* are screwed into blocks *H*, a locking washer with a 5/16-inch set-screw is put in place to hold them in position.

On the front, where the main adjustment is made by the operator, five holes are drilled. The middle one is drilled to slot *I*, in which is placed the washer that holds screw *K* in place. A gear turning on this screw *K* turns gears *L*, which turn the wheels on the long screw rods *D*, so that by turning the center screw *K* with a wrought-iron wrench *M*, every gear is turned, as they are connected, and consequently the long screw rods are turned, thus moving the two large jaws together, either in or out, as the case may be. When all the gears are in place, a wrought-iron plate with bevel edge is fastened over them as a gear guard.

The blocks *H* are removable in order that the driving-box may be put on or taken off the chuck and are just set in. They are kept in place by the lug on blocks *E*, but can easily be removed by loosening screws *N*, as they are 6 inches between their lugs and the screw blocks *E* are only 5⅝ inches long. It is usually necessary to remove only one of these blocks when a box is to be put on or taken off. The base is cast iron, the jaws are steel castings, and the gears, pins, screw rods and blocks are of soft axle steel.

The box is held in place and central with the sides, so that it can be so bored, because of the right-hand and left-hand threads on the screws *D* passing through the large jaws *A*. The two smaller jaws *H* are for adjusting the box the other way, namely, to bore more or less out of the part of the shell that rests on the axle, as is desired. These smaller jaws are independent of each other, and when the box is in the proper location, all the jaws are tightened, and the set-screws in the large jaws are tightened. To pull the box loose from the



Construction of Chuck for holding Driving-boxes

machine would take about as much energy as would be required to pull the machine off its heavy foundation. With this chuck the cost of boring boxes can be greatly reduced, as it holds the box when the heaviest cuts are taken.

* * *

The National Board of Fire Underwriters points to the experience of the Copley Cement Mfg. Co., Allentown, Pa., as illustrating the danger of using untested hose. A fire was discovered in a stone bunker in the plant, started presumably from a locomotive spark. The bunker was of slow-burning construction, the fire was quickly detected, and the mill fire squad responded promptly, so that there should have been little loss. The fire squad attached a coupling to a new fire hose, ran it to the blaze and turned on the water. The hose burst in five or six places, and a new length was substituted which failed in the same way. Thus the fire had made considerable headway before it was possible to obtain an effective stream. The loss amounted to $7000, which was almost entirely due to the failure of the hose. Hose tested by the National Board of Fire Underwriters is subjected to 300 pounds pressure, and each length that has successfully withstood this test bears the Underwriter's label.

SCHEMES THAT DIDN'T WORK

FAULTS IN MACHINE DESIGNS AND SUGGESTED IMPROVEMENTS

BY F. B. JACOBS[1]

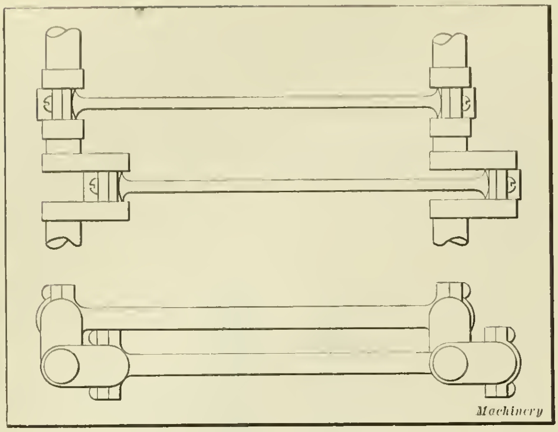


Fig. 1. Double Connecting-rod Drive

THE average all-around machinist who has been employed on experimental work to any extent can recall numerous instances wherein the carefully laid plans of the inventor and designer have fallen short of expectations. A drawing of a new machine, no matter how carefully executed, is theory, pure and simple—a child of the inventor's brain, as it were. Until practical results have taken form in the shape of the finished machine, no one, no matter how well versed in theory, can be certain of the actual results. When a finished machine does not come up to the originator's expectations, it is a pretty good sign that simple mechanical principles have been overlooked; for while many ideas look well on paper, they do not work out in practice. Those who read technical papers have ample opportunity to familiarize themselves with correct mechanical details; so, for a change, it may do no harm to analyze a few brief details that fell short of the originator's expectations.

In cases where it is necessary to operate two rapidly revolving shafts in the same direction, one driving the other, it is common practice, among manufacturers of certain kinds of sewing machines, to use the double connecting-rod drive illustrated in Fig. 1. As the cranks on the shafts are set at 90 degrees, one rod pulls the other over the dead center. This mechanism gives a positive, noiseless drive at especially high speeds, so it is often preferred to bevel gearing or other means of transmitting the necessary motion.

A prominent Eastern manufacturer wished to utilize this principle, but considered the cost of the two crankshafts prohibitive; so he attempted to use two straight shafts connected with eccentrics, as shown in Fig. 2. The plan failed utterly, as any mechanic ought to see at the first glance. While an eccentric is an excellent means for converting rotary motion into reciprocating motion, as in the valve gear of an ordinary steam engine, it is a very poor way in which to try to convert reciprocating motion into rotary motion, which was what was attempted in using an eccentric and strap for turning a shaft. One set of eccentrics would pull the other set off center, when both shafts were turned by hand in the same direction, but otherwise practical results were impossible owing to the friction between the eccentrics and their straps. This will be readily understood when we consider that an eccentric is nothing more nor less than a greatly enlarged crankpin. Notwithstanding the fact that the straps fitted the eccentrics freely enough to make a running fit and that the rods were adjustable to give the correct center distances which, of course, was necessary, one shaft absolutely failed to turn the other by the slightest fraction of a revolution.

Designs Having Poor Lever Arrangements

In Fig. 3 is shown a feeding mechanism used on a semi-automatic press for fastening thin sheet-metal caps on round-headed steel rivets. Sixteen dies were set in a revolving cast-iron disk that was rotated by a ratchet and pawl through the medium of a lever. To prevent overfeeding, due to the momentum that the disk might develop, a slight friction was provided by means of a large nut and fiber washer. A trial of the machine showed that something was radically wrong because the disk failed to stop at just the right station, which, of course, spoiled the alignment between the dies and the single punch that worked in connection with them. At first glance the lever appears to be of the correct design, as it is of the well-known second class; that is, a lever with the weight or converted motion between the fulcrum and the point of applied power. A careful inspection showed that the ratchet was accurately cut and that the holes were correctly spaced. If the designer had given a little more thought to the problem when he made his lay-out, he would have seen where the trouble lay. The radial distance at the actual point of converted motion, that is, at the dies themselves, is much greater than the periphery of the ratchet, and as the amount of friction on the bottom of the disk was greater at its periphery than at an imaginary circle under the periphery of the ratchet, an unnecessary amount of force

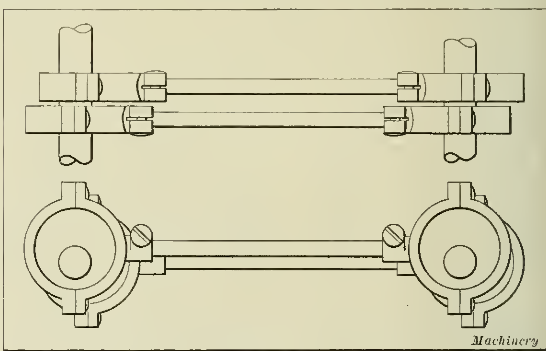


Fig. 2. Eccentrics used with Double Connecting-rod Drive

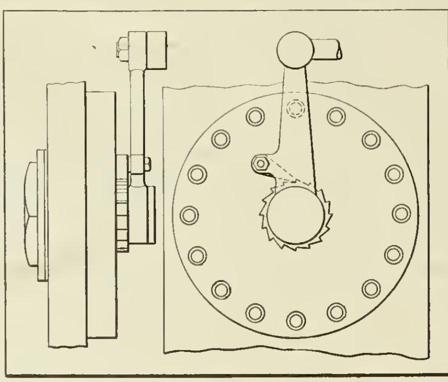


Fig. 3. Feeding Mechanism on Semi-automatic Press for fastening Metal Caps on Steel Rivets

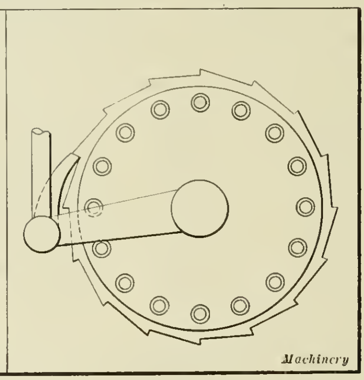


Fig. 4. Corrected Design of Feeding Mechanism shown in Fig. 3

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was required to turn the disk. This resulted in a certain amount of springing motion in all the parts actuating the disk, which accounted for the error in spacing. The difficulty was entirely overcome by redesigning the feeding mechanism as shown in Fig. 4. Here a large ratchet is placed over the outside of the disk and the pawl is of more substantial construction. The lever is still of the second class; and as the point of applied force is outside the radius of greatest friction, there is not as much chance for inaccurate spacing to develop. As a matter of fact, the machine in question worked very satisfactorily after this simple change was made.

Another simple leverage problem was easily solved by the proprietor of a small shop through the application of a correct principle. He was called upon to repair the valve gear of a high-speed, Corliss engine that persisted in heating its eccentric to an alarming degree. The lay-out of this particular valve gear is shown in the upper view of Fig. 5, where A is the eccentric, B the rocker, and C the wrist-plate. As the wrist-plate and main shaft are in the same plane, the designer could not resist the temptation to employ the principle of the third-class lever, that is, one with the point of applied force between the fulcrum and weight, and thus make the eccentric and reach-rods work in as nearly horizontal lines as possible. In this case, however, it was necessary to actuate a valve gear weighing several tons, 200 times per minute, as the engine ran at a speed of 100 revolutions per minute. Besides, the dash-pots were six inches in diameter, which necessitated overcoming a resistance of about 415 pounds, due to atmospheric pressure, 200 times every minute. Quick-acting dash-pots are necessary on a high-speed engine of the

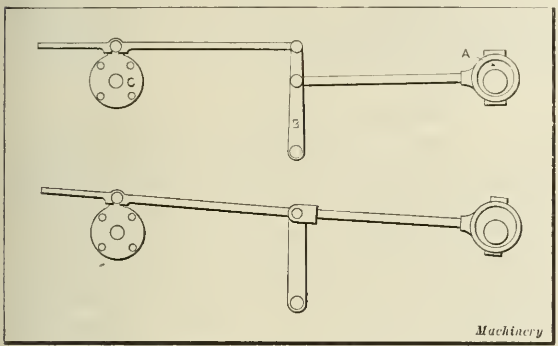


Fig. 5. Faulty and Correctly Designed Valve Gear

Corliss type, as the comparatively long stroke necessitates closing the valves with lightning-like rapidity the instant the crab claws release the valve stems.

The man who undertook to remedy the difficulty of overheating ascertained that the trouble started a few weeks previous, after the engine had been speeded up some twenty-five revolutions per minute. In the lower view of Fig. 5 is shown the method of overcoming the trouble. The eccentric was given a greater stroke so that it would move the wrist-plate the required number of degrees without multiplication of the stroke by the rocker arm. The rocker was shortened to bring the main shaft in line with the wrist-plate pin; and the end of the eccentric rod was provided with a yoke for carrying the pin that pivoted it to the rocker and reach-rod. The third-class lever gives a greater movement to the actuated part than is given by the driving unit. Every mechanic is aware that it takes force to multiply leverage, and here the force was developed at the expense of friction. The engine ran all right at its original speed, but the increased speed offered too much resistance (as the rocking parts reversed) for the eccentric to take care of without heating.

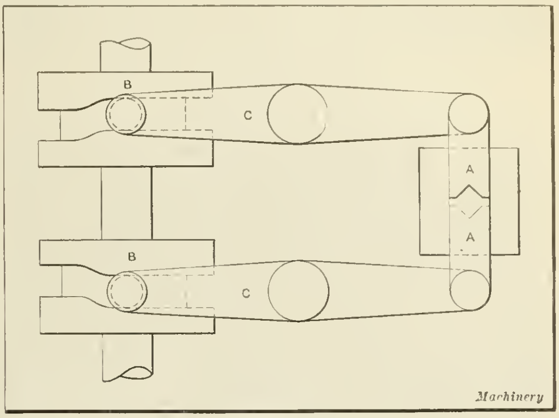


Fig. 8. Poor Lever Arrangement

Friction Drives

Some years ago the proprietor of a small shop desired to perfect a variable-speed friction drive. His idea is shown in Fig. 6. A shaft A, rotating as shown by the arrow, was supposed to drive the friction wheel B. The shaft C that carries the friction wheel is provided with means for moving it toward or away from the driving shaft A. The two large friction disks D are made to grip the friction wheel B by means of a heavy spring E. The ball thrust F is to reduce the friction caused by the spring pressure as much as possible. We all know how easy it is to roll a pencil between the fingers of both hands and the "boss" had this principle in mind when he designed the drive in question. But it refused to work. He tried cast-iron disks with a fiber friction wheel, fiber-faced disks with a cast-iron friction wheel, aluminum disks with a wooden friction wheel, and as a last resort he knurled the faces of the disks, hoping to coax them to drive a leather friction wheel. All these experiments were fruitless.

But before trying to ascertain why the drive refused to work it may be well to consider a friction drive that does work and then compare the two. The friction drive illustrated in Fig. 7 has been used successfully instead of the ordinary form of transmission in a light-powered automobile. The motor shaft A is fastened to the driving disk B and a ball thrust bearing C eliminates end thrust. The friction wheel D drives the jack-shaft E and means are provided for moving it across the face of the wheel to obtain different speeds; the greatest speed is obtained when in the position shown. By moving the friction wheel past the center of the driving disk, the reverse motion is gained. The jack-shaft brings the friction wheel in close contact with the friction disk through the medium of a foot-pedal. All things considered, it is a neat simple device. The friction disk and friction wheel are of the same diameter, so that when transmitting the greatest speed, the speed of the jack-shaft does not exceed that of the engine shaft. To gain power to climb hills the ratio between the engine shaft and jack-shaft is, of course, reduced.

In the device shown in Fig. 6 it was attempted to make the driving shaft drive the driven shaft at a

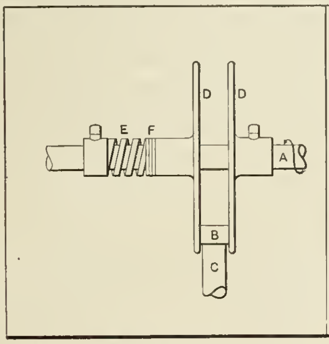


Fig. 6. Variable-speed Friction Drive of Faulty Design

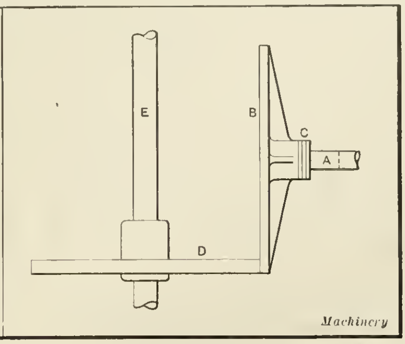


Fig. 7. Improvement on Friction Drive Design shown in Fig. 6

greatly increased speed, to say nothing of also driving another friction wheel in an opposite direction. With the spring adjusted loosely, the coefficient of friction was not great enough to drive the friction wheel; and by compressing the spring to its utmost, the coefficient of friction was too great for the device to overcome. These experiments were, of course, interesting, but after the "boss" had spent several hundred dollars without getting any tangible results he decided that he did not want a friction drive anyway.

Faulty Cam Designs

That we frequently make mistakes in proportioning levers few will dispute; a typical illustration of this is shown in Fig. 8. This illustration represents part of an automatic machine in which the two dies *A* grip the work by the action of the cams *B* working through the medium of levers *C*. Pivoting the levers midway between the cams and points of applied force resulted in a very hard-working motion, as several hundred pounds pressure was required to grip the work. As a result, the strain on the cams caused them to wear out in about two weeks. Fig. 9 illustrates the manner in which the difficulty was overcome. Here the distance from the fulcrum to the point of conveyed motion is considerably less than the distance from the fulcrum to the point of applied force. It was, of course, necessary to increase the stroke of the cams, but as it took less than a third as much force on the part of the cams to grip the work the cam was much longer-lived.

Another interesting cam motion is shown in Fig. 10. This motion is as follows: Starting from the point *A* and traveling clockwise there is first a drop of 1⅜ inch in 90 degrees, then a period of rest of 150 degrees, then a rise of 1⅜ inch in 30 degrees followed by a period of rest of 90 degrees. The cam ran at a speed of 1000 revolutions per minute and it was necessary for the sharp rise of 1⅜ inch to be a uniform motion. Uniform rises are necessary in some cases even though they are hard-working except at slow speeds. In this case, the motion was very hard-working, as an excessive side strain was brought to bear on the cam bar. After several cam bars had been bent, and a pair of spur gears that drove the cam-shaft had been stripped of their teeth, an effort was made to remedy the trouble. It was impossible to alter the design of the cam motion to the extent of dispensing with the cam bar; neither was it possible to do away with the uniform rise and, worst of all, it was not practicable to reduce the speed of the machine.

Fig. 11 shows the method used for overcoming this difficulty. A swinging lever was interposed between the cam and the roll on the cam bar. Thus when the sharp cam rise strikes the roll on the swinging lever, the side strain that came on the cam bar in the previous design is absorbed by the swinging lever in the form of tensional strain. The roll on the swinging lever serves to lift the cam bar under a compression strain only.

The few instances cited are mechanical bulls, and had they

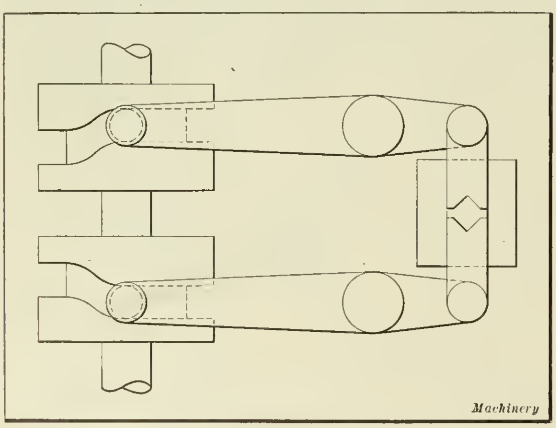


Fig. 9. Correct Arrangement of Levers shown in Fig. 8

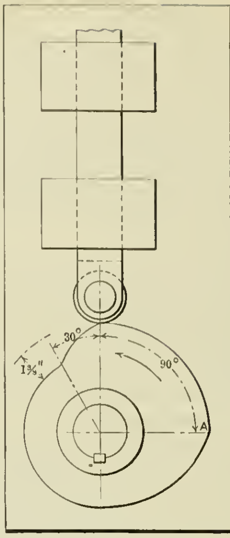


Fig. 10. Cam Arrangement having Excessive Side Strain

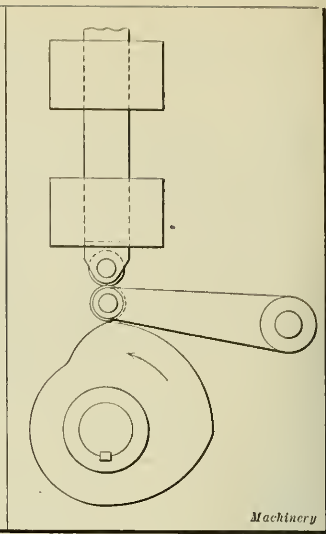


Fig. 11. Improvement on Cam Arrangement shown in Fig. 10

been the work of mechanical students instead of hard-headed, dollar-chasing business men we, no doubt, would smile knowingly as we prided ourselves on our superior knowledge of mechanical problems. The mistakes, however, were committed by mechanical men who were supposed to know better. These mistakes are of value, however, as it is through them that we learn by experience, building the successes of today on the ashes of the failures of yesterday.

* * *

CHARACTERISTICS OF INVAR

The fact that all metals expand and contract more or less with every variation of temperature introduces complications in the making of instruments concerned with absolute standards of time or space. After much research, a nickel-steel alloy, containing about 36 per cent nickel and about 0.5 per cent each of carbon and manganese, was found to have a remarkably small thermal expansion at ordinary temperatures. To this the name "invar" has been given. A summary of the results obtained during the last twenty-five years by various investigators of this property of invar and related nickel steels shows that a bar of ordinary invar expands or contracts about one millionth of its length for each degree alteration in the temperature within the range of 0 to 40 degrees C. A much higher degree of constancy than this, however, is sometimes obtained; much depends on the amount of carbon and manganese present. Small quantities of invar have been manufactured that showed a change in length of less than half a millionth per degree between 0 and 20 degrees C.; this alloy contains 0.06 per cent carbon and 9.39 per cent manganese. Samples have even been prepared that showed a negative coefficient of expansion, contracting slightly instead of expanding as the temperature rose. Invar possesses this peculiar property only with a moderate temperature range. From 40 degrees upward, the coefficient of expansion steadily increases as the temperature rises, until at 200 degrees it is almost the same as that of Bessemer steel. Like certain other alloys, invar gradually elongates with time, so when it is used on a length standard, a periodic correction must be made to allow for this. The effect may be largely diminished, however, by prolonged heat-treatment prior to finishing. M. E.

* * *

Aluminum castings that will take a high polish, according to a paper read by E. A. Barnes before the American Foundrymen's Association, may be made by adding from 8 to 10 per cent of tin to the copper-aluminum mixture. A rich aluminum-copper-tin alloy is made up and cast into bars which are added to the aluminum at the proper time. Castings made of this alloy do not contain the small blue specks that are due to the presence of gas in the metal.

EFFICIENCY OF FORWARD AND REVERSE DRIVES

DETERMINATION OF EFFICIENCY OF WORM-GEARS AND SPUR GEARS BY GRAPHIC METHOD

BY JOHN S. MYERS [1]

IN all mechanical devices for the transmission of energy there is some loss due to friction, the efficiency of the mechanism being the ratio of the energy output to the energy input. It is well known that the efficiency of a device may be fairly high when transmitting energy in one direction and yet quite low when operating inversely. For instance, a small pinion driving a large gear is somewhat more efficient than the same gear driving the pinion. A screw jack is a reasonably efficient means of raising a load, but the load acting against the screw is unable to turn it, for the efficiency in the reverse direction is negative, that is, less than zero. The ordinary non-overhauling worm drive, frequently used for hoisting purposes, and various other so-called self-locking mechanisms are designed upon this principle of negative efficiency for reverse operation. While there is considerable literature on the subject of worm-gearing and its efficiency, the worm is invariably treated as the driver. It is the object of the present article to present a simple graphic method for determining the efficiency of such drives, with either the worm or the worm-wheel the driver, giving formulas and curves that are based on the graphic analysis of the various forces involved.

Worm and Wheel with Worm the Driver

Referring to Fig. 1, triangle ABC represents the worm in static equilibrium, while triangle CBI represents a similar state for the worm-wheel. $P(=AB)$ represents the rotative force acting at the pitch diameter of the worm, that is, the driving force; $T(=CB)$ is the component of P that acts normal to the worm-wheel teeth; $R(=AC)$ is the component of P that acts against the thrust washers; $F(=IB)$ is the component of T that acts as a tangential effort on the worm-wheel teeth; $H(=CI)$ is the component of T that acts on the worm-wheel hub.

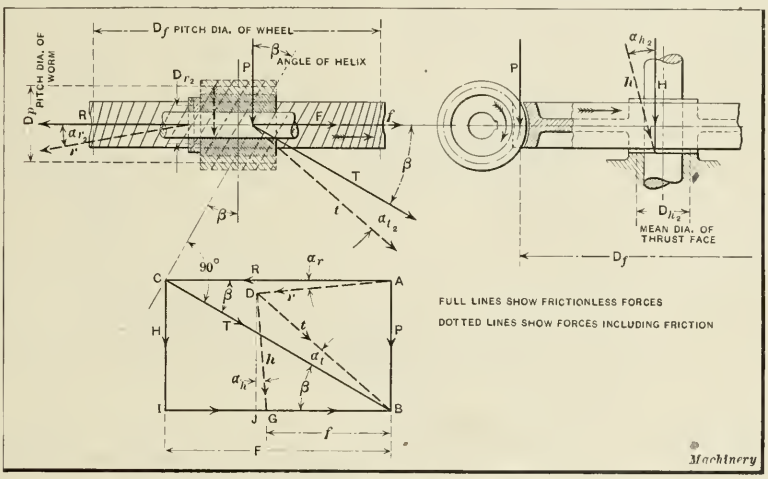


Fig. 1. Forces acting on Worm and Worm-wheel when Worm is Driver

When in motion, in order that the surfaces may slide upon each other, the forces acting on these surfaces make an angle with the normal such that the tangent of the angle is equal to the coefficient of friction. Triangle ABD represents the forces acting on the worm, and triangle DBG those acting on the worm-wheel when in motion. $t(=DB)$ is the tooth load; $r(=AD)$, the force on the thrust bearing; $h(=DG)$, the force on the worm-wheel hub; and $f(=GB)$ is the effective tangential force on the worm-wheel teeth.

As F is the force on the worm-wheel teeth necessary for static equilibrium if there were no friction, and f is the effective effort taking into account the friction, the efficiency E_p may be expressed as:

$$E_p = \frac{f}{F} \quad (1)$$

The sub letter $_p$ designates the force P at the worm as the driving force.

In laying out the resolution of forces, the angles in the diagram are made such that their frictional components are reduced to their equivalent values at the pitch line.

Let C_{t_2} = coefficient of friction at teeth;
C_{r_2} = coefficient of friction at thrust bearing;
C_{h_2} = coefficient of friction at hub of wheel;
C_t = effective value of C_{t_2} at pitch line;
C_r = effective value of C_{r_2} at pitch line;
C_h = effective value of C_{h_2} at pitch line;
α_t = effective value of angle α_{t_2} at the pitch line;
α_r = effective value of angle α_{r_2} at the pitch line;
α_h = effective value of angle α_{h_2} at the pitch line;

The effective values are:

$$\text{Tan } \alpha_r = C_r = C_{r_2} \frac{D_{r_2}}{D_p} \quad (2)$$

$$\text{Tan } \alpha_h = C_h = C_{h_2} \frac{D_{h_2}}{D_f} \quad (3)$$

C_{t_2} acts directly at the pitch line; hence:

$$C_t = C_{t_2},\ \alpha_t = \alpha_{t_2},\ \text{and tan } \alpha_t = C_{t_2} = C_t \quad (4)$$

For D_{r_2}, D_p, D_{h_2} and D_f, see Fig. 1.

Limiting Conditions

An inspection of Fig. 1 will show that as angle β becomes smaller, the theoretical force F increases much more rapidly than the effective force f, resulting in low efficiency. When $\beta = 0$, F is infinite, while f has a measurable value, and, consequently, the efficiency is zero. This is one limit of the efficiency curve. For large values of angle β the effective force f decreases rapidly, again resulting in low efficiency. When angle JDG = angle JDB, line DG coincides with line DB, $f = 0$, and the efficiency is zero. From the geometry of the figure it can be seen that this condition will exist when $\beta + \alpha_t + \alpha_h = 90$ degrees. The maximum value of the angle β is then:

$$\beta_{max} = 90 - \alpha_t - \alpha_h \quad (5)$$

For values of β equal to or greater than this the worm cannot drive the worm-wheel; this is the limiting condition for steep-angle worms. It is interesting to note that angle α_r does not appear in Formula (5). An inspection of the diagram will show that, as α_r increases, the value of f, and consequently the efficiency, decreases; but while f decreases, it will not actually become zero until α_r becomes 90 degrees. The significance of this is that, however great may be the friction of the thrust bearing, the device will not lock from this cause alone unless it actually seizes. A roller or ball thrust bearing for the worm will increase the efficiency of a drive that is operative, but it will not prevent a quick angle worm that locked from doing so; the cure for this is a reduction of the friction on the teeth and on the worm-wheel hub.

Formulas for Efficiency with Worm the Driver

For purposes of analysis or comparison with other data, the results of the foregoing graphic method may be expressed by formulas. In Fig. 2, P is the load applied at the pitch line of

[1] Address: 4157 N. 9th St., Philadelphia, Pa.

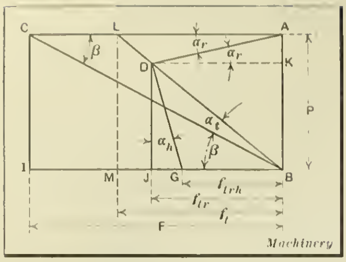


Fig. 2. Diagram used in developing Formulas for Efficiency when Worm is Driver

the worm, BC is the tooth load, and BI its tangential component on the worm-wheel if frictionless. Considering the friction of the teeth only, BL is the tooth load and $BM = f_t$ is the effective tangential component. From the geometry of the figure, $f_t = \dfrac{P}{\tan(\beta + \alpha_t)}$ and $F = \dfrac{P}{\tan\beta}$, from which the efficiency is:

$$E_{pt} = \frac{f_t}{F} = \frac{\tan\beta}{\tan(\beta + \alpha_t)} \qquad (6)$$

From general trigonometric formulas:

$$\text{Tan}\,(\beta + \alpha_t) = \frac{\tan\beta + \tan\alpha_t}{1 - \tan\beta\tan\alpha_t}$$

Also, from Formula (4), $\tan\alpha_t = C_t$. Substituting in Formula (6) gives:

$$E_{pt} = \frac{\tan\beta\,(1 - C_t\tan\beta)}{\tan\beta + C_t} \qquad (7)$$

This formula is identical with the formula given by Prof. Barr; it includes the tooth friction only.[1] Taking into account the friction of the worm thrust bearing also, the tooth load is BD and its effective component is $BJ = f_{tr}$. As $BK = JD = f_{tr}\tan(\beta + \alpha_t)$, $KA = f_{tr}\tan\alpha_r$, $F = \dfrac{P}{\tan\beta}$, and $P = BK + KA$, $f_{tr} = \dfrac{P}{\tan(\beta + \alpha_t) + \tan\alpha_r}$. The efficiency is then:

$$E_{ptr} = \frac{f_{tr}}{F} = \frac{\tan\beta}{\tan(\beta + \alpha_t) + \tan\alpha_r} \qquad (8)$$

Substituting the value of $\tan(\beta + \alpha_t)$ previously given, together with $\tan\alpha_t = C_t$ and $\tan\alpha_r = C_r$, this reduces to:

$$E_{ptr} = \frac{\tan\beta\,(1 - C_t\tan\beta)}{\tan\beta + C_t + C_r - C_tC_r\tan\beta} \qquad (9)$$

If the friction on the thrust bearing is equal to the friction on the teeth, $C_r = C_t$; and if the term $C_tC_r\tan\beta$, which is small, is dropped, Formula (9) becomes:

$$E_{ptr} = \frac{\tan\beta\,(1 - C_t\tan\beta)}{\tan\beta + 2C_t} \qquad (10)$$

This formula agrees with that given by Prof. Barr for similar conditions. Taking into account the friction of the teeth, of the thrust bearing, and of the worm-wheel hub, the tooth load, as before, is represented by BD. The effective tangential component is now $BG = f_{trh}$. From the geometry of the construction, $JD = BK = f_{tr}\tan(\beta + \alpha_t)$ and $JG = JD\tan\alpha_h$. Substituting the value of JD, $JG = f_{tr}\tan(\beta + \alpha_t)\tan\alpha_h$. Then $f_{trh} = f_{tr} - JG = f_{tr}\,[1 - \tan(\beta + \alpha_t)\tan\alpha_h]$. Substituting the value of f_{tr} previously developed gives:

$$f_{trh} = \frac{P\,[1 - \tan(\beta + \alpha_t)\tan\alpha_h]}{\tan(\beta + \alpha_t) + \tan\alpha_r}$$

The value of F being as previously given, the efficiency is:

$$E_{ptrh} = \frac{f_{trh}}{F} = \frac{\tan\beta\,[1 - \tan(\beta + \alpha_t)\tan\alpha_h]}{\tan(\beta + \alpha_t) + \tan\alpha_r} \qquad (11)$$

If the trigonometric value of $\tan(\beta + \alpha_t)$ is substituted, together with the values $\tan\alpha_r = C_r$ and $\tan\alpha_h = C_h$, this becomes:

$$E_{ptrh} = \tan\beta\,\frac{1 - C_t\tan\beta - C_h\tan\beta - C_hC_t}{\tan\beta + C_t + C_r - C_rC_t\tan\beta} \qquad (12)$$

Worm and Wheel with Wheel the Driver

The foregoing is for the usual condition; that is, when the worm is the driver. When the worm-wheel is the driver, friction is opposing action in the other direction, the forces being as indicated in Fig. 3. For the theoretical, frictionless drive, $F(=IB)$ is the rotative force acting at the pitch diameter of the worm-wheel, that is, the driving force; $H(=IC)$ is the component of F that acts on the worm-wheel hub; $T(=CB)$ is the component of F that acts normal to the worm teeth; $R(=CA)$ is the component of T that acts against the worm thrust washers; $P(=AB)$ is the component of T that acts as the tangential effort on the worm.

Taking into account the friction: $h(=ID)$ is the force on the worm-wheel hub; $t(=DB)$, the tooth load; $r(=DG)$, the force on the worm thrust washers; $p(=GB)$, the effective tangential force at the pitch diameter of the worm.

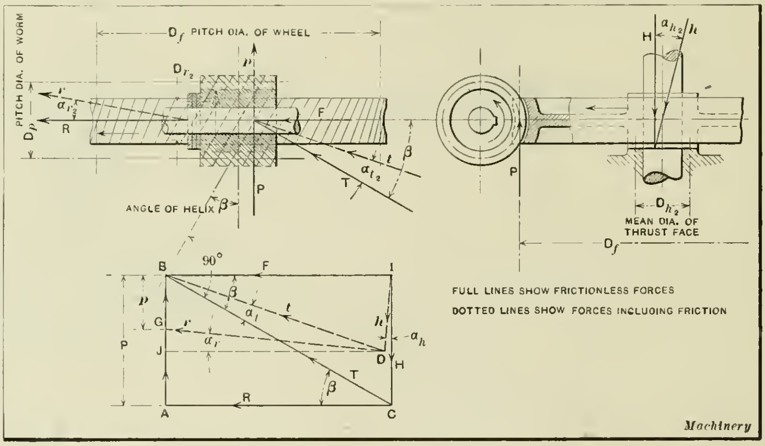


Fig. 3. Forces acting on Worm and Worm-wheel when Wheel is Driver

The efficiency E_f, when the worm-wheel is the driver, is:

$$E_f = \frac{p}{P} \qquad (13)$$

Limiting Conditions

As angle β approaches a right angle, the theoretical force P increases much more rapidly than the effective force p, and hence the efficiency falls, becoming zero when $\beta = 90$ degrees. For small values of angle β, the effective force p decreases rapidly, becoming zero when angle JDG = angle JDB. From Fig. 3 it can be seen that $JDG = \alpha_r$ and $JDB = DBI = \beta - \alpha_t$. Then $p = 0$ when $\alpha_r = \beta - \alpha_t$; or the worm cannot be driven through the worm-wheel if β is equal to or less than:

$$\beta_{min} = \alpha_r + \alpha_t \qquad (14)$$

In hoisting work or similar service, when the worm is the driver and it is desired that the load will not overhaul, that is, that it cannot drive the worm through the worm-wheel, the lowest possible values of α_r and α_t are used in Formula (14) to determine the maximum safe value of β for a non-overhauling drive.

Formulas for Efficiency with Worm-wheel the Driver

Formulas for the efficiency may now be developed to express the results of the foregoing graphic method. Referring to Fig. 4, $IB = F$ is the driving force applied tangentially at the worm-wheel teeth.

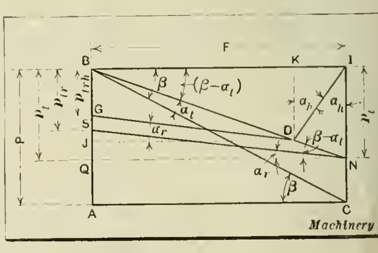


Fig. 4. Diagram used in developing Formulas for Efficiency when Wheel is Driver

[1] For simplicity's sake, the fact that the teeth may be of the 15- or 20-degree involute form is in all cases neglected; the treatment is as though the faces of the worm teeth were radial. The error involved is small as far as efficiency is concerned.

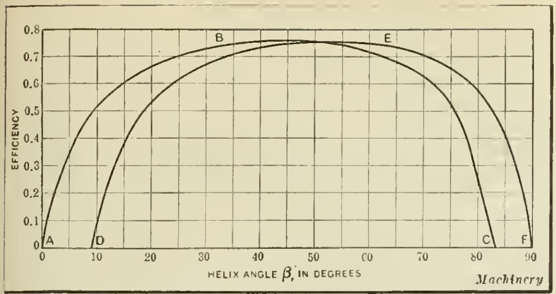


Fig. 5. Efficiency of Worm-gearing for Various Helix Angles

Neglecting friction, CB is the normal tooth load and $AB = P$ is its component acting tangentially to the pitch diameter of the worm. Considering the friction on the teeth only, NB is the tooth load and $QB = p_t$ is the effective tangential component.

Then $P = F \tan \beta$, $p_t = F \tan (\beta - a_t)$, and the efficiency is:

$$E_{ft} = \frac{p_t}{P} = \frac{\tan (\beta - a_t)}{\tan \beta} \qquad (15)$$

From trigonometric formulas, $\tan (\beta - a_t) = \dfrac{\tan \beta - \tan a_t}{1 + \tan \beta \tan a_t}$, also $\tan a_t = C_t$; hence Formula (15) may be expressed thus:

$$E_{ft} = \frac{\tan \beta - C_t}{\tan \beta\,(1 + C_t \tan \beta)} \qquad (16)$$

Considering now the friction of the worm thrust bearing as well as the tooth friction, in Fig. 4, NB is the tooth load and $SB = p_{tr}$ is the effective tangential force developed at the worm. $QS = F \tan a_r$, $p_{tr} = p_t - QS$. Substituting values of p_t and QS, $p_{tr} = F \tan (\beta - a_t) - F \tan a_r = F\,[\tan (\beta - a_t) - \tan a_r]$, and the efficiency is:

$$E_{ftr} = \frac{p_{tr}}{P} = \frac{\tan (\beta - a_t) - C_r}{\tan \beta} \qquad (17)$$

Substituting in this the trigonometric value of $\tan (\beta - a_t)$ previously given, together with $\tan a_t = C_t$, Formula (17) becomes:

$$E_{ftr} = \frac{\tan \beta - C_t - C_r - C_t C_r \tan \beta}{\tan \beta\,(1 + C_t \tan \beta)} \qquad (18)$$

If the term $C_t C_r \tan \beta$, which is small, is dropped and C_r is taken to equal C_t, as an approximate formula:

$$E_{ftr} = \frac{\tan \beta - 2C_t}{\tan \beta\,(1 + C_t \tan \beta)} \qquad (19)$$

If the friction on the face of the worm-wheel hub is now taken into account, as well as the tooth and thrust bearing friction, in Fig. 4, the line DB represents the tooth load and $GB = p_{trh}$ is the effective tangential force at the pitch diameter of the worm. Then $JD = BK = \dfrac{DK}{\tan (\beta - a_t)}$, $KI = DK \tan a_h$, and $F = BK + KI$, from which $DK = \dfrac{F \tan (\beta - a_t)}{1 + \tan (\beta - a_t) \tan a_h}$. Substituting this in the formula for JD gives:

$$JD = \frac{F}{1 + \tan (\beta - a_t) \tan a_h}$$

Now $JG = JD \tan a_r = \dfrac{F \tan a_r}{1 + \tan (\beta - a_t) \tan a_h}$. But $p_{trh} = GB = JB - JG = DK - JG$. Substituting the values of DK and JG, this becomes:

$$p_{trh} = \frac{F\,[\tan (\beta - a_t) - \tan a_r]}{1 + \tan (\beta - a_t) \tan a_h}$$

If frictionless, the tangential force at the worm is $P = F \tan \beta$; the efficiency is then $E_{ftrh} = \dfrac{p_{trh}}{P}$. Substituting in this the values of p_{trh} and of P, together with the relations $\tan a_h = C_h$ and $\tan a_r = C_r$, gives:

$$E_{ftrh} = \frac{\tan (\beta - a_t) - C_r}{\tan \beta\,[1 + C_h \tan (\beta - a_t)]} \qquad (20)$$

Expanding this formula by substituting for $\tan (\beta - a_t)$ its trigonometric value $\dfrac{\tan \beta - \tan a_t}{1 + \tan \beta \tan a_t}$, it becomes:

$$E_{ftrh} = \frac{\tan \beta - C_t - C_r - C_r C_t \tan \beta}{\tan \beta\,(1 + C_t \tan \beta + C_h \tan \beta - C_h C_t)} \qquad (21)$$

For the usual proportions, the terms $C_r C_t \tan \beta$ and $C_h C_t$ will be small. Dropping these, the formula becomes:

$$E_{ftrh} = \frac{\tan \beta - C_t - C_r}{\tan \beta\,(1 + C_t \tan \beta + C_h \tan \beta)} \qquad (22)$$

Worm-gear Efficiency Curves

In order to represent more clearly the relation between the helix angle and the efficiency, for both forward and reverse drives, a series of diagrams like Figs. 1 and 3 may be laid out for various values of β and the results plotted as a curve. If in Fig. 1 we choose some convenient scale and make $F = 1$, then f = efficiency. Similarly in Fig. 3, if $P = 1$, then p = efficiency. A number of such diagrams were laid out, with a coefficient of friction $C_{t_2} = C_{r_2} = C_{h_2} = 0.1$, for heavy, slow-speed work, assuming ratios $D_{r_2}/D_{p_2} = 0.6$ and $D_{h_2}/D_{t_2} = 0.2$. The plotted results are shown in Fig. 5, where curve ABC shows the efficiency when the worm is the driver, while curve DEF shows the efficiency when the worm-wheel is the driver. These curves are intended more to illustrate the general law of variation than the actual efficiency for any specific case, the latter being readily determined for the actual quantities involved by the methods previously given.

It will be noted that both curves are comparatively flat for a considerable distance on each side of the point of maximum efficiency. Owing to this peculiarity, there is little choice in efficiency for angles between 30 and 58 degrees when the worm is the driver, or between 40 and 66 degrees when the wheel is the driver. The limiting conditions are brought out clearly. The forward drive point A on the curve represents the helix angle $\beta = 0$; and since there is then no motion transmitted, there is no useful work done; hence the efficiency $E_p = 0$. At point C, the angle is so steep that the worm locks and cannot drive the wheel; hence the efficiency is zero.

For the reverse drive, that is, the wheel driving the worm, at point F the helix angle is 90 degrees, the worm-wheel teeth are at right angles to its axis, the worm has become a spur gear and no motion is transmitted; hence no useful work is done and the efficiency becomes zero. At point D the helix angle is so flat that the wheel cannot drive the worm, and the efficiency is therefore zero. This is the case of a non-overhauling worm drive. It will be noticed that for the angle β corresponding to this point D, the efficiency of the forward drive, as given by curve AB, is approximately 50 per cent. This is, then, the maximum efficiency for a non-overhauling worm of the particular proportions and friction coefficients for which the curves are drawn. In practice, designers make the angle somewhat less than this to provide some margin of safety against overhauling; hence the efficiency is further reduced.

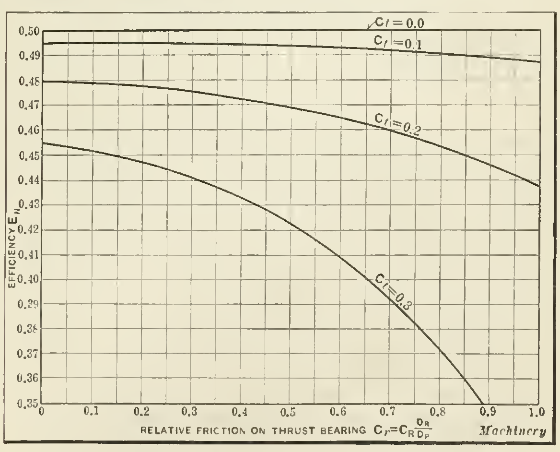


Fig. 6. Maximum Efficiency of Non-overhauling Worm-gears

Efficiency of Non-overhauling Worms

In the foregoing the efficiency of a non-overhauling worm of specific proportions and friction coefficients was shown to be approximately 50 per cent. It will be of interest to deduce a general formula that will give this maximum efficiency directly from the various values involved. The friction on the worm-wheel hub is small when angles β are sufficiently flat to be non-overhauling and may be neglected. The maximum value of the helix angle β for non-overhauling is given by Formula (14) as $\beta = \alpha_r + \alpha_t$, and since the efficiency increases with an increase in the angle on this part of the curve, the efficiency for this condition will be a maximum when this maximum value of the angle is used. Substituting this value of β in Formula (8) gives for the maximum efficiency of a forward drive that is non-overhauling the expression:

$$E_n = \frac{\tan(\alpha_r + \alpha_t)}{\tan(\alpha_r + 2\alpha_t) + C_r} \qquad (23)$$

From Formulas (2) and (4), $\tan \alpha_r = C_r$ and $\tan \alpha_t = C_t$.

Then from trigonometric formulas: $\tan(\alpha_r + \alpha_t) = \dfrac{C_r + C_t}{1 - C_rC_t}$

and $\tan(\alpha_r + 2\alpha_t) = \dfrac{C_r + \tan 2\alpha_t}{1 - C_r \tan 2\alpha_t} = \dfrac{C_r - C_rC_t^2 + 2C_t}{1 - C_t^2 - 2C_rC_t}$.

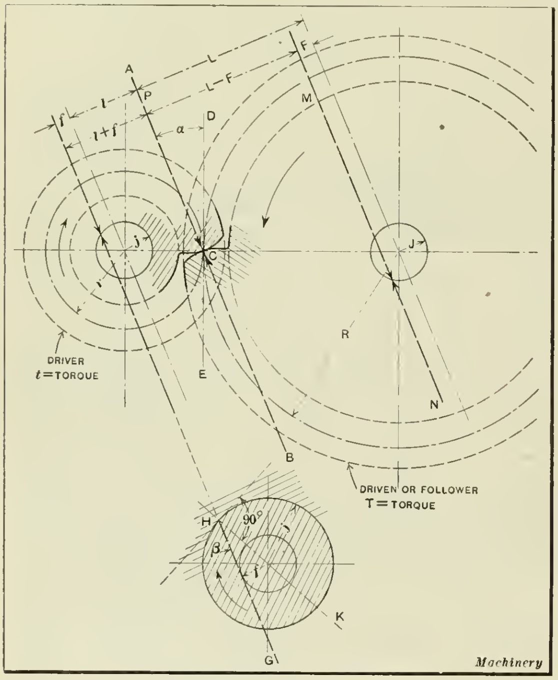


Fig. 7. Forces acting on Spur Gear

Substituting these values in Formula (23) and reducing gives the expression:

$$E_n = \frac{C_r + C_t - 3C_rC_t^2 - 2C_r^2C_t - C_t^3}{2C_r + 2C_t - 4C_rC_t^2 - 4C_r^2C_t + 2C_r^2C_t^3 + 2C_r^3C_t^2} \qquad (24)$$

When the tooth friction is small, as in well cut worm-gears with an oil bath, the friction of the thrust bearing becomes an important item in preventing the drive from overhauling. If the friction of this bearing is increased, for instance, by increasing its mean diameter, the helix angle β may be increased, causing a decrease in tooth friction that will nearly compensate for the increase in bearing friction. This is advisable, since it decreases the wear on the teeth, the extra wear occurring on the bearing, which is cheaper to replace. This peculiarity is clearly shown in Fig. 6, which shows four curves plotted from values calculated by Formula (24). The upper line for the tooth friction $C_t = 0$ shows the efficiency to have a constant value of 50 per cent, irrespective of the amount of friction on the thrust bearing. With this value of C_t, the helix angle is $\beta = \alpha_r$ or $\tan \beta = C_r$. For $C_t = 0.1$ the curve is also very flat, there being but a slight decrease in efficiency when the thrust bearing friction C_r is as great as ten times the tooth friction C_t. Even for the comparatively high coefficient of tooth friction $C_t = 0.2$, the curve is quite flat.

It thus appears that it is poor economy to use roller or ball bearings on worms that are required to be non-overhauling, since their use would increase the efficiency but little and compel the use of a flat helix angle, which means low efficiency of tooth action and, hence, rapid wear, unless the gears are quite large for the power transmitted. The most striking feature about a non-overhauling drive of this nature is, however, its low efficiency, which cannot be over 50 per cent and may be considerably less if the helix angle is made much flatter than its maximum value. By arranging a simple automatic brake to make the device non-overhauling and using a quick-pitch worm, an efficiency of 75 per cent may readily be obtained and the drive will have a longer life.

Spur Gear Efficiency, Pinion versus Gear as Driver

As a sequel to the foregoing the spur gear problem is treated in a somewhat similar manner. It is quite generally believed that, with a set of spur gears, if the smaller gear of the pair is the driver, the efficiency is higher than when the larger gear is the driver; that is, that the efficiency for a velocity reduction is higher than for a velocity increase. Stated another way, "gearing down" is more efficient than "gearing up." Just why this should be so is perhaps not so generally understood. It is not the object here to discuss the amount of sliding that takes place between the gear teeth, the probable amount by which the friction on the arc of approach exceeds that on the arc of recess, or the many other factors entering into the problem of tooth friction which are fraught with considerable uncertainty; but to consider the journal friction only, with especial reference to the contrast between the efficiencies for forward or reverse drives.

Referring to Fig. 7:

r = pitch radius of driver;
R = pitch radius of follower;
j = journal radius for driver;
J = journal radius for follower.

Consider AB as the line of action, passing through the point of tooth contact C and making an angle α (known as the angle of obliquity) with the tangent line DE. If the teeth were frictionless, a line representing the forces acting upon the teeth would coincide with this line of action. However, in addition to the rolling of the teeth upon each other, more or less sliding takes place, and in order to make line AB represent approximately the correct direction of the forces acting on the bearings, angle α must be taken greater than the angle of obliquity. If K is the coefficient of tooth friction, α is the angle of tooth obliquity plus an angle having K as its tangent.

The tooth load P, acting along line AB, has its equal and opposite reactions at the bearings. In order for sliding to occur, these reactions do not pass through the center of the journals, but, as indicated by GH, make an angle β with the normal line HK such that tangent β = coefficient of journal friction. In the figure, f and F represent the amount the forces pass to one side of the journal center and may be termed the frictional lever arms of the journals. If C = coefficient of journal friction, $\tan \beta = C$, $f = j \sin \beta$, and $F = J \sin \beta$. But for small angles the sine and tangent are about equal, hence:

$$f = jC \qquad (25) \qquad\qquad F = JC \qquad (26)$$

The lever arm of the driver, including friction, is then:

$$l + f = r \cos \alpha + jC \qquad (27)$$

The similar lever arm of the follower is:

$$L - F = R \cos \alpha - JC \qquad (28)$$

Let t be the torque expended at driver and T the torque developed at follower; then:

$$T = t\,\frac{L - F}{l + f} = t\,\frac{R \cos \alpha - JC}{r \cos \alpha + jC} \qquad (29)$$

If the drive were frictionless, the torque developed would be:

$$T_{theo} = t\,\frac{R}{r} \qquad (30)$$

The efficiency, being the actual torque divided by the theoretical torque, is then:

$$E = \frac{T}{T_{\text{theo}}} = \frac{R\cos\alpha - JC}{r\cos\alpha + jC} \times \frac{r}{R} = \frac{\dfrac{\cos\alpha}{C} - \dfrac{J}{R}}{\dfrac{\cos\alpha}{C} + \dfrac{j}{r}} \qquad (31)$$

For a given angle of obliquity and coefficient of friction, $\dfrac{\cos\alpha}{C}$ = constant. If the diameter of the journals were proportional to the diameter of the gears, that is, if $\dfrac{J}{R}$ = constant and $\dfrac{j}{r}$ = constant, according to Formula (31), the efficiency would be constant irrespective of the relative sizes of the driver and follower, that is, irrespective of the gear ratio and of whether it was a velocity increase or a velocity decrease. But the diameter of the journals cannot be said to bear any such constant ratio to the diameter of the gears; and while no specific rule can be established, each peculiar case being a law unto itself in this respect, we can generalize to a certain extent.

Any general analysis intended to illustrate how the efficiency varies for various gear ratios, when driving forward or backward, must be based upon some assumed proportions and constants, or else be exceedingly complex. It is here assumed that the two sets of journals are of equal size and that the gear centers are constant, which makes the size of both gears vary for a varying gear ratio; also a high coefficient of friction suitable for slow-speed, heavy-duty work is chosen.

Assuming the gear centers to be 24 inches, that is, $R + r = 24$; the journals to be 3 inches in diameter, $j = J = 1.5$; taking angle $\alpha = 14.5 + 5.5 = 20$ degrees; and the coefficient of friction $C = 0.1$, by substitution in Formula (31):

$$E = \frac{\dfrac{\cos 20}{0.1} - \dfrac{1.5}{R}}{\dfrac{\cos 20}{0.1} + \dfrac{1.5}{r}} = \frac{9.4 - \dfrac{1.5}{R}}{9.4 + \dfrac{1.5}{r}} \qquad (32)$$

This is an empirical formula for the journal efficiency corresponding to the specific assumed conditions. Values of R and r for various gear ratios were inserted in Formula (32) and the efficiencies calculated. The results for ratios from 1 to 20 are plotted in Fig. 8. The upper curve gives the efficiencies when the smaller gear of the pair is the driver, the velocity ratios for this curve being velocity reductions. The lower curve is for the efficiency when the larger gear of the pair is the driver, that is, for a velocity increase. This lower curve thus represents the reverse drive if the upper curve is considered the forward drive.

Limiting Conditions

It is not practicable to secure excessive velocity reductions with one pair of spur gears, as the pinion becomes too small for strength or the gear too large for convenience. With a given journal diameter and center distance, the smaller the pinion the less is the efficiency. The theoretical limit is reached when the radius r of the driver is zero. The velocity reduction is then infinite, there is consequently no motion transmitted, no useful work is done, and the efficiency becomes zero. The practical limit of velocity reduction depends entirely on specific conditions, but is seldom more than 10 to 1.

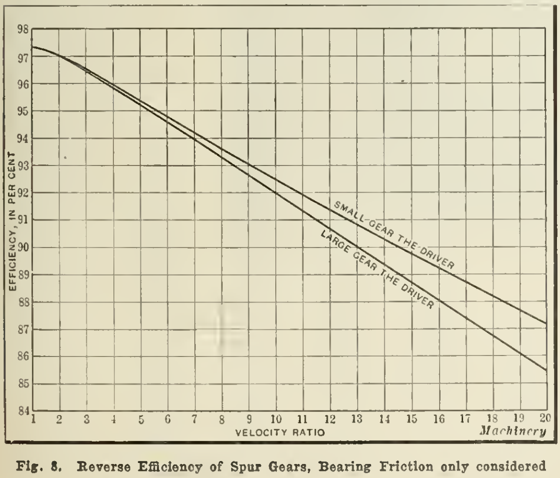


Fig. 8. Reverse Efficiency of Spur Gears, Bearing Friction only considered

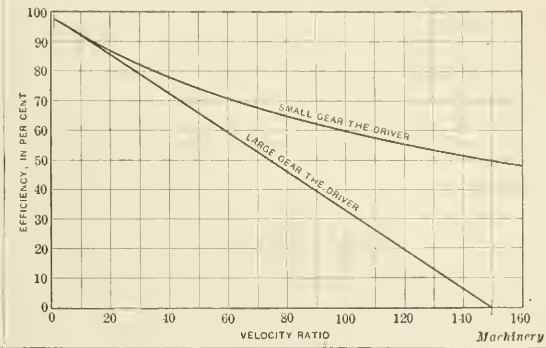


Fig. 9. Reverse Efficiency of Spur Gears Same as Fig. 8 but with Curves extended

For a velocity increase, the theoretical limit is reached when the lever arm of the driven gear has been reduced until it is equal to the journal frictional lever arm, that is, when $L = F$. This would be when AB, Fig. 7, coincides with MN. The gears would lock because the tooth load would be sustained by the journal without developing any torque, since the applied force would have no effective lever arm. This would be a case of a non-overhauling drive. Expressed as a formula, the minimum radius of the driven gear is:

$$R_{\min} = \frac{JC}{\cos\alpha} \qquad (33)$$

In Fig. 9 curves for the specific proportions represented by Formula (32) have been carried out to show this theoretical limiting condition, which is indicated by the lower curve cutting the zero line at a velocity ratio of about 149.4 to 1. It will be noted that for the same ratio of velocity decrease the upper curve shows an efficiency of approximately 50 per cent.

In the case of worm-gears, it was shown that the maximum efficiency of a non-overhauling drive was 50 per cent. In fact, it is a rule applicable to a large class of mechanism that when the efficiency of a device is 50 per cent or less its reverse efficiency is zero, and it is therefore non-overhauling. The most notable exceptions to this rule are those devices in which the friction is an exponential function of the driving force, a familiar example of which is an automatic brake.

Effect of Lubrication on Friction

The foregoing is all predicated upon a constant coefficient of friction for a specific case, so that friction varies directly as the load applied to the rubbing surfaces. In older textbooks on machine design this is recognized as one of the laws of friction. It is now known that this is only true for greasy or poorly lubricated surfaces.

Surfaces that are chemically clean adhere to one another and present a variety of phenomena, depending on the nature of the materials and the smoothness of the surfaces. Surfaces which are slightly unctuous, that is, not absolutely clean, approach the condition of friction being proportional to pressure. When perfect lubrication exists, there is no actual contact of the rubbing surfaces, for the surfaces are separated by a film of lubricant; in this case the resistance to motion depends on the nature of the lubricant. This film of lubricant interposed between the moving surfaces is virtually at rest in relation to the surface where it is in immediate contact with that surface, and the sliding motion occurs between successive layers of the lubricant itself. It is thus "being sheared," and its shearing strength, which is another way of viewing viscosity, is the real measure of friction. This shearing resistance does not increase directly as the load, as does the friction of slightly

greasy surfaces. In fact, it may decrease slightly with an increase of load, so that for perfect lubrication the friction is nearly independent of the load and depends on the velocity and the viscosity of the lubricant.

Where there is imperfect lubrication the surfaces are partly separated by a stable oil film, and at spots the film is ruptured or broken down and contact occurs. The contact is, however, not between chemically clean surfaces, so that adhesion does not take place, although some abrasion may occur. This case is then somewhere between the laws governing perfect lubrication and those usually applied (as in the preceding discussion) to low-speed, heavy-service bearings.

For high-speed perfect lubrication the term coefficient of friction is a misnomer. The real resistance to motion is in the viscosity or shearing strength of the film of lubricant separating the surfaces.

Summary

The graphic methods of Figs. 1 and 3 offer a ready solution of worm-gear efficiency problems. Their principal advantage over formulas is that the individual influence of the various quantities involved is more apparent. The contrast between the efficiency for a forward or reverse drive is clearly indicated by the curves of Fig. 5. Somewhat similar curves for forward drives have been published, but, so far as known, this contrast has not been clearly pointed out.

Formulas for efficiency are given for those who prefer them to the graphic method. For a forward drive, that is, when the worm is the driver, Formula (6) or (7) may be used, each including tooth friction only; Formulas (8), (9) and (10), though, include tooth and thrust bearing friction; and Formulas (11) and (12) include tooth, thrust bearing, and worm-wheel hub friction. For a reverse drive, that is, where the worm-wheel is the driver, Formulas (15) and (16) may be used, each of which includes tooth friction only; Formulas (17), (18) and (19), though, include tooth and thrust bearing friction; and Formulas (20), (21) and (22) include tooth, thrust bearing and worm-wheel hub friction. Formulas (10), (19) and (22) are approximations only, and Formulas (6), (8), (11), (15), (17) and (20) have the simplest forms; the others given for worm-gear efficiencies are expanded to take the same form as those usually quoted.

For non-overhauling worms, the maximum efficiency is given by Formulas (23) and (24) and by the curves of Fig. 6. For this condition, the efficiency cannot exceed 50 per cent, and roller or ball bearings are not generally desirable, since the helix angle must be reduced to secure non-overhauling.

* * *

TRAINING CRIPPLED SOLDIERS

Every industrial country has an army of cripples who suffered their injuries in the pursuit of various trades and activities incident to trade or manufacture. The war will make many more cripples and it will bring before us acutely the necessity of training these men to earn their living at useful labor. A government bureau to promote the training of industrial and war cripples may result, which will direct the teaching of teachers for this work. At present there is little being done systematically in this country to teach cripples to do work that is useful. The blind have been given some training, but the work should be extended to include cripples of all kinds. In this connection it is of interest to consider what is being done for the blind soldiers in France. Besides learning Braille in all branches, they are taught typewriting, stenography, commercial courses, music, handicrafts, modeling, sports, games, etc. In fact, they are instructed in any branch that will enable their training to be of the greatest service to themselves and to the community.

The training of cripples should be conducted with reference to their previous training and aptitude, so that they can continue to carry on work for which they are best adapted. They should be so taught that their efficiency will be as high or nearly as high as that of normal persons. Let us have organized industrial training for cripples started immediately in order that when the acute need for teachers is felt they will be available.

* * *

WEIGHT OF IRON BOLTS AND NUTS

BY GEORGE W. CHILDS[1]

By means of the accompanying table, the weights of United States standard bolts and nuts can be readily found. For example, the weight of a 1⅝-inch bolt 6 inches long, with a square head and nut, is found to be 8.055 pounds. This result is obtained by multiplying by 6 the weight per inch of a 1⅝-inch bolt, or 0.588 pound, and adding to this the weight of the head, 2.356, and the weight of the nut, 2.171; thus $6 \times 0.588 + 2.356 + 2.171 = 8.055$ pounds. In the same way, the weight of a 5½-inch bolt 12 inches long, with a hexagonal head and nut, is found to be $6.732 \times 12 + 71.22 + 60.413 = 212.417$ pounds.

* * *

Researches by the United States Coast and Geodetic Survey prove conclusively that the mountains (at least in the United States) are not held up above the surface of the sea by the rigidity or strength of the earth's materials, but by the fact that underneath them the materials (in the outer portion of the earth) are lighter than normal. The higher the mountain or plateau, the lighter is the material underneath it, which extends down to a depth of about 60 miles. On the other hand, the bottom of the ocean is depressed because the material underneath it, to a depth of about 60 miles below sea level, is heavier than normal. The normal condition may be considered that which obtains in the large river valleys and under the coastal plains.

[1]Address: American Steel Foundries, Chester, Pa.

WEIGHT OF IRON BOLTS AND NUTS

Diameter of Bolt, Inch	Weight, Pounds					Diameter of Bolt, Inches	Weight, Pounds				
	Bolt per Inch	Square Head	Square Nut	Hexagonal Head	Hexagonal Nut		Bolt per Inch	Square Head	Square Nut	Hexagonal Head	Hexagonal Nut
¼	0.014	0.018	0.015	0.015	0.012	2	0.890	4.272	3.945	3.700	3.312
5/16	0.022	0.029	0.025	0.025	0.021	2¼	1.127	6.003	5.513	5.198	4.481
⅜	0.031	0.045	0.040	0.039	0.034	2½	1.391	8.146	7.492	7.054	6.084
7/16	0.043	0.058	0.053	0.058	0.050	2¾	1.683	11.817	9.843	9.307	7.979
½	0.056	0.094	0.085	0.081	0.071	3	2.003	13.851	12.237	11.994	9.894
9/16	0.070	0.127	0.099	0.110	0.096	3¼	2.351	17.500	16.014	15.155	12.965
⅝	0.087	0.168	0.153	0.145	0.127	3½	2.726	21.740	19.900	18.827	16.106
¾	0.125	0.273	0.250	0.238	0.206	3¾	3.129	26.615	24.381	23.047	19.729
⅞	0.170	0.416	0.381	0.360	0.313	4	3.561	32.170	29.385	27.862	23.754
1	0.223	0.598	0.552	0.520	0.453	4¼	4.020	38.448	35.095	33.296	28.358
1⅛	0.282	0.834	0.769	0.797	0.630	4½	4.506	45.493	41.509	39.400	33.488
1¼	0.348	1.120	1.030	0.970	0.842	4¾	5.021	53.351	48.668	46.200	39.300
1⅜	0.421	1.465	1.353	1.269	1.127	5	5.563	62.065	56.547	53.775	45.640
1½	0.501	1.875	1.725	1.624	1.409	5¼	6.133	71.680	65.252	62.075	52.645
1⅝	0.588	2.356	2.171	2.040	1.771	5½	6.732	82.240	74.887	71.220	60.413
1¾	0.682	2.912	2.690	2.521	2.217	5¾	7.358	93.789	85.247	81.219	68.729
1⅞	0.782	3.549	3.267	3.069	2.660	6	8.011	106.372	96.737	92.118	77.792

Machinery

MULTI-MACHINING IN PRODUCTION QUANTITIES

JIGGING THE WORK ON MULTIPLE-SPINDLE DRILLING MACHINES

BY A. E. CARLE [1]

IN multiple drilling, reaming, countersinking, counterboring, or end-milling pieces in production quantities, using standard multiple-spindle drilling machines, the method of jigging the piece is of considerable importance. Consider setting up for the drilling and reaming of six 5/8-inch holes in the flange of the inner hub of a wire wheel for an automobile. The holes are drilled and reamed, with a 0.003-inch tolerance, on a bolt circle of approximately six inches.

The first and most simple method is to place the piece in a suitable jig and use individual slip bushings so that after the holes are drilled, the bushings can be replaced with reamer-size bushings, the jig moved under the reamers, and the holes machined. The loss of time in handling these slip bushings is so great that the production costs increase very rapidly, especially when the operator has to stop to pry up bushings with a screwdriver or some other tool, as is often the case. This style of bushing will frequently catch the drilling or reaming tool and turn with it, thus wearing the bushing plate. To prevent its turning, a number of engineers use the groove-cut bushing, with which most shop men are familiar. This consists of an ordinary slip bushing in which a slot is cut spirally around one-quarter of the outer periphery. This slot accommodates a pin in the bushing plate, so that when the bushing starts to slip, the pin prevents its making a full turn. One source of trouble from individual slip bushings is the accumulation of chips, which must be carefully removed before the bushings are changed; another is the possibility of interchanging the drilling and the reaming bushings (even though they are carefully marked) and thus spoiling the tools or the work.

[1] Address: Baush Machine Tool Co., Springfield, Mass.

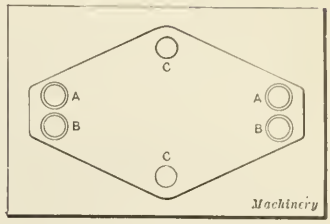


Fig. 3. Small Piece machined by Use of Indexing Jig shown in Fig. 4

An improvement over the individual slip bushings is the plate bushing holder, which is especially useful on such work as crank-cases, cylinders, and in practically all work where six or more holes are to be machined. The work is placed in a box jig or frame in which there are either two dowel-pins or two slots. The removable bushing plates used with this frame have holes or hinged binders to correspond with these pins or slots and so are correctly located. Large pieces may be handled in a similar way to that used in machining the crank-cases shown in Fig. 1. Here the case is mounted on a slide, shoved into the frame, and there securely clamped. Attention is called especially to the hand-wheel for clamping the slide and the simple construction of the frame. After the holes are drilled, the piece is removed and taken to a machine similarly arranged where the reaming and the counterboring are done. This method necessitates two handlings but is, nevertheless, economical.

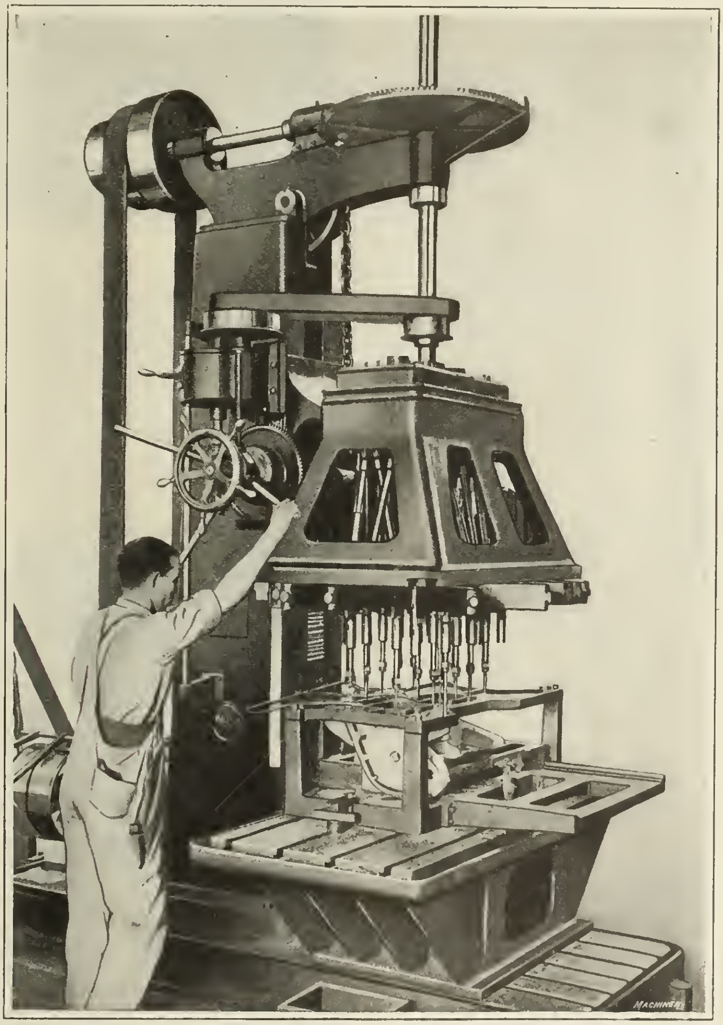


Fig. 1. Plate Bushing Holders used in machining Crank-cases on Multiple-spindle Drilling Machine

A combination roughing drill and finishing reamer, shown in Fig. 2, is used in a number of the automobile factories for drilling and reaming holes in one operation. The lower part is a three-lip drill and the upper, a rose reamer. This tool is guided in the bushing by the reamer flutes. Although this combination tool practically halves the production time, its use is not always economical because of the cost of special construction.

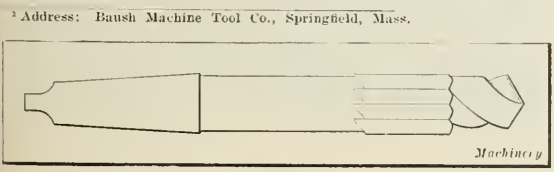


Fig. 2. Combination Drill and Reamer

In a large plant in Springfield, Mass., the drilling and reaming are done with multiple-spindle drills without the use of separate bushings for the drills. The material is malleable iron and the piece is placed in a box jig provided with reamer-size bushings only. On the multiple-drill table, there is a V-

block in which the jig is placed for the drilling operation. The drilling is against a finished surface, and great care is taken to have the spindles of the machine lined up accurately and the drills carefully ground. These points insure, for the most part, the correct location of the holes and prevent any side running of the reaming tools, which remove only 1/64 inch. The reamed holes must be within limits of ± 0.003 inch, so this method is sufficiently reliable.

The production of multi-machined parts is increased greatly when an indexing table having two or more stations is utilized. As in this case an accurate indexing method must be used, the indexing table is frequently quite costly to make. The practice is to carry a bushing plate or fixed center head on the post

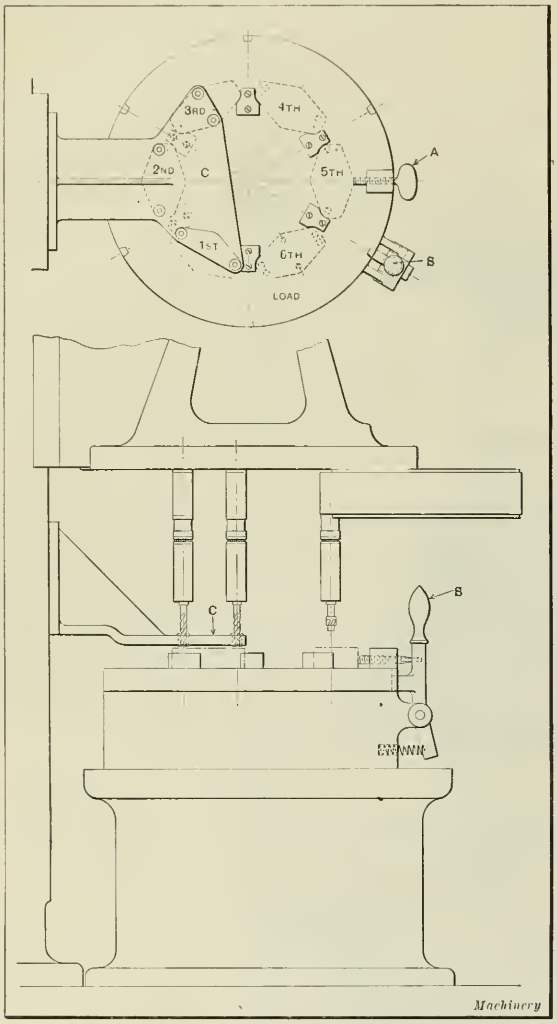


Fig. 4. Indexing Table with Six Stations in Use on Multiple-spindle Drilling Machine

of the drilling machine. In drilling six holes at close center distances and counterboring four holes in the piece shown in Fig. 3, the six-station revolving table illustrated in Fig. 4 is used. Although the table is shown without projecting handles, they are generally furnished for the convenience of the operator. Thumb-screw A holds the pieces in place and a handle B is provided for locking and releasing the table before and after indexing. Ten spindles are used. The work at the six stations is as follows: First station, drilling holes A, Fig. 3; second station, drilling holes B; third station, drilling holes C; fourth station, counterboring holes B; fifth station, counterboring holes A; sixth station, loading and unloading. The jig plate C, Fig. 4, is fastened to the head of the post for guiding the drilling tools. The counterboring tools are piloted into the drilled holes; if the holes were to be reamed it would be necessary to extend the jig plate over the fourth and fifth stations.

Fig. 5. Machining Ford Flywheels on Multiple-spindle Drilling Machine

Another plan is to arrange the jig plate so that it will be carried integral with the head. This necessitates carrying a number of holding devices on the indexing table, and if extreme accuracy in machining the piece is required these individual holding devices must be arranged to float universally and be accurately centered under the head by a wedge-shaped

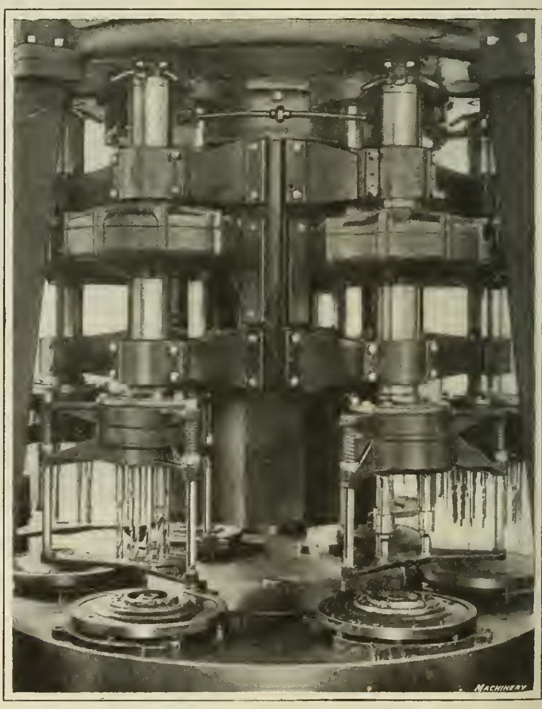


Fig. 6. Arrangement of Large Drills and End-mills for machining Flywheels

piece integral with the head locating in the vee on the holding device. This method produces work as nearly interchangeable as possible and is well illustrated in the Baush station machines for drilling, reaming, counterboring, countersinking, and end-milling the Ford flywheel at the rate of one flywheel every fifty-eight seconds with one operator. The larger number of the holes are held to limits of ± 0.001 inch, and three of the large holes must be as nearly dead right as mechanical means will permit. Fig. 5 shows the tongue *A* on the fixture holding the flywheel. The handle *B* is for clamping and loosening the wheel in the fixture. At the right is shown a reaming head and a jig plate. Fastened to the under part of the plate is a piece *C* grooved to receive the tongue of the holding device. Fig. 6 shows, at the left, a head holding large drills and, at the right, three end-milling tools in the head.

When several small holes necessitating two or more operations are to be machined, the following plan works well from a production standpoint. Pilots of a common diameter are fastened to the drills, reamers and other tools to locate them

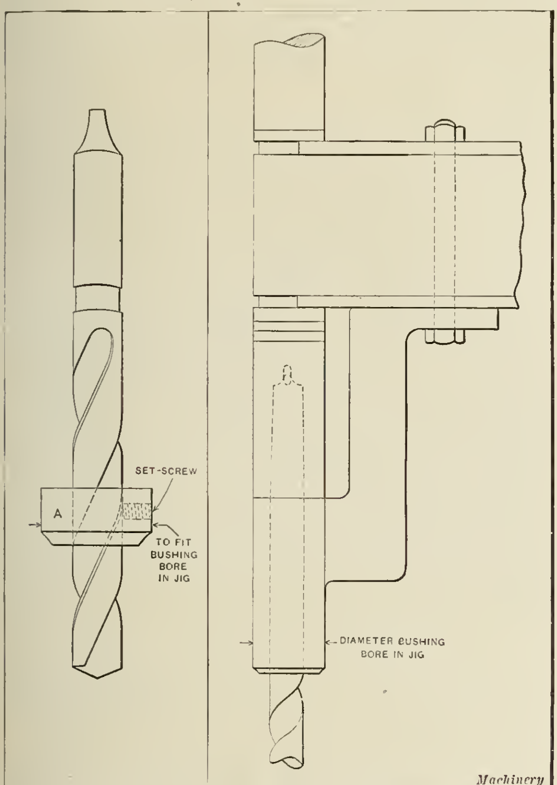


Fig. 7. Drill with Pilot attached **Fig. 8. Stationary Pilot for Multiple Drilling and Reaming Tools**

in the bushings in the plate, the bushings having a common bore. Thus, when drilling or reaming, the tools will be guided from the pilot *A*, Fig. 7. This method is not recommended for holes over one inch deep, as there is a tendency for the drills to spring out of alignment, especially if the drilling is done against a rough surface, since the end of the drilling tool will be some distance from the auxiliary pilot guiding it. This arrangement is effective for drilling steel, as the space between the jig plate and the work allows room for the curled chips. The diameter of the pilot, however, must be kept as small as possible, since this piece has a tendency to heat and stick owing to the peripheral speed. This sticking and the wear on the bushing plate may be avoided by using a stationary pilot similar to that shown in Fig. 8. A Z-shaped casting with a bore equal to the tool size and a nose equal to the jig bushing diameter, is secured to the arm of the multiple-spindle drilling machine by a bolt that extends through the slot in the arm, as shown in the illustration. This device is of recent origin and can be used to advantage for multi-machining in quantities.

PENETRATION OF HARDENING EFFECT IN CHROMIUM AND COPPER STEELS[1]

The minimum rate of cooling required to render the influence of quenching efficacious varies according to the quality of the steel. The rate of cooling is lower when hardening special steels than when hardening ordinary carbon steel, so that the penetrative influence of heat-treatment is more efficacious in the case of special steels than in that of carbon steels, and this, as is well known, constitutes one of the chief characteristics of the former.

Steels that contain less than 5 per cent nickel and over 4 per cent copper forge badly. But it has been observed that copper alone, while slightly increasing the depth of penetration of the hardening effect of forgeable steels, does not increase the penetration sufficiently to confer on the steels the property of air-tempering, even when such small parts as bars 10 millimeters square are concerned. In the presence of chromium, however, the copper increases the depth of penetration of the hardening effect.

The addition of nickel to steels containing chromium and copper increases the depth of the penetrative influence of quenching, but to the detriment of the property of softening by annealing. The simultaneous addition of copper, nickel and chromium, permits the easy preparation of steels that possess a tendency to deep penetration of the hardening effect sufficiently marked to render the air-hardening of large enough pieces (for example, gears) efficacious, without such steels losing the property of becoming softened by the annealing processes employed in the case of ordinary carbon steel. Both chromium-copper and chromium-nickel-copper steels possess, after hardening and tempering, practically the same mechanical properties (tensile and impact) as chromium-nickel steels having approximately the same percentage of carbon and the same penetrative capacity for hardening. However, the chromium-copper steels assume, on quenching at somewhat low temperatures, a rather coarser grain on fracture than that exhibited by nickel-chromium steels; there is, therefore, more danger of their becoming burnt. Apart from its influence on the depth of penetrative influence of quenching, the author has failed to detect any useful effect of copper on the properties of steel.

The most common special steels generally contain more nickel than chromium, because the somewhat violent action of chromium is likely to cause cracks while quenching. The rate of cooling required to produce hardening varies within wide limits. It is difficult to insure a uniform degree of hardening when metals requiring a rapid rate of cooling are treated; and, on the other hand, the hardening will be energetic and uniform, though the conditions of cooling vary, in the case of metals that undergo energetic hardening on air-cooling, when they are cooled in a liquid in which the cooling effect is more rapid.

Steels containing at least 1.4 per cent chromium and a little copper or nickel can be quenched in a liquid between the temperature of 120 and 350 degrees (real Colza oil does well) without the energy of the cooling varying much, and under these circumstances there is not much fear of cracks developing.

Generally speaking, pieces of medium thickness (30 millimeters or less), if made from air-hardening steels, soften in ordinary annealing, and after annealing, are easy to machine. Naturally, if it is desired that the hardening effect should penetrate to the core in very thick pieces, or if air-hardening is to be adopted, metals should be employed that have a greater susceptibility to the penetrative effect of hardening.

* * *

The Chicago, Milwaukee & St. Paul Railway is planning to extend the electrification of its road to the Pacific coast. The work is now completed for 416 miles in Montana, where it is estimated that four hours are saved by each train of sixty-two cars on each 100 miles. The electric engines haul heavy freight trains at fifteen miles an hour up grades on which three or four steam engines could pull small trains at only half this speed.

[1]Abstract of a paper by L. Grenet, read before the Iron and Steel Institute of Great Britain, May, 1917.

COMPOUND SUB-PRESS WATCH DIES[1]

MAKING MASTER AND WORKING PUNCHES AND DIES—EXAMPLES OF DIES FOR WATCH PARTS

BY W. H. DUNBRACK[2]

ALTHOUGH many watch parts are punched in drop- and double-action presses, sub-presses are used when very accurate work is required. These sub-presses are of the regular type, except that the bases are made longer than usual and need no clamps to hold them to the bolster of the punch press. A base and means of fastening it to the lathe are shown in Fig. 1. These sub-presses vary in size, by two centimeters per press, from a small open-front press with a plunger two centimeters in diameter, up to a press with a sixteen-centimeter plunger.

When starting to make a die, it is first necessary to see that the sub-press is in good condition. The presses are made by machinists and are "run in" by a machine built especially for that purpose. But this test is not considered good enough for fine watch work, so the plunger is taken out and the babbitt scraped and pressed in again until a good bearing is procured. Usually the babbitt is tightened until the plunger can be driven down by five or six blows of a lead hammer. The upper part of the press is then put on lathe centers, bored out, and faced true with the plunger; this must be done carefully, or there will be difficulty in aligning the punch and the die later on.

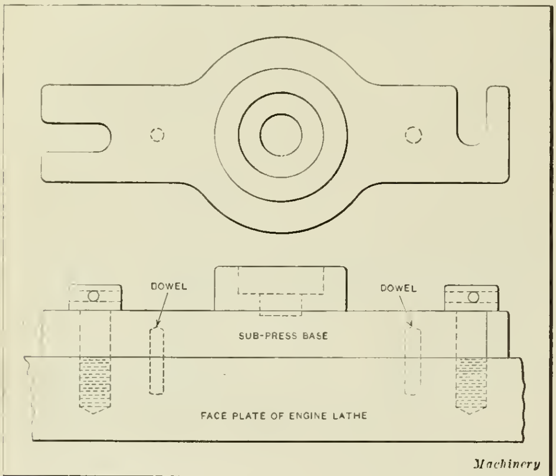


Fig. 1. Extra Long Sub-press Base

Making Master Punches and Plates

A model of the part to be punched is given to the workman, who makes a master punch to conform with it. The method is as follows: A center hole is drilled and reamed in the model, and when possible, two other holes are drilled and reamed for relocating. The model is then soldered to the master-punch blank, the center hole being located in the center of the blank punch, and then the locating holes of the model are transferred to the punch. This punch is milled almost to the model, about 0.002 inch being left for lapping; if there are square or odd-shaped corners, the punch must be milled until the model is touched by the milling cutter. The model is then removed and the punch is hardened and drawn to a light straw. Then the punch is aligned by lapping the bottom until the center hole runs true with the diameter of the base. After the model is relocated on it by means of pins or dowels, as shown in Fig. 2, the punch is lapped cylindrically by a diamond lap held in the bench lathe, as shown in Fig. 3. The punch is held against a drill pad, or flat center, in the tailstock of the lathe and the lap is revolved at the highest speed possible. The punch is then moved around the lap, using a light pressure, until the model is touched evenly. Master punches are usually made 6 or 7 millimeters long.

To make the lap, a piece of drill rod slightly smaller than the smallest curve of the punch is ground true and straight, for a distance of about ⅜ inch. The rod is ground instead of being turned, because diamond powder "charges in" better in a ground surface; grinding also makes a smoother cutting lap. Diamond powder is then rolled in.

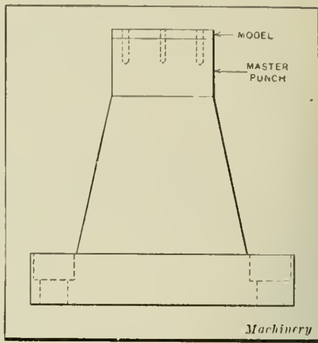


Fig. 2. Master Punch and Model

For constructing a compound die with piercing punches, a master plate, Fig. 4, is usually made, and this is kept for future reference. A blank plate is clamped to the faceplate of a lathe and a recess about one millimeter deep is turned to fit the base of the master punch; a center hole of some standard size is also bored through the plate, and this size must be maintained on all the holes in the plate. The master punch is then set in the recess, screws and dowels holding it in position, and the plate is moved on the faceplate until the holes in the model on the master punch run true. A very good indicator must be used, as this is one of the most important operations. When a hole is trued, the master punch is taken out and a hole is bored through the plate, corresponding to the hole in the model. When all the holes in the model have been transferred to the master plate, the plate is removed and located "on center" by a pin that fits the center hole of the plate. A larger recess is then turned for the die-holder. All punches and die-holders are standard sizes for a given size of press.

Making Die-holder and Die

The die-holder is left soft. After it is made to fit the recess in the master plate, all the holes in the master plate are transferred to it. Both straight and back taper holes are used, and both are backed up by a hardened plate in the plunger. If straight punches are used, they must have button heads to prevent their being drawn out of the holder. The die blank is then made to fit the holder, which has a taper shoulder of 20 degrees, as illustrated in Fig. 5. The sub-press

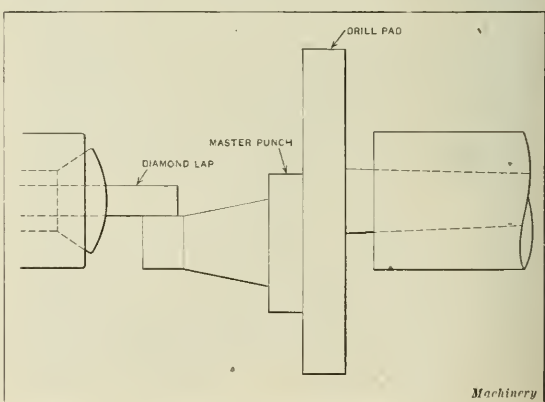


Fig. 3. Lapping Master Punch

[1] For other articles on sub-press dies, see "Sub-press Piercing Die," September, 1914; "Sub-press Dies for Armature Manufacture," July, 1914; "Sub-press Die for Piercing and Shaving," November, 1913; "Sub-press Die for Making a Cleat," August, 1912; "Standard Parts for Pillar Dies," September, 1911; "Operation and Construction of the Sub-press Die," July, 1910, and articles there referred to.

[2] Address: 128 Claremont Ave., Jersey City, N. J.

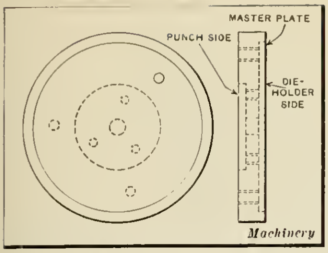


Fig. 4. Master Plate for Die Work

plunger is now recessed to fit the die-holder, and the holder and die are screwed to the plunger.

Sub-press Base

The sub-press bases, Fig. 1, are extra long, as previously mentioned. Two dowel holes of different sizes are drilled part way through the bottom, using a jig, and the dowels are then located in the lathe faceplate to hold the blank base nearly central. Two bolts hold the base to the faceplate, as shown. The base is now recessed for the master punch and the stripper plate; it is also turned to fit the upper part of the sub-press. The advantage of using dowels for locating the base to the faceplate is that if the base has to be relocated on the faceplate, it is not necessary to use an indicator, the two dowels making location certain. The master punch is now located in the base in such a position that the maximum number of pieces can be punched from a given length of stock.

The blank die is next covered with solder and faced off true, to get what is called a "lead impression"; this is generally done in the screw press, but if the master punch is delicate a lead hammer is used. After the die has been drilled out and rough-filed to this impression, the lead is turned off and a steel impression is taken, which need not be more than a few thousandths of an inch deep. The die is then filed to within about 0.002 inch of the correct size, the excess stock being shaved off. The amount to leave for shaving is a matter of judgment rather than measurement; if too much stock is left, the die will tear and rough up and a poor job will result. The shaving is done by pounding the plunger with a lead hammer, as the screw press tears the work; only about 0.015 inch can be shaved at one time. The plunger is then drawn out and the burr, or shaving, is carefully removed. This operation is repeated until the punch has been forced through the die.

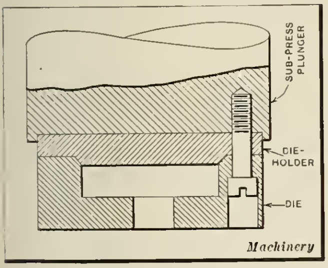


Fig. 5. Die-holder and Die

If a very smooth die is required, as in trimming, or compound blanking and swaging work, the die is not shaved by the master punch; but when ready to be shaved, it is hardened. A brass blank is then soldered over the hole and worked out to the design of the die. This blank is shaved by the master punch to the correct shape, and the die is lapped to this shape in a filing machine. For this work a diamond lap, which is a soft file blank charged with diamond powder, is used; No. 1 powder is used for roughing and No. 2 for finishing. After the die has been lapped to the brass impression, it will be found that the master punch will not enter the die, as the brass blank shrinks after shaving. The brass impression is then removed and the die is lapped again until the master punch enters the die about 1/32 inch, which means that the die is slightly bell-mouthed. This amount is later ground off, leaving a perfectly straight die, a little smaller than the master punch; it is necessary for the die to be smaller than the punch, as the die blanks expand after coming out of the die.

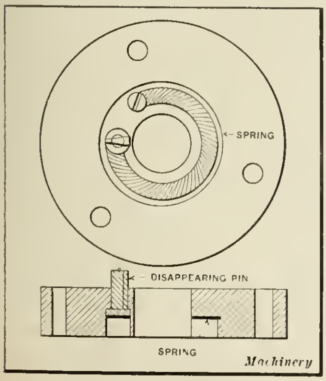


Fig. 6. Stripper and Guide Pin

Working Punches

It has been found that, on an average, one die will last as long as eight or ten working punches; hence it is necessary to make a set of punches. The punch blanks are covered with solder, faced off true, and a lead impression is taken from the die. This impression is rough-milled in a bench lathe, using a table rest. Saws and form cutters are used on the saw arbor in the head of the lathe. In this operation, the top of the punch must be set level with the center line of the lathe, or the work will "hog in." The punch is held against the saw, free hand. This is a quick way of milling punches. It gives a radius cut, but all that is wanted is to make a steel impression. The solder is turned or ground off, and a steel impression about 1/16 inch deep is taken. As this is a heavy cut it makes the punch too small. If the punch were milled to this size, there would be nothing to shave, so the edge of the punch is peened slightly or upset and the punch is shaved down again almost to the previous depth.

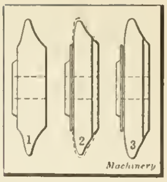


Fig. 7. Rolls for spinning Watch Case

The punch is now ready for milling, which, again, is a matter of judgment, for if just enough is left for shaving, a smooth punch will result. The punches are set up in the master plate and the holes are transferred in the same way as in making the die-holder, except that the opposite side of the master plate is used. After this, the punches are hardened and drawn to a purple; the dies should be drawn to a light straw. The punches are aligned by lapping the bottom on a cast-iron lap, using fine emery, until they cut tissue paper evenly. This is done by sharpening both punch and die and bringing them together in a sub-press with tissue paper between; then, with a light blow of the lead hammer, the tissue is marked. The side of the punch that cuts the paper first is the side that must be drawn toward the center. If the paper is cut evenly, the punch is in line.

Shedder, Stripper Plate, and Guide Pin

A brass punching is then made. This punching is soldered to the shedder blank, and the shedder blank is milled until the cutter touches the punching. The holes in the master plate must be transferred through the shedder. This is done by putting the master plate on a lathe, the die-holder being placed in the recess of the master plate and the die (with the shedder inserted) on the holder; then the holes are bored as in the holder. The shedder is then hardened, replaced and ground out, using diamond laps if the holes are small.

A stripper plate, Fig. 6, is next made to strip the stock from the lower punch, but it must not fit the punch closely;

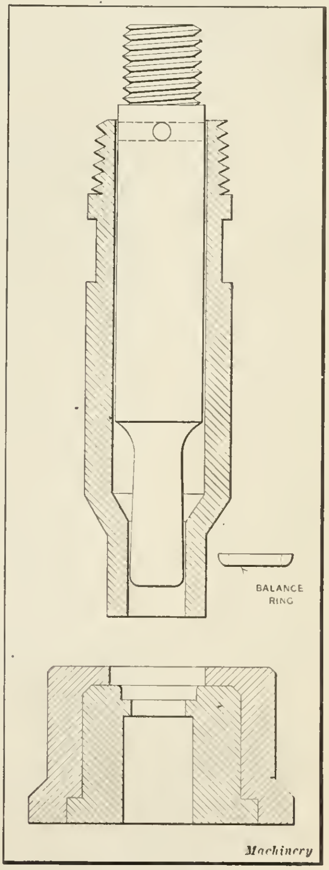


Fig. 8. Double-action Balance-ring Die

there should be a space of 0.004 or 0.005 inch between the punch and the stripper.

A disappearing guide pin seems the best for most work. Sometimes a track slightly wider than the punch is milled through the stripper plate, but this necessitates the use of stock that is perfectly straight and of a certain width, whereas watch stock is rolled for thickness in the works, and is likely to come from the rolls slightly curved. The disappearing pin permits the use of stock of any width; the strip does not have to be held at exactly right angles, but it must be held close to the guide pin.

In the foregoing a general outline of the method of making dies for fine watch work is given. A more detailed description is necessary to give a clear idea of the several varieties of watch dies.

Blanking and Burnishing Dies

Dies for steel parts blank, pierce and burnish the edges in one operation. The die is made as already described, except that the cutting edge is stoned round and polished to a high finish. The radius of the round edge must be determined by experiment; it is best to start with a small corner and work up until the edge of the blank shows perfect burnishing. The inside of the die must be very smooth and the radius of the cornering must blend in without sharp corners. The punches must fit perfectly in the die, or a ragged edge will result on the punching. This method of burnishing, or drawing, the edges of steel work is used in optical work on gold-filled flat stock, in which the pure gold must be drawn from one side, over the edge of the composition, to meet the gold on the opposite side, and withstand the acid test.

Brass and nickel parts are usually blanked and trimmed, the trimming being done in a die about 0.005 inch smaller than the blank. The die is placed in the plunger of the sub-press, the punch being in the base with the stripper and nest to locate the blank. A gash is milled through the back of the sub-press into the plunger, so that punchings may pass through the die and out back of the press. In very high-grade work, a burnishing die must be used after trimming. This die is made slightly tapered and lapped very smooth. The top is large enough to start a blank without cutting, and the small end is finished to size.

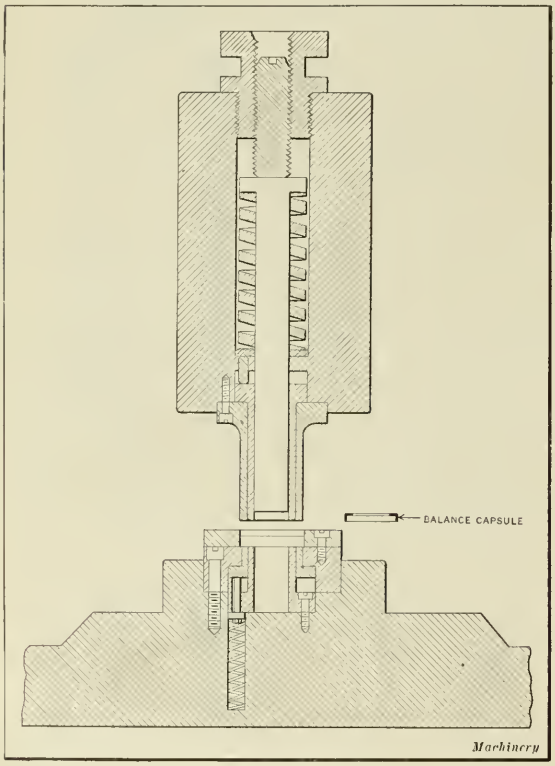


Fig. 9. Balance Capsule Die

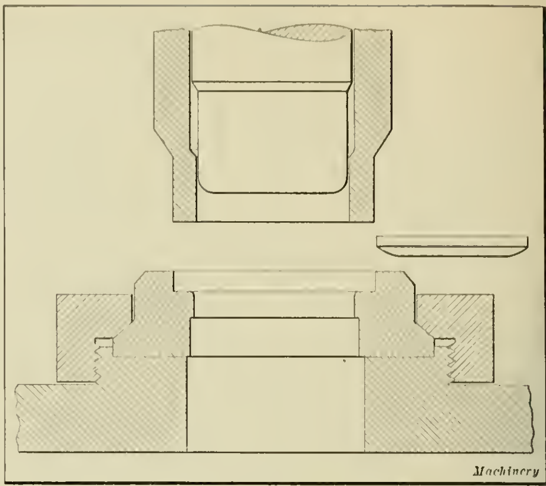


Fig. 10. Blanking and Drawing Die for Watch Case

Dies for Balance Ring and Balance Capsule

Brass balance rings are punched from flat stock; they are drawn to cup shape and the bottoms are punched out in one operation. This work, however, is not done in a sub-press, a double-action punching and drawing die being used, as shown in Fig. 8.

Balance capsules are punched from what is called "low brass"; that is, brass that melts at a higher heat than the balance ring, which is a "high brass." These capsules are used to hold the steel center and brass rim of the balance together while brazing, as the brass rim fuses to the steel before the capsule melts. The sub-presses of the capsule dies are not babbitted. The cast-iron shell is bored out perfectly straight and lapped smooth, using a lead lap and emery. The plunger is made from machine steel, casehardened and ground to fit the press; there are no guide slots nor ribs, as in babbitted presses, as the punches are round. Presses made in this way withstand the swaging operation better than the babbitted press. This press is called the double compound die because it blanks, draws, swages and pierces in one operation. The base contains the blanking die, lower punch and lower shedder; the plunger holds the blanking punch (which is also the drawing die), swaging shedder and center punch. These dies have an automatic roll feed, but to make sure that every piece is ejected, a blast of compressed air is placed so as to strike the capsule as it is ejected from the lower punch, blowing it into a wire basket. This die is shown in Fig. 9.

Watch-hand Dies

The dies for second hands are of the compound type; that is, they blank and pierce the center hole in one operation, using an automatic finger feed. The die is made in two pieces, which are ground together as one, one-half the hand being produced in each piece. In making a die of this kind, the first operation after fitting the sub-press is to make a holder for the split die. This is made with a one-degree taper, one centimeter deep. Two die-blocks are made to fit this holder, and then one-half is cut away, making one block split exactly in the center. The holder is now indicated in the lathe with the split blocks in place, and a center hole is drilled and reamed to the size wanted in the hub of the second hand, leaving enough to lap after hardening. If the hand is of the design known as a "ball second," this hole in the die is also drilled and reamed. The dies are then hardened and drawn. The two parts are blocked or lapped flat on the parts that join. The center hole is lapped to size, using a drill rod or brass lap and flour of emery as an abrasive. The two die-blocks are next held together by wire and soldered. A pin, or arbor, is ground true in the lathe and the die is wrung on and ground

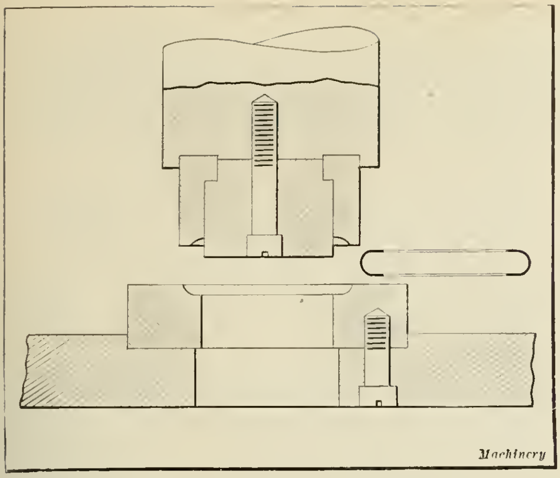


Fig. 11. Punching and Curling Die for Watch-case Rim

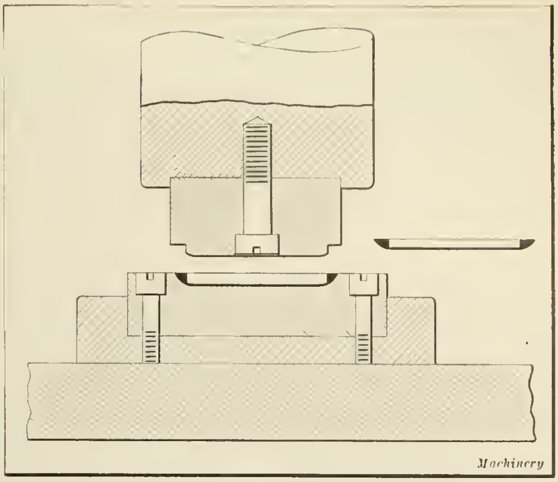


Fig. 12. Swaging Die for Watch Case

on the outside to fit the holder. A novel surface grinder is used to grind the arms, or center web, and the tail of the hand. A bench lathe is used, with an angle iron having micrometer adjustment in the head of the lathe. The screw is removed from the slide-rest and a cam movement substituted. The diamond form laps are about one inch in diameter. If the second hand is to be a "spade second," a form lap must be used to grind the form of the spade.

The punches are made in large quantities, as their life is short, owing to their delicate size and shape. They are made as already described, except that all the milling is done in the bench lathe. The radius cut of the saw, or cutter, leaves enough of the punch straight to make further milling unnecessary. A depth of 0.025 inch is sufficient, this being reduced after hardening to 0.015 inch. High-carbon steel makes better punches than any other steel, as it can be drawn to a purple, which is the proper color, and still be tough.

Three operations are necessary for making the hour and the minute hands—blanking, swaging and piercing. The blanking dies are made in two pieces, held together with screws and dowels, and used in sub-presses. Swaging is done in a drop-press, as a uniform blow is necessary; the piercing is done in small, open-front sub-presses. The fancy hands are first blanked and the intricate shapes are punched out in separate operations, after which the hands are swaged in drop-presses.

Dies for Metal Dials

Metal dials are made in many shapes other than round. They are blanked and pierced and the figures and dial foot recesses are swaged in one operation. The die is like most compound dies, except that the force, or swage (which is the dial in relief), is on the upper shedder. Therefore, after a blank has been punched, the plunger must be carried down until the shedder "hits bottom." Careful adjustment must be made to swage the figures to the correct depth. The recesses for the dial-foot pins are on the opposite side of the dial from the figures, and are swaged by pins projecting above the surface of the lower punch, backed up by a hardened steel plate under the punch. These swaging pins are very near the rim of the punch, making it difficult to harden the punch without cracking. This difficulty is overcome by drilling the hole part way through from the bottom, leaving about 1/4 inch solid, and piping it out after hardening.

The method may be of interest. The punch is aligned by lapping the bottom until the center hole runs true. Then the punch is placed in the master plate and located on the lathe faceplate, as previously described. A pipe is then made, the outside diameter of which is from 0.01 to 0.015 inch smaller than the hole wanted. The hole in the pipe must be large enough to leave only a thin wall of about 0.015 inch. This pipe is mounted in a traverse spindle grinder (care being taken to get the spindle on the dead center of the lathe) and used as a diamond lap, cutting on the end. The speed of the spindle should be about 20,000 revolutions per minute. Loose No. 1 diamond powder is used freely, being placed in the cut; the lap charges itself. After cutting out the center, the hole is brought to size with an ordinary diamond lap.

The swaging plates, which stamp the figures on the dials,

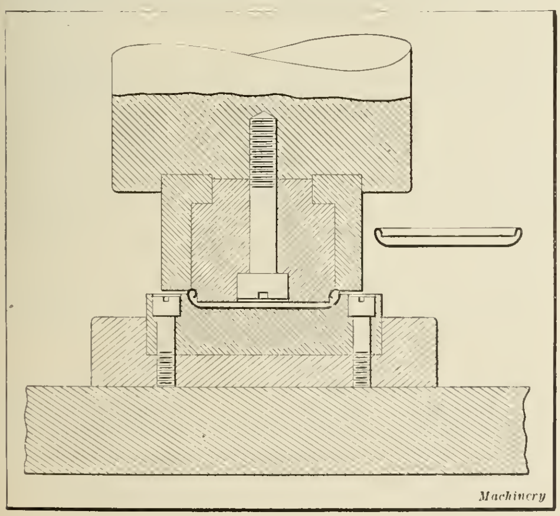


Fig. 13. Curling Die for Watch Case

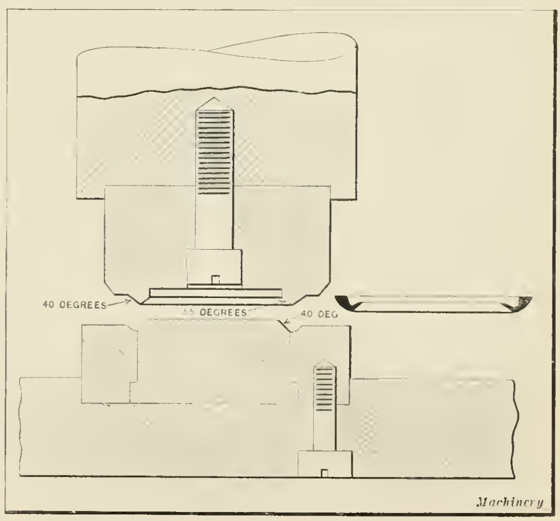


Fig. 14. Swaging Die for Reflector of Bezel

are about 0.055 inch thick, when finished, and are held to the upper shedder by a button stud made from "Hecla" vanadium steel. These plates are first decarbonized and the figures raised by swaging in the screw press. A steel block ½ inch thick is engraved to correspond with the dial, and hardened. The swage blank is placed in the center of the dial block and pressed until the figures are raised perfectly. A punch with flat teeth is used to swage the plate, as small sections are thus driven down at one time, the punch being turned around slightly after each blow of the press.

Swaging Dies

Swaging dies are made by a force or master punch, and are used where rounded shapes and steps are necessary, as in regulators, pallets, etc. Swaging-die blanks are surfaced off and lapped on a ground-glass lap, using powdered oilstone and oil. This gives a dead smooth gray finish, without scratches, which is absolutely necessary, as all imperfections are carried down by the force and cannot be polished out. The force is pressed into the die blank to slightly more than the required depth, and ground off after hardening. The impression is polished with a peg-wood stick and No. 4 diamond powder. Blanks of the part wanted are placed over the impression and struck by a drop-press, leaving a flash, which is trimmed off in the trimming die that also burnishes the edges. The round corners of the trimmer also help to locate the work to be trimmed.

Mainspring Dies

Mainsprings are trimmed on the end, and a hole is pierced in one operation; the presses used for this work are small, open-front sub-presses. Master punches and a series of master broaches for the holes are used when making the dies.

Wheel Dies

Dies for punching the escape wheel and other wheels are compound, but they do not punch the teeth or the center hole. The teeth are cut on a slotted arbor that holds the wheels by the inside of the rim. The center hole is drilled and bored by holding the wheel by the pitch diameter of the teeth in special machines. The most important parts of wheel die work, and the most difficult to make, are the segment punches; they are ground by holding them in a block that has been planed to give correct angles, a surface grinder being used.

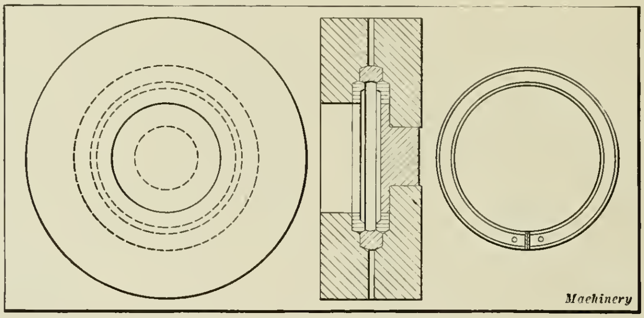


Fig. 15. Spinning Die and Holder for Watch Case

Dies for Watch Cases

As an article on watch dies would be incomplete without a description of the dies for the cases, a set of such dies for a plain, nickel, screw-back and bezel case is described. The first operation on the rim is to punch and draw a cup-shaped blank in a double-action press, using a die like that shown in Fig. 10. This die is of the same design as the balance-ring die, except that the blanks do not cling to the center punch, but pass on through the die. As the blank passes the sharp shoulder of the lower die, it expands slightly, which prevents it from returning with the punch. It will be noted that the die is held in the recess of a cast-iron plate by a large hexagonal nut; this method is used on all dies of this kind.

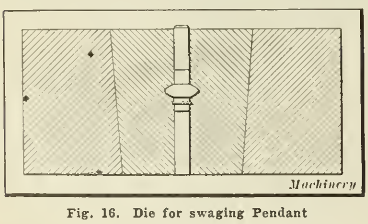


Fig. 16. Die for swaging Pendant

After the work passes through a punching and curling die, Fig. 11, it is ready for spinning; the punching and curling are done in one operation. Spinning a watch-case rim is usually done with three form rolls, shown in Fig. 7; the dies and holder are shown in Fig. 15. These die rings are made interchangeable to facilitate quick operation. The rings are ground absolutely smooth and all grinding marks are lapped out, as the slightest amount of wear on the angles will make an imperfect fit, producing fins and burrs on the work. The die and holder (with the ring in place) are held by hydraulic pressure in a spinning machine, and the first roll shown in Fig. 7 is placed on a bar and inserted in the die through the large hole. By the use of an eccentric lever, the roll is forced into the ring. The first roll is an opener, the second roll forms the center of the rim, but not the bottom, and the third roll is the finishing roll, which leaves the rim ready to thread; this is done in a bench lathe with a threading attachment.

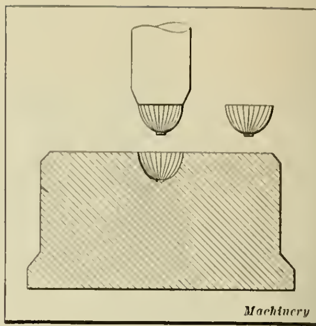


Fig. 17. Die for swaging Crown

Watch-case backs are blanked and drawn in a die like that shown in Fig. 10. These blanks are then passed through a curling die, Fig. 13, which curls the blank to the form shown; this die is used in a sub-press. After the curling operation, the back is swaged, as shown in Fig. 12, which leaves the work ready to thread. This operation, as in the case of the rim, is done in a bench lathe with a threading attachment. The bezel is the same as the back, except that the bottom is punched out after swaging. A die that swages the reflector of the bezel is shown in Fig. 14. The pendant die, shown in Fig. 16, is a two-piece die; one-half of the pendant is worked out of each section, both pieces being held in the hardened ring. A piece of hardened wire is placed in the lower part of the die with a piece of nickel wire in the center, ready to swage. Another hard pin is placed on top of the nickel wire, and when forced down, swages the wire into the desired form. A die for swaging crowns is shown in Fig. 17. The blank crown is curled and swaged on the stem. There are, of course, other operations on watch-case work, but this description is confined to the die work.

* * *

THE SOCIETY OF INDUSTRIAL ENGINEERS

The Society of Industrial Engineers was organized in Washington, D. C., June 15, and Charles Buxton Going, for twenty years editor of the *Engineering Magazine*, New York City, was chosen provisional president and pro tem chairman of the board of directors. This board comprises fifteen prominent men, chosen from various sections of the United States, among whom are Charles Buxton Going, C. E. Knoeppel, Frank B. Gilbreth, E. C. Shaw, Harrington Emerson, Charles Piez, Irving A. Berndt, G. DeA. Babcock, Willard E. Hotchkiss, Harry Franklin Porter, H. Thorpe Kessler, Dexter Kimball, Morris L. Cooke, C. Day and Herman Schneider.

The society is to be a national organization and the membership will comprise men and women who are industrial engineers, professional technical engineers, accountants, managing executives of commercial and industrial activity, writers, educators and students. Upon completion of the organization its services will be tendered to the government through Howard E. Coffin, chairman of the Advisory Committee, Council of National Defense, and others who can utilize its services.

LETTERS ON PRACTICAL SUBJECTS

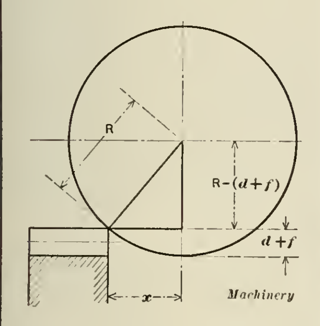
We pay only for articles published exclusively in MACHINERY

TRAVEL OF CUTTER WHEN MILLING GEAR TEETH

It is well known that in milling gear blanks a certain allowance must be made before the cutter cuts to the full depth, and that this must be added to the face when figuring the cutting time. The accompanying diagram and table show just how much this extra travel is. For example, the distance x is shown, in the accompanying table, to be 1.052 inch for a five-pitch cutter, 3 inches in diameter. This amount must, therefore, be added to the face of the gear to get the full travel required.

There is nothing difficult about the method of figuring, as it requires only the solution of a right-angle triangle in which the hypotenuse R represents the cutter radius; $R - (d + f)$, the perpendicular; x, the base of the triangle; $d + f$, the whole depth of the tooth. In the example given, the cutter radius is 1.5 inch. For a five-pitch cutter $d + f$ is 0.4314; therefore

OVER TRAVEL OF CUTTER WHEN MILLING GEAR TEETH



Cutter Diameter, Inches	Diametral Pitch of Cutter 4	5	6	7	8	9	10	12
4¼	1.414	1.353	1.184	.....	.....	.....	.....	.....
3⅞	1.342	1.219	1.124	.....	.....	.....	.....	.....
3¾	1.316	1.196	1.039	.....	.....	.....	.....	.....
3⅝	1.290	1.174	1.083	1.012	.....	.....	.....	.....
3½	1.263	1.150	1.062	0.991	0.934	0.884	0.842	0.773
3⅛	1.181	1.078	0.997	0.932	0.877	0.831	0.792	0.727
3	.....	1.052	0.974	0.911	0.858	0.814	0.775	0.712
2⅞	.....	.....	0.951	0.889	0.838	0.794	0.757	0.695
2¾	.....	.....	0.926	0.867	0.818	0.776	0.739	0.680
2⅝	.....	.....	.....	0.845	0.796	0.755	0.721	0.662
2½	.....	.....	.....	.....	0.776	0.736	0.702	0.646
2⅜	.....	.....	.....	.....	.....	0.715	0.682	0.627
2¼	.....	.....	.....	.....	.....	.....	0.663	0.610
2⅛	.....	.....	.....	.....	.....	.....	0.642	0.591
2	.....	.....	.....	.....	.....	.....	.....	0.572

$R - (d + f) = 1.5 - 0.4314 = 1.0686$; and $x = \sqrt{1.5^2 - 1.0686^2} = \sqrt{2.25 - 1.14188596} = 1.052. +$.

The table also shows the advantage of a cutter having a small diameter over one of larger diameter. Thus, in a five-pitch cutter, 4¼ inches in diameter, $x = 1.353$; whereas in a five-pitch cutter, 3 inches in diameter, $x = 1.052$, a difference of 0.3, so that on a number of gears the saving of time is considerable. Of course a table for keyway cutting could be arranged to show the amount of material cut into beyond the full depth of cut. The accompanying table is sufficient to cover most standard sizes of cutters. The over travel is given to the third decimal place for the sake of exactness, but of course the nearest thirty-second inch will be near enough for practical use.

Christchurch, New Zealand PERCY W. FRAMPTON

MAKING A TAP FROM A WORN-OUT SCREW

In repairing machinery and machine tools, it is often necessary to make special taps. Lead-screws and nuts wear out, and in order to make a quick repair a tap corresponding to the lead-screw is necessary. Making a special tap for a repair job involves considerable time and expense. In one instance, the "man on the job" suggested converting the worn-out screw into a tap. The repair to be effected was the making of a new nut and screw for raising the grinding head on a Brown & Sharpe grinder. The old screw was perfect on one end for a distance of six inches; so this section was cut off, fluted, squared, hardened, and used to finish the new nut. This obviated the necessity of cutting a thread on the tap, and as the screw had an eight-pitch Acme thread, the operation would have consumed considerable time.

Jersey City, N. J. W. H. DUNBRACK

CARE OF LATHE CENTERS

In a large shop where machines were not assigned to the workmen, it was found difficult to keep good centers in the lathes. A man finding the centers running out of truth would take one of them out, anneal it, turn it down so that it would run true, and finish his job, without stopping to harden the center. Oftentimes, what was originally the live center would be in a soft condition and in the tailstock of the lathe. As a result, much work was spoiled through the tailstock center being soft and burnt off, before the operator was aware of its condition.

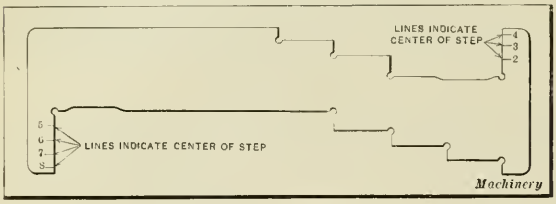
In some shops where similar conditions exist, it is common to find soft lathe centers because no center grinding attachment is available, or where there is one it may be in use and the men decide that it is quicker to anneal and turn a center true than to wait their turn for the grinder. In some cases, the centers have been taken out of one lathe and inserted into another, because the operator has carelessly burnt off the center. In others, much time has been wasted by men wandering around the shop until they found a lathe fit to be used; of course, after a man has centered his work at the proper angle, it is bad policy to try to turn it with centers of any angle.

In one shop, this difficulty of poor lathe centers was overcome by having two sets of centers for each machine, one being in the tool crib while the other was in use. Every lathe center was given the same number as the lathe it went into, and each live center had a scratch line that corresponded with a mark on the spindle of the lathe. When a man had lathe work to do, he procured his centers, in a good condition, from the toolroom attendant, and when he got through with the lathe he returned the centers and received his brass checks. If anyone carelessly burnt off one of the centers, the culprit was thus easily located. By this method good centers were always obtainable, and much time was saved.

New Haven, Conn. ERIC LEE

INSIDE MICROMETER GAGE

The accompanying illustration shows a convenient gage for setting inside micrometers. The gage was made from machine steel, 3/16 inch thick, and after roughing down to within 0.015 inch of size was carbonized 1/32 inch deep. It was then hardened at 1420 degrees F., after being secured between two 1- by 3/8-inch iron bars. These bars prevented the gage from bending and kept the center practically soft; there was, however, an expansion of 0.005 inch in the length. In finish-grinding, size blocks were used, which made it possible to work to a close limit. The steps were ground first, as near to size as possible, and about 0.002 inch was left on the base until the steps were lapped to size, or, in other words, exactly 1 inch apart. Then the base was ground to the finished size. This gage is light and takes up little room in the tool-box. By its use, an instrument having a 1/2-inch adjustment can be set from 2 to 8 inches. For example, if the micrometer is to be set to 3.400 inches, the three-inch step on the gage is used, the thimble first having been set to 0; then the thimble is adjusted to 0.400 inch, giving the correct measurement of 3.400 inches. If the micrometer is to indicate 3.800 inches, it is set to the four-inch step, the thimble having been screwed out



Gage for setting Inside Micrometer

to 0.500 inch; the thimble is then screwed in 0.200 inch, giving the correct measurement of 3.800 inches.

Toronto, Canada. H. E. GOODGER

SPRING WINDING TOOL

A handy spring winding tool, shown in Fig. 1, consists of a strip *A* of common sheet steel with a hole at each end. The wire from the spool passes through the hole *B* at one end, over the strip, through a hole *C* at the other end, and thence around the arbor *D*. In this case, the operator uses his thumb to govern the tension, which he can do by placing it on the wire or on a small strip of leather that is riveted to the tool and is laid over the wire. The holes *C* should be drilled different sizes according to the diameter of the wire used and should allow about 0.02 inch clearance. They can be spaced to suit the conditions of standard springs and whenever a special spring is to be wound, the space between the coils can be calculated and a hole drilled in the strip the proper distance from

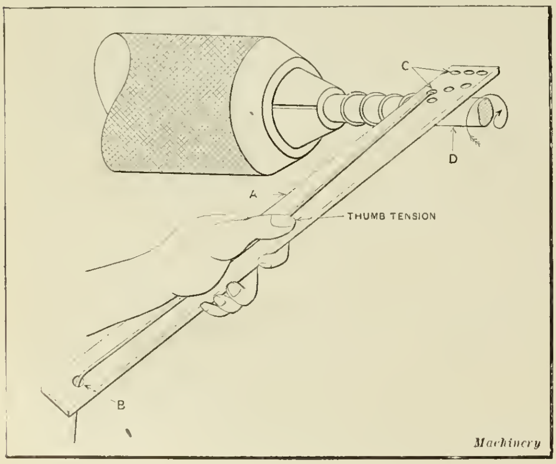
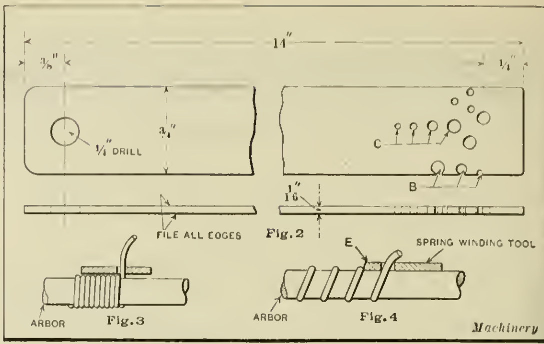


Fig. 1. Handy Method of winding Springs



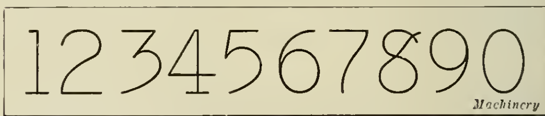
Figs. 2-4. Spring Winding Tool and Methods of using

either side of the tool. The side from which the dimension was taken should act as a guide *E*, Fig. 4. When a slight space is required, the tool is drilled and filed through the outer edge, as shown at *B* in Fig. 2. For close-wound springs, center holes *C* are used; the tool is then laid flat on top of the completed coils and a slight tension exerted sidewise toward the coils, as shown in Fig. 3. For open springs, the tool is held as shown in Fig. 4; the edge of the tool touches the last complete coil, which acts as a guide and gives uniform spacing.

Lynn, Mass. W. B. POHLE

PLAINER FIGURES FOR THE SHOP

When steel stamp letters and figures reach the well worn condition that seems to be typical in most machine shops, it is no wonder that the threes, fives, sixes and eights are often mistaken for one another. This is especially true when the surface upon which they are stamped is scaly or rough. The smaller the sizes of the figures, the greater is the likelihood of confusion, because the openings in the figures are less pronounced. The same condition holds true of pattern letters and figures. Of course, we all know that letters and figures should not be allowed to reach this condition without renewal, but the fact remains that they do.



Plainer Figures for the Shop

One large manufacturing concern has greatly improved matters by changing the form of the figures used. It will be seen in the illustration that the threes, fives, sixes and eights differ more than usual, having as large openings as possible in the formation. Since the adoption of this style of figures, mistakes in reading serial numbers, pattern numbers, etc., have been largely eliminated, and for this reason the same style of figures has been adopted for drafting-room use. C. L. L.

QUICK METHOD OF DRAWING ELLIPSE

The method of drawing an ellipse here shown eliminates all unnecessary construction lines which must be rubbed out after the ellipse has been constructed. It is not an exact geometrical construction, but is taken from the old method that has stood the test of time in nearly every drafting-room. The old method is as follows: On the major axis *AB* set off *AE* equal to *CD*, the minor axis, and divide *EB* into three equal parts. With *O* as a center and a radius equal to the length of two of these parts describe arcs cutting the major axis *AB* in *F* and *G*. Upon *FG* as a side construct two equilateral triangles *FHG* and *FIG*. With *H* as a center and a radius equal to *HD* describe the arc *JDK* intersecting *HG* and *HF* produced in *J* and *K*. With the same radius and with *I* as a center describe the arc *LCM* intersecting *IG* and *IF*

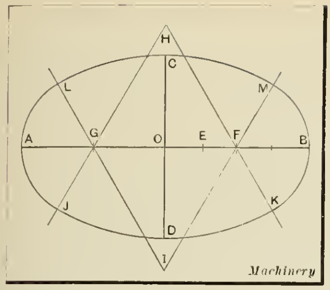


Diagram illustrating Quick Method of drawing Ellipse

produced in L and M. With A and B as centers and a radius equal to the chords of the arcs AL or BM, describe arcs cutting AB at the points F and G. From the points of intersection of these arcs with the line AB, and the same radius, describe the arcs LAJ and MBK.

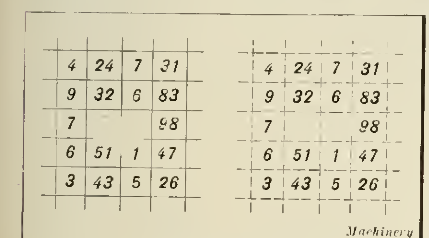
By the new method, let AB be the major axis, CD the minor axis and DH the radius for large arc on minor axis; then $DH = 1.15AB - 0.65CD$. After the large arcs are drawn, complete the ellipse by drawing an arc on the major axis tangent to the two large arcs and the ends of the major axis.

The accuracy of this method is shown by finding the value of DH from the old method: $OF = (AB - CD)\ 0.66$; $OH = OF \times \tan 60$ degrees; $DH = (OF \times \tan 60 \text{ degrees}) + 0.5\,CD$; $DH = [(AB - CD)\ 0.66 \times \tan 60 \text{ degrees}] + 0.5CD$. $0.66 \times \tan 60 \text{ degrees} = 0.66 \times 1.732 = 1.15$; $DH = [(AB - CD)\ 1.15] + 0.5CD$. By simplifying, $DH = 1.15AB - 0.65CD$. This formula checks back with a circle, as in a circle the major and minor axes are equal. For instance, take a circle 8 inches in diameter. AB, the major axis, $= 8$; CD, the minor axis $= 8$; DH, the radius of circle or arc $= 4$. The proof is $DH = 1.15\,AB - 0.65\,CD$; or $1.15 \times 8 - 0.65 \times 8 = 4$. The numerical coefficients of this formula are easily retained in the memory, by keeping in mind that $1.15 - 0.65 = 0.5$.

Brooklyn, N. Y. P. L. Gadol

RULING DATA SHEETS ON TRACING CLOTH

The writer often has to change information on data sheets, and in making the erasures has found that parts of the lines forming the columns were also erased. It was then necessary, after the change was made, to re-ink the erased parts of those lines, which seldom coincided with the lines already ruled in unless considerable care was taken. However, this trouble is easily avoided if the lines are ruled on the opposite side of the tracing cloth; that is, the information is put on one side and the lines on the other.



Erasures when Lines and Data are on Same and Opposite Sides of Cloth

New York City Andrew F. Burgwald

PENCILING DRAWINGS

A method of penciling drawings that makes them take on a clear-cut and finished appearance is to use two kinds of drawing pencils. A hard pencil (about 6H) with a wedge-shaped point is used for roughly laying out the detail, and for center and dimension lines, and a softer, or 4H, pencil with a round point is used for drawing in the solid or dotted lines of the detail and for arrowheads and lettering. By this plan a drawing can be easily traced, as there is a clear distinction between the lines, which gives almost the appearance of an inked paper drawing. The writer does not recommend this method of penciling for drawings such as assemblys upon which much time must be spent, as the soft pencil will cause the drawings to become smudgy, but for details, where the work can be traced quickly, or where the pencil drawing is shellacked and sent into the shop, the use of two pencils will be found well worth the small additional effort required.

Chicago, Ill. Ralph R. Weddell

MAKING A PRESSED STEEL COVER

The steel cover shown in Fig. 1 is made in two operations from 18-gage hot-rolled steel. It is then given a coat of black enamel. To eliminate trimming to length, the cover is made from a developed blank 3 17/32 inches in diameter. This is drawn into the cup shown at A, Fig. 1, on a compound blanking and drawing punch and die, Fig. 3. This cup is then put through an upsetting, perforating, and flanging die, Fig. 2, which produces the cover shown at B, Fig. 1. This is a finished article free from burrs and ready to go to the paint shop to receive a coat of black enamel.

The blanking and drawing die shown in Fig. 3 is more desirable for drawing shells that are afterward submitted to a finishing operation than is a double-action press. It produces a shell of uniform depth and height which is essential where no trimming is to be done. The punch-shoe A and the die-shoe B are made of cast iron and are aligned by steel guide-pins C and bronze bushings D. The blanking punch E, which also acts as a die, is made of hardened tool steel and is set in a counterbored shoe, being held in position by screws F. It has a spring knock-out pad G, which is actuated by a spring H. The blanking die, which is made of tool steel and

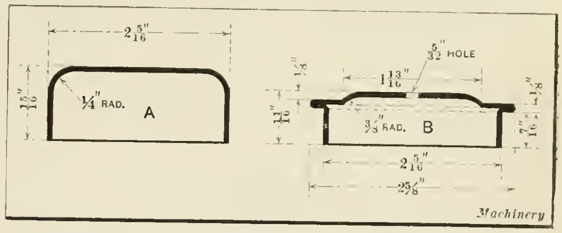


Fig. 1. Cup for Pressed Steel Cover and Finished Cover

is hardened and ground with plenty of shear, consists of a ring I that is set in die-shoe B and is held by screws J; K is the spacing gage. The forming punch L is held in position by a stud bolt M, which also holds in place rubber buffer N and pressure plates O with nut P. Rubber buffer N must be carefully adjusted when the dies are set up and care must be taken that excessive pressure is not exerted on pressure pad R, from the rubber buffer through pins S, as this would strain the metal or cause it to break or stretch. The stripper plates T, which are held by screws V, are made in two pieces and do not completely surround punch E while in operation; this is not in accordance with common practice. The top view is shown at Y-Y. This stripper is very satisfactory, as it gives the operator a good view and better command of his work. A channel X passes through the forming and drawing punch L and the stud bolt, then under the die to the opening XX. Its purpose is to eliminate suction while the shell is being stripped from punch L, making the stripping easier and causing less wear on the punch. Tapped holes W are provided for fastening the die to the bed of the press.

The flanging and perforating punch and die, Fig. 2, is

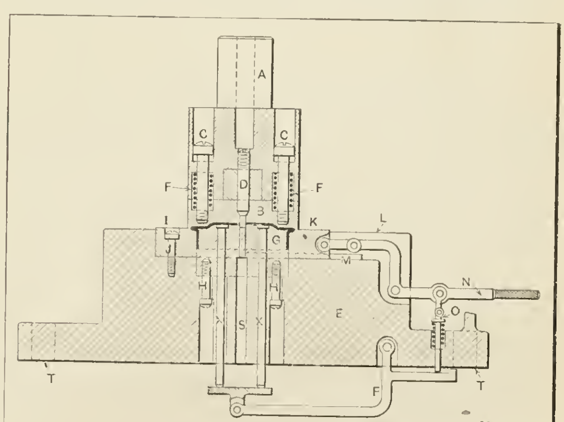


Fig. 2. Upsetting, Flanging, and Perforating Punch and Die

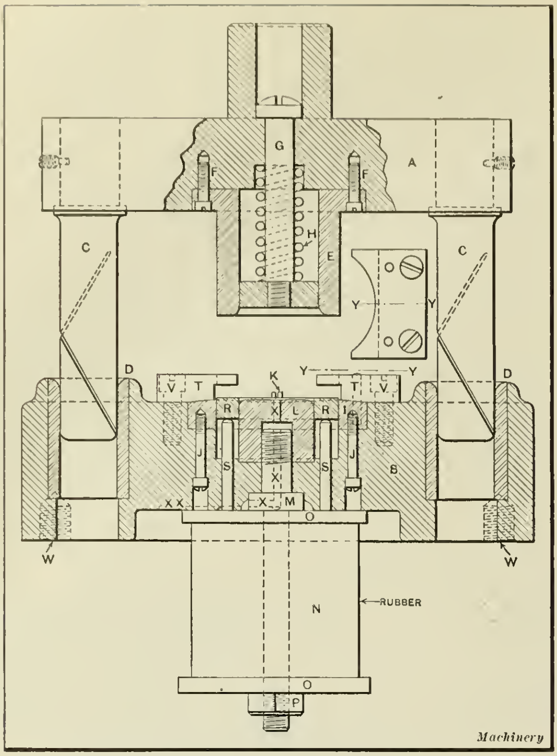


Fig. 3. Compound Blanking and Drawing Punch and Die for Steel Cover

shown closed with the finished cover in place. The punch *A* is made of machine steel and is counterbored to seat the tool-steel, hardened, working pad *B*, while under pressure. Pad *B* is held in place by screws *C*, which are ¼ inch long in order to allow the pressure pad ¼ inch movement from springs *F*. This movement releases the shell from the perforating punch *D* when the punch leaves the die on the upward stroke of the ram. The die-shoe *E* is made of cast iron and seats die *G*. The holes for screws *H* are elongated 1/16 inch to allow the die a forward motion of 1/16 inch, which is necessary when the die is open to give the proper freedom in placing or removing the shell. The rear flanging sections *I* are made of tool steel, hardened and ground and held stationary by screws *J*, while the forward section *K* moves horizontally in channel *L* and bevel gibs *M*. The front section *K* moves forward when the lever *N* is pressed down. At the same time, this lever, through stud *O*, causes lever *P* to raise knock-out pins *X* the proper height to discharge the cover, which is quickly removed and replaced by an unfinished shell. *S* is a channel for the discharge of slugs, and holes *T* are for fastening the die to the bed of the press.

Highland Park, Mich. Ernest A. Walters

HELP FOR THE TOOL DESIGNER

Many of the largest factories whose systems are otherwise efficient neglect to inform the tool designer how many pieces are to be machined and what is the highest price that the fixture may cost, with the result that his designs for a jig or fixture may be rejected because of excessive cost. This cost, if three or four thousand pieces were to be machined, perhaps, would not be excessive, but in the case of a few hundred it might be unreasonable. With the larger number of pieces, the use of an automatic or semi-automatic device might be valuable because the saving of a few seconds on a piece would soon overbalance the increase in the cost of the jig. If the designer were given this information, there would be a great saving in designing time and in manufacturing costs, as there would be fewer cheaply constructed tools used on large orders and fewer overdesigned jigs on small orders

Detroit, Mich. Lloyd L. Lee

EMERY WHEEL ON MOTOR SHAFT

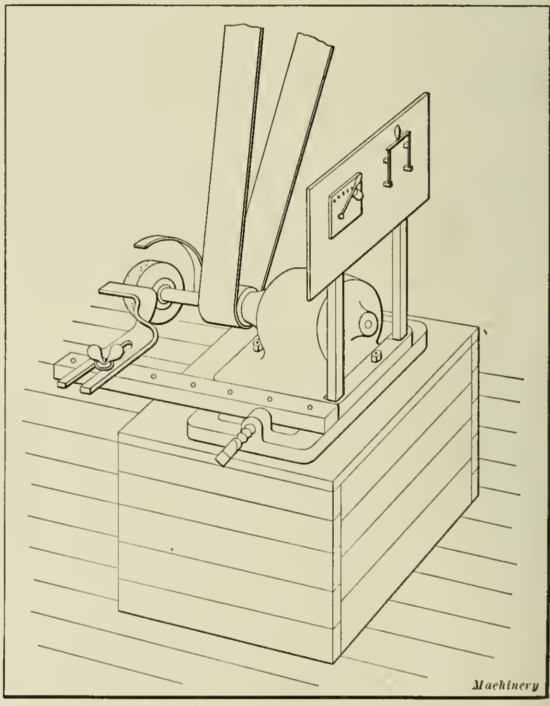
The little job shop with nine men and nineteen kinds of work for each man every nine hours cannot be expected to devote much time to stop-watch efficiency and motion study. Still the little shop does things that are well worth noting by mechanics who may be doing similar lines of work. In one small shop the writer has visited, several grinding machines are scattered through the shop—two or three ordinary stands of two stones each and one fine water-grinder. But because of the time required for the wheel to get up speed when starting an emery grinder, and as frequent trips to the grinding machine are necessary, an emery wheel has been set up on a motor shaft.

As shown in the illustration, the motor that drives the lathes was on a plank box of sufficient height to bring the shaft high enough for a grinder shaft. So an extension was fitted to the motor shaft on the pulley side of the motor and a 12-inch wheel with 1½-inch face, placed on it. The shaft extension is a piece of cold-rolled rod, a little larger than the motor shaft, which was fitted with a flange, collar, and nut to receive the grinding wheel; the opposite end of the extension was drilled and reamed to fit snugly over the motor shaft, the pulley of which was removed, bored out, and replaced outside of the motor-shaft extension.

The rest was attached to a 2 by 2 inch bar, which had evidently at some time done clamp duty on one of the planers in the shop. This bar was put on the base of the motor as shown, and held in place by means of the belt-tightening screw, which bore against the bar instead of against the motor base. After the motor bolts had been tightened, a turn of the belt-tightening screw exerted a vise-grip upon the rest-bar. The rest proper was forged from a bar of ½ by 2 inch black steel and was slotted and held in place by a wing nut, as shown. A guard was forged from another piece of flat steel and fastened with cap-screws to the rear of the sliding motor-base.

Although this device has been in daily use for more than five years, the dust and metal particles from the grinding operations have not done any damage whatever to either the motor or its bearings. The proper speed is there, the grinder never has to be stopped or started, and it consumes practically no power when not in use.

Another economical arrangement was the fastening of two



Attaching a Grinder directly to Motor

vertical angles to the sliding base and mounting a switchboard on these verticals. The knife-switch and the starting rheostat were located on this board, where they are convenient to the motor and to the workman who starts and stops it.

Indianapolis, Ind. JAMES F. HOBART

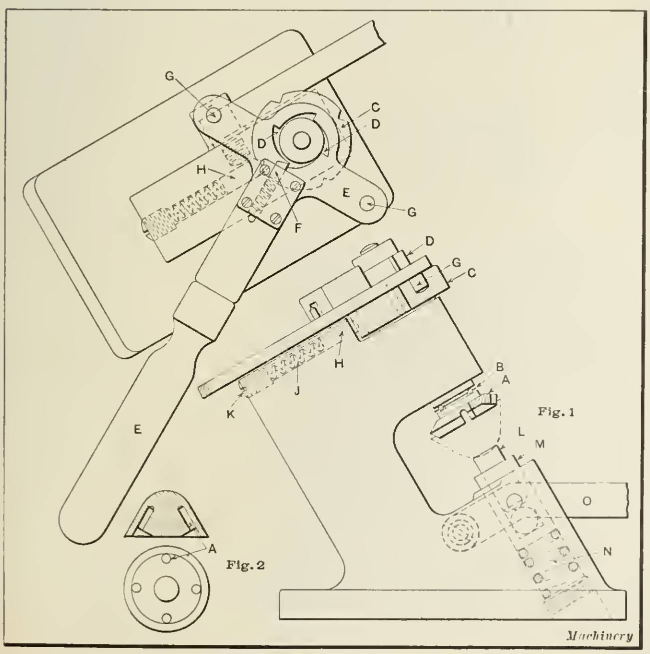
FAST INDEXING DRILL JIG FOR TIME FUSE CAP

The drill jig shown in Fig. 1 was designed for drilling four angular holes *A*, Fig. 2, in a brass time fuse cap. However, the principle can be easily applied to other work. The jig consists of a hardened steel locating plate *A*, Fig. 1, mounted on a hardened spindle, which runs in a bushing that is also hardened. A ball bearing *B* takes the thrust of the spindle. At the other end of the spindle is an index plate *C*, in which are cut four 90-degree notches. Keyed to the index plate, and also to the spindle, is a ratchet wheel *D*, having four teeth. A hand-lever *E*, which has a bearing and turns around a hub on the index-plate, carries a spring pawl *F* that engages with the ratchet wheel *D*. The lever also carries, at the outer ends, two pins *G* that project downward, so that when it is pushed back and forth the pins strike on the body of the jig and prevent carrying the index plate beyond the locking pin *H*. This locking pin is a hardened steel sliding pin, one end of which is rounded and engages with the notches in the index plate. Back of the pin and held in place by a headless set-screw *K* is a coil spring *J*, which holds the locking pin against the index plate. The tension of this spring is just enough to hold the work from turning while being drilled, but not enough to prevent its being readily indexed by a quick pull on the indexing lever.

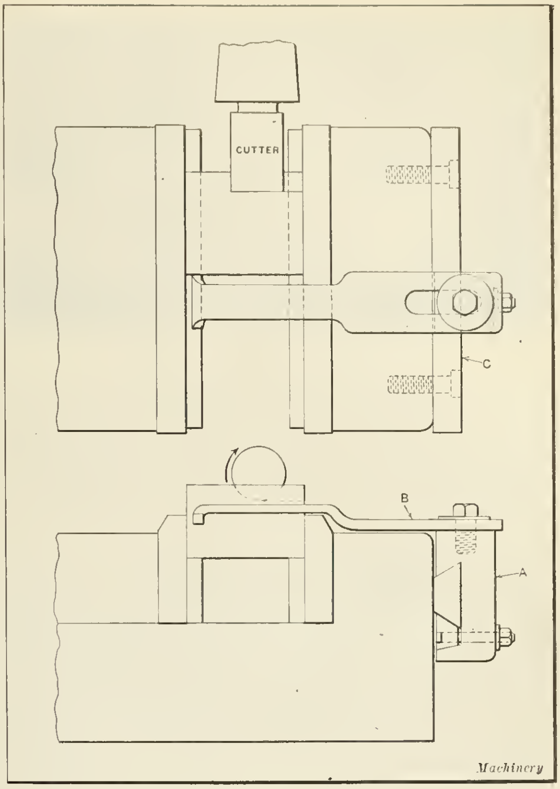
The work is held in position against the locating plate *A* by the plunger *L*, which rests on a single ½-inch hardened steel ball that acts as a bearing while the work is being indexed. Plunger *L* is carried in a second plunger *M*, which is held up by a powerful coil spring *N*. This spring should be longer and stiffer than the one shown, as an enormous pressure can be obtained with drills as small as the No. 30 used with this job. The outer plunger *M* is operated by a foot-treadle connected to the lever *O*. In operation, the foot-treadle is depressed and a piece of work is placed between the plunger *L* and the locating plate *A*. When the treadle is released, the work is held by the tension of the spring *N* while the indexing is done by the lever *E*.

The locating plate *A* has slots milled in it with a radius cutter of the same radius as the drill to be used. This feature, in connection with the lip on the work, answers the same purpose as a drill bushing, no other means of guiding the drill being necessary. The production of this jig is about 4000 caps per day.

New York City DONALD A. BAKER



Fast Indexing Drill Jig



Stop for locating Work in Milling Machine

VISE STOP FOR MILLING MACHINES

When a number of duplicate parts are to be machined, the vise stop here shown enables the operator to place each piece quickly in exactly the same location. The sliding block *A* and the finger *B* can be instantly adjusted to any position or removed when not in use. As the tongue *C* is never in the way, it can be left on the vise. The slot in the finger *B* allows it to be adjusted from the solid vise jaw to the position shown. The only strain on the stop is that from the hand holding the work against it and the solid vise jaw, which is square, until the vise is closed.

Beverly, Mass. V. G. TERRY

USING THE SLIDE-RULE

In the March number of MACHINERY, under the heading "Uses of Slide-rule," a method is given for setting the runner accurately to the decimal equivalent of a mixed number containing a common fraction. While the method gives the decimal value sought, it involves a mental calculation that may result in mistakes, and the estimate has to be made between 0.05-inch graduations, which may cause further discrepancy.

A more direct method, whereby the value may be read off directly within 0.0005, is to eliminate the integral and consider the fraction only. To find the decimal equivalent of 13/32 inch, set 32 on the C scale to the right index on the D scale, and under 13 on the C scale will be 0.4063 on the D scale. Any fraction may be solved in the same manner. To find the decimal of 24/39, set 39 on the C scale to the

Fig. 1. Raise One Side Two or Three Feet

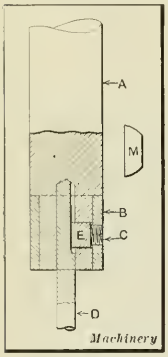
Fig. 2. Grasp Two Edges with Teeth Together

right index on the D scale, and under 24 on the C scale will be 0.6153 on the D scale. To convert a decimal into a fraction of any denomination, set the denominator of the fraction to the index, as before, and over the decimal on the D scale will be the numerator of the fraction on the C scale.

Bridgeport, Conn. A. C. HANNIBAL

SIMPLE DRILL CHUCK

In the February number of MACHINERY is an interesting article on "Drill Chucks." The following modification of one of the simple types of chucks described there may be of interest to some readers. One end of the spindle *A* is turned down to receive a collar *B* in which is a slotted-head set-screw *C*. In the end of the spindle is drilled a hole of the same diameter as that of the shank of the drill to be used. A slot is then cut across the spindle to a point a little less than half way through it. Block *E*, a plan of which is shown at *M*, is then fitted to this slot. The shank of the drill *D* is ground as shown. Chucks of this kind have been in use for a number of years on a multiple-spindle drill head and have proved very satisfactory where a high degree of accuracy is not required.



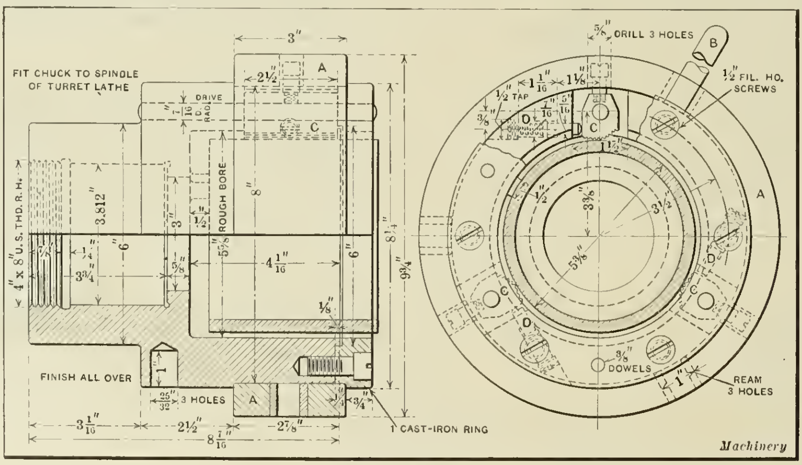
Simple Form of Drill Chuck

Beaver Dam, Wis. S. W. PALMER

QUICK-ACTING CHUCK

The accompanying illustration shows a quick-acting chuck designed for boring the inside of a steel tube. As the outside of the tube had only a small amount for finishing, it was necessary to bore the inside concentric with the outside. This chuck is made to fit a turret lathe or chucking machine. To open the jaws for inserting a tube, it is only necessary to revolve ring *A* slightly by means of pin *B*. This movement causes the jaws *C* to act against the pressure of the springs *D*. When the piece is inserted, the pin *B* is removed from the ring *A* and the springs *D* force the jaws to grip the work. The design of the jaws is such that the heavier the cut, the tighter will be the hold.

H. FRANCIS

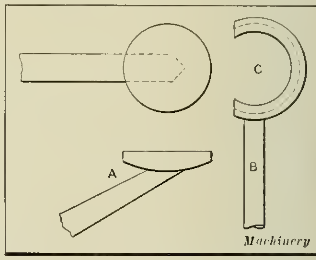


Quick-acting Chuck

MAGNETIZING PIECES THAT ARE TO BE SWEATED

In MACHINERY for February is described a method of preventing the slipping of two pieces of steel while being sweated together, to the value of which the writer can testify from experience. But he would like to add a hint for the benefit of anyone who has occasion to use this method with a magnetizing apparatus consisting of a coil of wire and an alternating current, as difficulty is sometimes met by men who do not understand the little peculiarities of the alternating "juice."

It is as easy to magnetize with alternating as with direct current if the switch is opened before the part is removed from the coil. The only difference is that with the alternating current no one can tell which end of the piece will be the north and which the south pole, as this depends on the direction of the current at the instant when the switch is opened. The writer has seen a man, after magnetizing one piece, repeat the operation twenty times on the other, getting the polarity wrong each time. Knowing that the chance of its coming right is "fifty-fifty," and misinterpreting, as so many do, the law of probabilities, he persevered in the full belief that the next attempt must be crowned with success. Finally, a neighbor suggested putting both parts into the coil at once with one part in a position opposite to that which it was ultimately to occupy, and his troubles were over.



Parts to be sweated together and Holder used while sweating

A somewhat interesting application of this idea of magnetic clamping once came to the writer's attention. A bronze part *A*, in the accompanying illustration, was to have a thin steel disk soldered to its flat surface. The shape of the bronze made it difficult to hold the pieces with even pressure in pliers, so that the disks were found to be tilted. A tool like that shown at *B* obviated this trouble. The tool-steel part *C* embraces a little more than a semicircle and is recessed to fit tightly on the bronze, the recess not being

Fig. 3. Swing One Loop through the Other

Fig. 4. Drop the Saw to the Floor

quite deep enough to allow its upper surface to come flush with that of the tool. The shank *B* is of brass and has a wooden handle on its outer end. One of the bronze parts, with its flat side already tinned, is placed in this holder, the steel disk is laid on top, and the holder and parts are inserted in the magnetizing coil. The disk is then turned 180 degrees and the sweating done.

New London, N. H. GUY H. GARDNER

MAKING BLUEPRINTS WITHOUT A TRACING

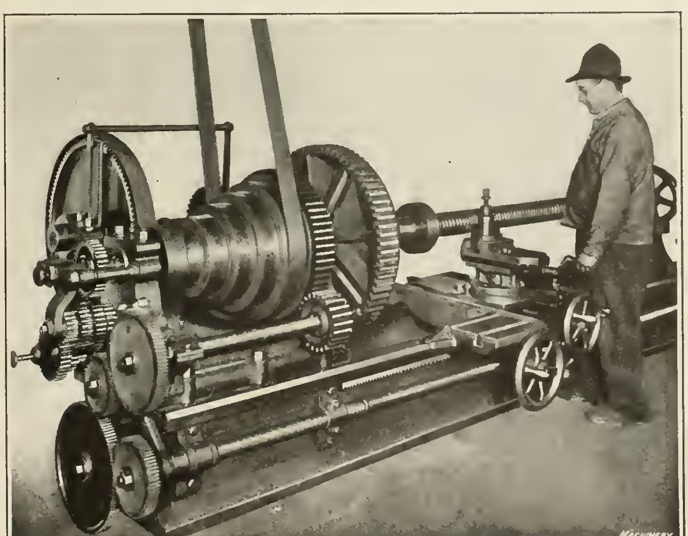
A good blueprint can be obtained from a soft-pencil drawing on a tough, light-weight bond paper. The method is useful when making shop fixtures, doing experimental work, etc., for the drawings can be readily changed, and, in experimental work, the drawings or prints can be used when making up the permanent tracings. The only disadvantage is that the drawings cannot be handled very much, because the soft-pencil lines rub off easily and the sheet soon becomes dirty. However, time is saved when only a few prints are required.

Beaver Dam, Wis. S. W. PALMER

LATHE ADAPTED TO CUT COARSE-PITCH SCREWS

An article appeared in the November, 1916, number of MACHINERY illustrating and describing how a lathe with a fine-pitch lead-screw was rigged to cut coarse-pitch screws. We used substantially the same scheme about thirty years ago in adapting an engine lathe that had a lead-screw with three threads per inch to cut coarse pitches. A jack-shaft was mounted on the front of the headstock, as shown, and was geared to the spindle gear in the ratio of 3 to 1. This gave us one inch movement of the carriage to one revolution of the spindle when two gears of the same number of teeth were mounted on the change-gear end of the jack-shaft and on the lead-screw. Movable studs were provided for mounting the intermediate gears, and provision was made for compounding. It will be noted that either right-hand or left-hand screws can be cut. The coarsest lead feasible to cut with this rig is about two inches. H. POTTS

Philadelphia, Pa.



Old Engine Lathe with Special Gear Train for cutting Coarse-pitch Screws

FOLDING A BAND SAW

To store band saws so that they can be handled easily, they should be rolled as tightly as possible. There are many ways of doing this, but unless one is skillful, there is danger of the saw kinking and injuring the person handling it. Fig. 1 shows a coiled band saw and another saw about to be rolled. The method of rolling is as follows: Raise one side, as shown, two or three feet with the teeth up; grasp the saw at about the center of the side opposite the raised part; carry this side over to the raised side, as in Fig. 2, and place the two edges with the teeth together. Raise the saw straight upward with the loops hanging down, the longer loop touching the floor, as in Fig. 3. Swing the shorter loop through the longer loop, at the same time dropping the saw to the floor. The saw will assume a circular position in three rolls, as in Fig. 4.

Moline, Ill. E. R. WIGGINS

COMB FOR DRAWING THREADS

Instead of using a thread pitch gage for spacing distances to lay out threads or cross-sections, I have found it convenient to use the ordinary comb with two sets of teeth. Simply ink the points of the teeth on an ink pad and press the comb on paper, and the spacing is instantly accomplished.

Bridgeport, Conn. JAMES MCINTYRE

THOUGHT VERSUS LABOR

In a shop where power presses were repaired, a shaft a half inch too long had been placed underneath the table of a press, so that the end came in contact with other working parts. It was therefore necessary to cut off the excess length. As the machine was assembled and it would have taken some time to take it apart, the parts that came in contact with the extra length of shaft were detached, and a slide-rest from a watch lathe was clamped to the under side of the press table. A belt was then run from the cone of a lathe over the press pulley and with a cutting-off tool inserted in the tool-holder the extra length was cut off the shaft. By this simple method, ten minutes' work saved taking the press apart and assembling it again, which probably would have taken twenty hours.

ERIC LEE

New Haven, Conn.

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

VANISHING THREAD JOINT

R. L. D.—What is a "vanishing thread" joint, and in what class of work is it used?

A.—A vanishing thread joint is a pipe joint made up of a tapered pipe thread screwed into a tapered thread socket. The taper of the thread is the standard pipe thread taper of 3/4 inch to the foot; the only difference lies in the fact that the thread is carried to the vanishing point instead of ending abruptly as is the case with commercial pipe threads. It is used for signal pipe and rotary drill pipe which require high tensile and torsional strength.

HOW TO PREVENT ACCUMULATION OF OIL ON MACHINE SHOP FLOORS

R. H.—I would like advice on means and methods of preventing an accumulation of oil on shop floors. The company with which I am connected has an automatic screw machine department using mostly cold-rolled steel stock, and cooling oil is used in the machines. Partly through the carelessness of the operators and partly through the carelessness of the men removing the chips, a considerable amount of oil gets onto the floor and is tracked all through the factory. The labor conditions are at present such that not much can be said to the men, as they quit on the slightest provocation. Sawdust on the floor has helped but little, and sweeping constantly would require too many laborers.

A.—The use of sawdust or shavings on the floor of screw machine departments is dangerous and is prohibited in many places on account of the increased fire hazard. The remedy in part lies in the use of well-fitted guards for preventing the oil from being thrown by the work from the machine, and in the use of convenient wheeled receptacles for the chips that enable the laborers to remove the chips from the chip pans without scattering on the floor. Systematic sweeping and mopping with alkaline solutions are necessary to keep the floors clean and free from slipperiness. The question is submitted to readers who have had success in overcoming the difficulty.

SOMETHING FROM NOTHING

J. B.—Fig. 1 shows a square measuring 8 inches on each edge. If cut into four pieces *M*, *N*, *P*, *Q* as indicated by the lines and dimensions, they can be rearranged to form a rectangle 5 by 13 inches, as shown in Fig. 2, by the full lines. Where does the extra square inch of area come from?

A.—We had supposed that it was universally understood and agreed that something cannot be obtained from nothing. Suppose that the square was a piece of steel plate, of a uniform thickness such that each square inch weighed one ounce, the entire plate weighing sixty-four ounces; then, according to the statement, by cutting and arranging the pieces as directed, they would weigh sixty-five ounces. If the plate were of gold or platinum, this would be a profitable operation, in fact it would be even better than a perpetual-motion machine; but as in such a case we would all be doing it, there would be nothing gained in the end. Many years ago someone told an English king that if a live fish were placed in a vessel of water, the vessel and its contents would weigh no more than it did before. The king referred the matter to his philosophers, who argued the question pro and con until the king was tired, so he ordered the matter to be settled by weighing the vessel and the water with and without the fish. In the present case, the question can be easily settled by making an accurate drawing of the pieces as rearranged. If the long sides of *M* and *N* are placed against the sides *AB* and *CD* of *P* and *Q*, the dotted lines show what the result will be. The edges *GH* and *IJ* overlap and their lengths are not equal to *EF*. In the question it is assumed that $AF + FB = 6 + 2 = 8$ inches; as a matter of fact, it is $\sqrt{5^2 + 6^2} = 7.81025$ inches. The question also as-

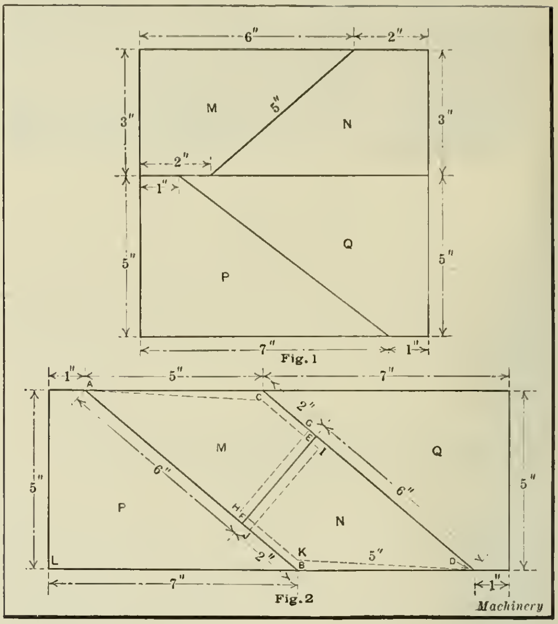


Diagram illustrating the Fallacy of obtaining Something from Nothing

sumes that the angle EDK = angle ABL, which is not true. Tan $EDK = 3/4 = 0.75$; tan $ABL = 5/6 = 0.833$; hence, ABL is greater than EDK. It is needless to say that the sum of the areas *M*, *N*, *P*, and *Q* subtracted from the area of the rectangle equals 1 square inch. J. J.

MEANING OF "LATERAL" WHEN APPLIED TO MECHANICAL MOVEMENTS

U. M. C.—Has the word "lateral" a fixed and settled meaning in mechanics, and can it be applied to any other than a horizontal movement in a horizontal plane? Can it be applied to the movement of any body, whatever its shape? What relation does this word bear to the words "longitudinal," "vertical" and "horizontal"? Has it any meaning when applied to an object not in motion?

A.—Most of the principles of mechanics are founded on considerations that refer to a material particle and not to solid bodies having appreciable dimensions. When such bodies are considered, the discussion is generally restricted to the movement of the center of mass (center of gravity). Referring to the accompanying illustration, suppose that the rectangular prism is any solid body having any shape whatever, and that O is its center of mass. Through O, pass a horizontal plane $A_1B_1C_1D_1$, a vertical plane $ABCD$, and another vertical plane $A_2B_2C_2D_2$, intersecting the other two at right angles. The lines of intersection of the planes are MN, M_1N_1 and M_2N_2, each line being common to two planes and perpendicular to the third plane. Suppose that the body moves so that its center O always lies in one of these lines, say the line M_1N_1; then it will have no lateral movement. If, however, the body moves so that its center lies in the plane $A_1B_1C_1D_1$, the projection of its path on the plane $A_2B_2C_2D_2$ being the line M_1N_1, the body has a lateral movement with respect to the plane $A_2B_2C_2D_2$. Again, if the body moves so that O always lies in the plane $A_2B_2C_2D_2$, the projection of its path on the plane $ABCD$ will be the line MN, and if O does not always lie in MN, the body has a lateral movement with respect to the plane $ABCD$. The body may also have a lateral movement with respect to the plane $A_1B_1C_1D_1$. It is evident from the foregoing that the word

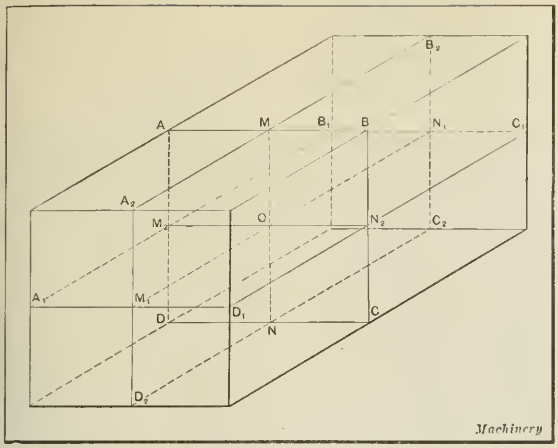


Diagram illustrating Meaning of "Lateral" as applied to Mechanical Movements

"lateral" can have no fixed relation to the words "longitudinal," "vertical" and "horizontal," but its meaning, as illustrated, is fixed and invariable. When applied to a stationary object, the upper and lower sides are called bases and the other sides are the lateral sides. Thus the lateral area of a prism is the total area exclusive of the bases—it is the area of the lateral sides. A house having a rectangular plan may be said to have a front and a back side and two lateral sides. Here "lateral" has a relation to the vertical, longitudinal plane. J. J.

STRENGTH OF A JIB CRANE

E. J. E.—The jib crane shown in Fig. 1 is loaded as indicated. Please advise if you would consider it safe without reinforcing the boom. A structural engineer advised me that a half-ton jib crane, having a boom 20 feet long, made of a 10-inch, 25-pound I-beam, was overloaded because the ratio of L/r was too high. A manufacturer of chain hoists illustrates, in his catalogue, a crane of the same length and size of beam, and rates it at 2 tons. There are a number of cranes of this type about the plant, and a difference of opinion has arisen as to where to draw the line for the proper safe loads. What is your opinion of Gordon's formula as applied to this case?

Answered by John S. Myers, Philadelphia, Pa.

The crane in question is similar to that shown in Fig. 2, reproduced from MACHINERY of March, 1908, where a similar problem is discussed by the writer. The sizes given for the present case are: L = 25 feet = 300 inches, and H = 9 feet = 108 inches. As the jib is made of a 10-inch, 40-pound, I-beam, area of section A = 11.76 square inches; flange width b = 5.1 inches; section modulus Z = 31.7; radius of gyration for lateral flexure r = 0.9 inch. The wheel-base is not given, but is assumed to be B = 20 inches. The loading is as follows:

	Pounds
Chain hoist capacity, 1½ ton	3000
Pull to raise load	110
Weight of hoist	130
Weight of trolley	175
Weight of one-half of beam	500
Impact, 25 per cent of above total	979
Total	4894

In round numbers, the total load W = 4900 pounds. It is not quite correct to include half the weight of the beam as if it were part of the moving load, but it simplifies matters.

Let M = bending moment under rear wheel;

D_r = distance to rear wheel from left support;

T = thrust on beam caused by angle of reaction;

S_b = bending stress due to wheel loading;

S = direct compressive stress due to thrust of tie-rod.

Then
$$M = \frac{WD_r}{L}\left(L - D_r - \frac{B}{2}\right) \quad (1)$$

$$S_b = \frac{M}{Z} \quad (2)$$

$$S = \frac{T}{A} = \frac{W}{HA}\left(D_r + \frac{B}{2}\right) \quad (3)$$

The combined stress in tension is $S_t = S_b - S$, and the combined compressive stress is $S_c = S_b + S$. This combined compressive stress S_c becomes maximum when:

$$D_r = \frac{LZ}{2HA} + \frac{L}{2} - \frac{B}{4} \quad (4)$$

Substituting values in (4), the location of the load for the maximum stress is found to be:

$$D_r = \frac{300 \times 31.7}{2 \times 108 \times 11.76} + \frac{300}{2} - \frac{20}{4} = 148.75\text{, say } 149$$

The bending moment with this value of D_r is:

$$M = \frac{4900 \times 149}{300} \times \left(300 - 149 - \frac{20}{2}\right) = 343{,}000 \text{ inch-pounds}$$

The bending stress is $S_b = \dfrac{343{,}000}{31.7} = 10{,}820$ pounds per square inch. The direct stress is $S = \dfrac{4900}{108 \times 11.76} \times \left(149 + \dfrac{20}{2}\right)$ = 614 pounds per square inch. The combined tensile stress in the lower flange is S_t = 10,820 — 614 = 10,206 pounds per square inch. The combined compressive stress is S_c = 10,820 + 614 = 11,434 pounds per square inch.

As only one flange is in compression, the total member is not a true column, because this flange receives some lateral support from the tension flange. A formula given in the Cambria Steel Co.'s Handbook for beams without lateral support, having the same general form as Gordon's formula, is:

$$S_c = \frac{18{,}000}{1 + \dfrac{L^2}{3000\,b^2}} \quad (5)$$

Here S_c = safe compression stress when the safe tensile stress is taken as 16,000 pounds per square inch. Applying this formula,

$$S_c = \frac{18{,}000}{1 + \dfrac{300^2}{3000 \times 5.1^2}} = 8360$$

The actual maximum stress is 11,434; hence the beam is loaded to a stress corresponding to $\dfrac{11{,}434}{8360} \times 16{,}000 = 21{,}900$ pounds per square inch. The apparent factor of safety based upon 64,000 pounds ultimate is then 64,000 ÷ 21,900 = 2.92, which is an inadequate margin. Hence, for this condition of loading, the compression flange should be reinforced or braced laterally.

If this were a simple boom with the load applied at the extreme end, as in Fig. 1, the thrust induced by the tie-rod would be:

$$T = \frac{WL}{H} = \frac{4900 \times 300}{108} = 13{,}600 \text{ pounds}$$

The direct stress is then S = 13,600 ÷ 11.76 = 1156 pounds per square inch. The member is now a pin-ended column, the ultimate compressive strength per square inch for which is, according to Gordon's formula:

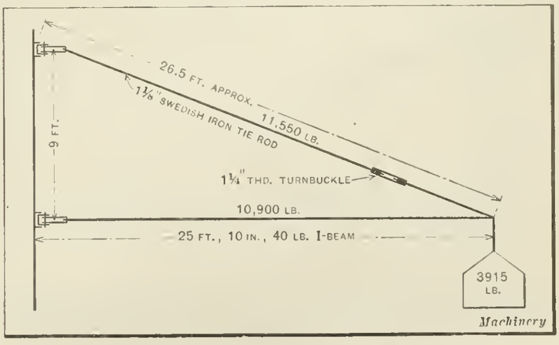


Fig. 1. Diagram illustrating Jib Crane, the Strength of which is to be determined

$$P = \frac{50{,}000}{1 + \dfrac{L^2}{18{,}000\, r^2}} \qquad (6)$$

For this case, $P = \dfrac{50{,}000}{1 + \dfrac{300^2}{18{,}000 \times 0.9^2}} = 6970.$

The factor of safety is, then, 6970 ÷ 1156 = 6.03, which is apparently ample for this condition of loading. But the "slenderness ratio" of the strut, that is, the ratio $\dfrac{L}{r}$, is 300 ÷ 0.9 = 333, which, as viewed by structural engineers, is not a permissible value. This is the real point of controversy—a mooted question which, it would seem, has not been as much discussed as its importance warrants.

Applying Euler's formula, $P = n\pi^2 E \dfrac{I}{l^2}$,

in which P = critical load, or the load that, acting with a continually increasing lever arm as the column deflects, will cause failure by buckling;

E = modulus of elasticity;

I = rectangular moment of inertia;

l = length in inches;

n = coefficient to take account of condition of ends.

As E = 29,000,000, I = 9.5, and n = 1, $P = 1 \times 3.1416^2 \times 29{,}000{,}000 \times \dfrac{9.5}{300^2} = 30{,}212$. The factor of safety is then 30,212 ÷ 13,600 = 2.22, a very small margin. Had the extreme case of n = 1/4 been taken, the critical load would have been less than the actual load.

The subject of compression members, in general, is rather unsatisfactory from a technical point of view, inasmuch as it is somewhat allied to the laws of chance, which are not supposed to have any place in the engineer's creed. Briefly stated, the salient points are about as follows:

Short compression members of compact cross-section, centrally loaded, fail by pure crushing or by shearing on an oblique plane.

Short compression members eccentrically loaded fail when the combined bending and compressive stresses reach the yield point.

Long columns, if absolutely perfect, should, in theory, fail in a similar manner; but owing to such imperfections as non-homogeneity of material, uncertainty as to absolute centrality of loading, accidental lateral stresses, etc., they collapse at or above some critical load, which depends largely on the slenderness ratio. Euler's formula is conceded to give this critical load for such columns.

The slenderness ratio L/r at which such failure occurs is usually conceded to lie between 100 and 120, but for struts very lightly loaded or redundant members, this ratio is often taken as high as 180 or 200.

Compression members that are lightly loaded but that have ratios of L/r exceeding these values may never actually fail, yet an element of chance is involved that no conscientious designer wishes to count upon when failure may mean loss of life.

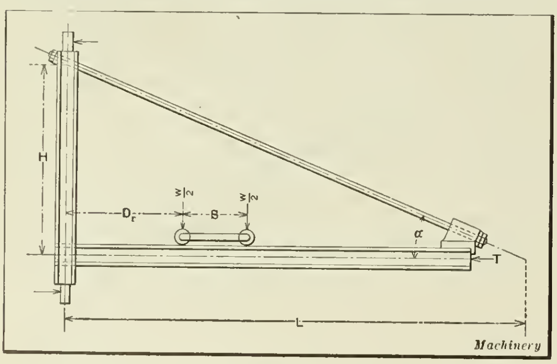


Fig. 2. Jib Crane supporting a Moving Load

Columns of built-up section usually fail by local buckling of some element of the section; the whole is thus weakened and total collapse follows.

Beams subject to combined flexure and compression are not true columns when one flange is in tension, because this flange lends lateral support to the compression flange.

As built-up columns fail by local buckling, a method of treating slender columns of such shapes as I-beams, when slightly loaded, would be to consider the load as carried by the flanges alone, in which case the radius of gyration is:

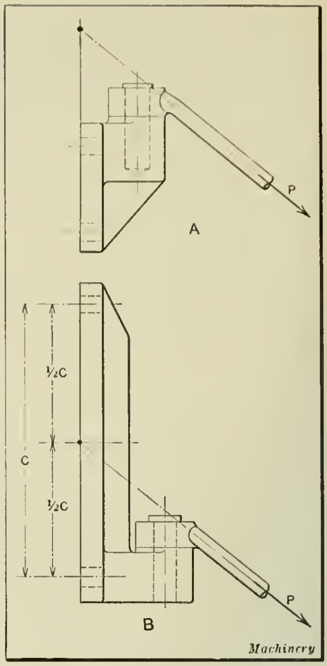


Fig. 3. Eccentrically Loaded Crane Attachments

$$r = b/\sqrt{12} = 0.289\, b \qquad (7)$$

Here b = breadth of flange.

Treating the present problem, for the condition of load applied at the end, in this manner we have the following:

As flange area is approximately 5.27 square inches, $S = \dfrac{T}{A} = \dfrac{13{,}600}{5.27} = 2580$ pounds per square inch.

The radius of gyration of the flange alone is $r = 0.289 \times 5.1 = 1.47$ inch.

Then $$P = \frac{50{,}000}{1 + \dfrac{300^2}{18{,}000 \times 1.47^2}} = 15{,}090$$

The factor of safety is then 15,090 ÷ 2580 = 5.84, and the slenderness ratio is $\dfrac{L}{r} = \dfrac{300}{1.47} = 204$. This is a considerably higher value than what is generally considered good practice, so that, while the apparent margin of safety is ample according to this treatment, there is the element of chance as to erratic behavior of such a slender member, and it would be well to reinforce or laterally brace the compression flange.

A frequent source of danger in poorly designed cranes of this variety is to be found in eccentrically loaded attachments. The writer has in mind constructions embodying the principle indicated at A in Fig. 3. Here the patternmaker and the blacksmith who built the crane supposed that the pull P is equally divided between the four bolts holding the bracket to the post, as it would have been had the bracket been constructed along the lines indicated at B.

Many examples of long compression members are to be found in engine valve gears. Some of these members, made thirty-six years ago, are intact today. On a high-speed engine, the steam-valve driving rod is 114 inches between centers and 1¾ inch in diameter. According to Euler's formula, the critical load is about 10,000 pounds, and according to Gordon's formula, about 25,000 pounds. The ratio of slenderness is L/r = 261; and while this ratio seems excessive, especially where there is vibration, as the actual load is light, no trouble is experienced. This does not say, however, that it is good practice, and later designs have been made of tubing with a lower slenderness ratio.

EPICYCLIC GEAR TRAINS[1]

FUNDAMENTAL PRINCIPLES, FORMULAS AND COMMON APPLICATIONS

BY REGINALD TRAUTSCHOLD[2]

An epicyclic gear train consists of a number of meshing gears, of which at least one revolves around a central gear, at the same time rotating about its own axis, so that the arm or bracket supporting such planetary gear, or gears, is given a definite speed of rotation by the driving gears. When the arm or bracket is the driving member of the combination, it imparts a definite speed to the driven gear, any intermediate gears or pinions simply acting as members for the transmission of motion between the principal parts—the driving and driven members of the combination. Obviously, the arrangement offers possibilities of securing high speed ratios with comparatively few gears, compactly disposed and of extremely quiet and smooth operation, the various gears being in constant mesh, thus minimizing the shock of impact between teeth. It lends itself to many transmission problems that would otherwise be solved with difficulty and require cumbersome gearing.

Adaptable and convenient as are epicyclic gear trains, their use has been largely limited to certain types of speed reducers, and special, intricate machines or mechanisms, etc.,

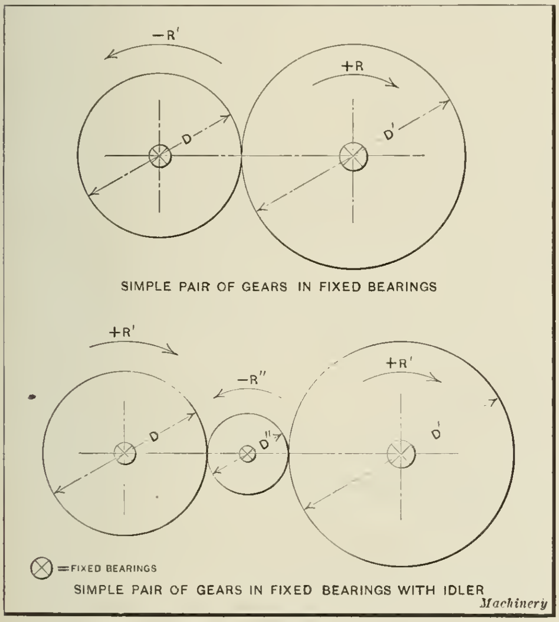


Fig. 1. Diagrama of Simple Gear Combinations

chiefly on account of the failure of designers to appreciate their adaptability. This is largely due to the complexity of the calculations—largely fancied—involved in their design and results in the frequent selection of more cumbersome, but more familiar gearing. The gear designer is only partly responsible for the limited use of epicyclic gear trains, however, as a general lack of familiarity on the part of possible users of such mechanism is the chief factor retarding their more general use. The individual gears comprising an epicyclic train are not at all special; they are customarily of the ordinary spur type of comparatively fine pitch. But it is in failure to clearly comprehend the action of the gears when in operation that there is likely to be confusion which so often results in the avoidance of the mechanism in general practice. A clear understanding of the principles of an epicyclic gear train simply necessitates familiarity with the action of ordinary gearing in fixed bearings. Such gearing may be simple or compound. It may consist of a train of gears mounted

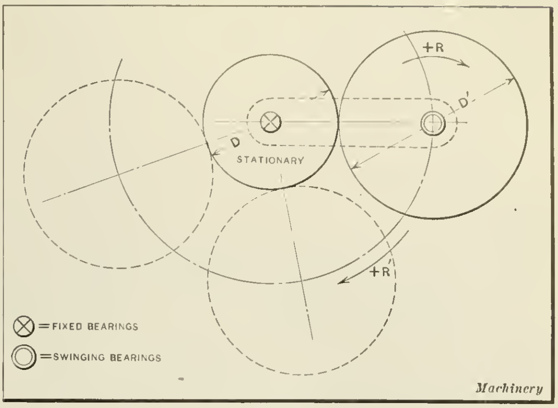


Fig. 2. Simple Epicyclic Train

on individual shafts, or a train in which at least two of the gears are connected so as to rotate as one unit, that is compounded. If of the latter type, the mating gears may be mounted on separate shafts, or if on the same shaft they must be free to rotate independently of one another.

Simple Gear Trains

Fig. 1 illustrates diagrammatically two simple gear combinations. One is a simple pair of gears in fixed bearings, the respective speeds of which are inversely proportional to their diameters, or the number of teeth which they contain; the other is a train of three gears, similarly mounted, the speed of the end gears of which bear the same relation to their respective diameters as does the train of two simple gears in fixed bearings. The only difference in the two arrangements, as far as the rotation of the effective members is concerned, is that the two simple gears turn in opposite directions, one clockwise (+) and the other counter-clockwise (—); while in the train of three gears the end gears—the driving and driven members—rotate in the same direction and the intermediate gear, or idler, alone turns in the reverse direction.

Any number of intermediate gears can be added to such a simple train without affecting the relations of speed and diameter between the end gears; the effect produced by the interposed gears is simply the regulation of the direction of rotation of the effective members. When the number of gears in the train is even, the end gears revolve in opposite directions; when the number of gears is odd, the effective members turn in the same direction. The velocity ratio of the smaller

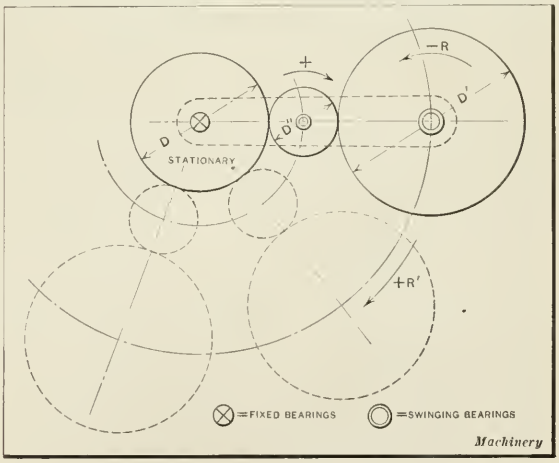


Fig. 3. Simple Epicyclic Train with Idler

[1] For additional information on the design of gearing, see "Internal Worm-gearing" in the April number of MACHINERY, and articles there referred to.
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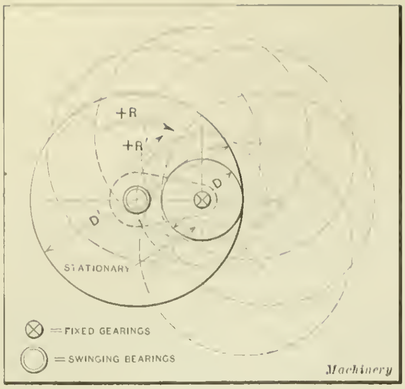


Fig. 4. Simple Internal Epicyclic Train with Arm Driving and Pinion Dead

end gear to the larger end gear is equal to the larger gear diameter divided by the smaller gear diameter.

The substitution of an internal gear for one of the externally meshing end gears does not affect the speed relationship of the train, but does alter the direction of rotation of the end members. The direction in which an internal gear, meshing with a simple pinion, will turn is the same as that of the pinion, and the interposition of any odd number of idler gears simply reverses the direction of rotation. That is, the direction of rotation of an internal gear actuated by an even number of gears is always opposite to that of the first of the gears, and for one running with an odd number of gears, the direction of rotation is the same as that of the first of the gears. It is these simple relationships between the diameters and speeds of meshing gears and the important consideration of direction of rotation that govern the action of simple epicyclic gear trains.

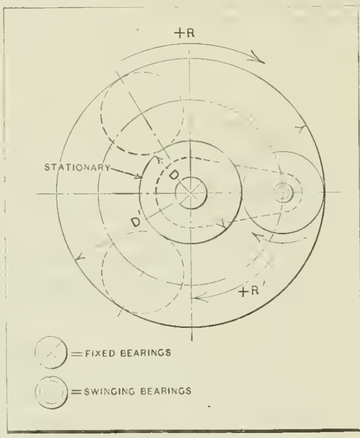


Fig. 5. Simple Internal Epicyclic Train with Planetary Pinion—Arm driving and Central Gear Dead

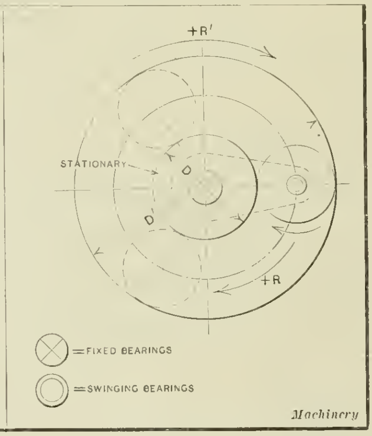


Fig. 6. Simple Internal Epicyclic Train with Planetary Pinion—Internal Gear driving and Central Gear Dead

Simple Epicyclic Gear Trains

The simplest epicyclic arrangement of externally meshing gears is that shown in Fig. 2. It consists of two simple gears in mesh, one of which is mounted on a fixed bearing, while the other is in a floating bearing, which may be swung about the center of the first gear; the floating, or swinging, bearing is supported by an arm as indicated. In its elemental form, the central gear, the one mounted on fixed bearings, is stationary, or a dead gear, and the driven gear and the driving arm are the rotating members.

To arrive at the rotary speed of the driven gear, in terms of the speed of rotation of the driving arm, two independent motions must be considered: first, that which the driven gear has by reason of its rotation about the center of the dead gear; and second, that which is imparted to the driven gear by being forced to roll about the central gear. In the first instant, considering the driven gear as fixed—that is, held in the driving arm so that it cannot revolve on its own axis but slipped out of mesh with the dead gear so that it can revolve with the arm—for each revolution of the driving arm any given point on the driven gear will make a revolution about the dead gear, which, as far as the driven gear is concerned, is equivalent to a revolution about its own axis in the same direction as that in which the driving arm revolves, the gear remaining stationary. In the second instant, considering the driving arm as fixed, the rotary speed that will be imparted to the driven gear in rolling about the dead gear is the same as would be imparted to it by a revolution of the central gear in a reverse direction while the driving arm remained stationary. The rotary speed of the driven gear in actual operation is then the sum of these two motions, or is equal to the rotary speed of the driving arm multiplied by one plus the quotient of the diameter of the stationary dead gear divided by the diameter of the driven gear.

The interposition of an idler, or any odd number of idlers, between the dead and driven gears, as shown in Fig. 3, causes the driving arm and the driven gear to revolve in opposite directions and materially affects the relationship between the rotary speeds of the driving arm and driven gear, the first gear, as before, being dead. The revolution of the driven gear about the dead gear, with the driving arm, is equivalent to a revolution of the driven gear in the same direction as that of the driving arm, but the rotary motion imparted to the driven gear by virtue of its rolling about the dead gear is reversed through the agency of the interposed idler, so that the rotary speed of the driven gear is equal to the sum of a positive motion and a negative one. That is, the rotary speed of the driven gear is equal to the rotary speed of the driving arm multiplied by one minus the quotient of the diameter of the dead gear divided by the diameter of the driven gear.

A simple epicyclic train with an odd number of idlers presents an interesting arrangement of gearing, for, if the driven gear is of the same diameter as the dead gear, no rotary motion will be imparted to the driven gear, no matter how speedily the arm might be revolved. The driven gear will travel with the driving arm, on which it is mounted, but the location of any point on its circumference, in reference to its axis, will remain constant. Should the driven gear be the larger, its rotation on its axis will be in the same direction as that of the driving arm; while, if the dead gear is the larger, its direction of rotation will be reversed. This gives a wide range of speed and the possibility of securing a high speed ratio, with but a comparatively small variation in the sizes of the effective members.

The two foregoing arrangements, representing elemental, or basic, types of epicyclic trains, have quite limited use, for the driven gear is mounted on a swinging shaft and the effective use of its rotary speed is a difficult matter, unless the train is used as a transmission medium in more complicated mechanisms, an example of which will be analyzed subsequently.

Simple Internal Epicyclic Gear Trains

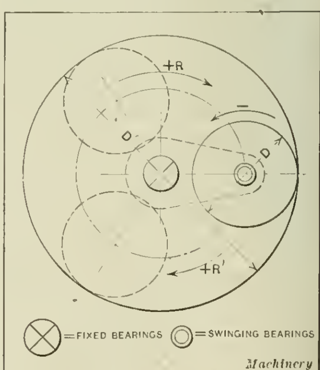


Fig. 7. Simple Internal Epicyclic Train with Arm driving and No Dead Gears

In Fig. 4 is shown a simple internal epicyclic train of two gears in which the pinion is the dead gear and the arm that carries the internal gear on swinging bearings is the driving member. Obviously, the internal gear has two independent motions, namely, rotation about the stationary dead gear with which it is held in mesh by the driving arm, and rotation about its own axis.

Considering the driven gear as fixed, a revolution of the driving arm, were that possible, would cause the driven gear also to make a revolution in the same direction. With the driving arm fixed and the stationary gear freed so it could make a revolution in a direction opposite to that of the driving arm—the direction in which it would revolve during the rotation of the driving arm were it free to do so—the driven gear (internal gear) would be rotated in a direction opposite to that of the driving arm by that part of a revolution measured by the quotient of the diameter of the dead gear divided by the diameter of the internal gear. The sum of these independent motions, the rotary speed of the driven gear, is equal to the rotary speed of the driving arm multiplied by one minus the quotient of the diameter of the stationary gear divided by that of the internal gear.

This arrangement of gears, like the simple epicyclic trains composed exclusively of externally meshing gears, has the disadvantage, for many services, of non-concentricity of driving and driven members; that is, the rotary path of the driven gear is not concentric with the revolving path of the driving arm, or *vice versa.* With the internal gear arrangement, however, this can be overcome without the necessity of additional parts or other complication of the mechanism. By making the pinion active instead of dead, the bearings of the internal gear fixed instead of swinging, and the pinion bearings of the floating type instead of fixed, as in Fig. 7, the rotating arm and the internal gear continue to be the effective members, and there is no change in the relationship of their respective speeds of revolution, no possibility of other motion being introduced. The rotary paths of the driving and the driven members are then concentric, and the construction can be used as a simple and effective speed reducer between two aligned shafts.

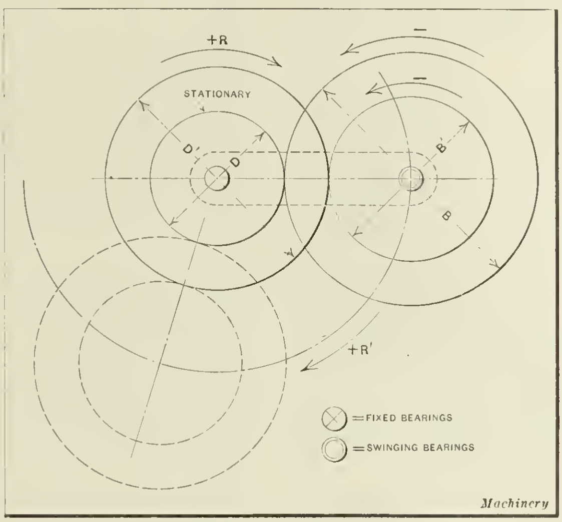


Fig. 10. Compound Epicyclic Train

As the diameter of the pinion is less than that of the internal gear with which it meshes, the direction of rotation for the driving and the driven members in the two latter arrangements of epicyclic gear trains must always be the same; and, by making the diameter of the pinion as large as possible, high speed ratios with but two gears can be secured. When the pinion is small in comparison with the internal gear, the speed ratio is small, and it frequently becomes advisable to use several such planetary pinions—such an arrangement being shown in Fig. 7—in order that the pinions, with their comparatively high speed of revolution, will not be overloaded. In such cases the driving arm is replaced by a driving bracket carrying the necessary number of pinions mounted in fixed relationship on a concentric circumference of swinging bearings. Any number of pinions for which there is sufficient accommodation may be installed without in any way affecting the speed ratio of the mechanism, for the pinions simply distribute the load.

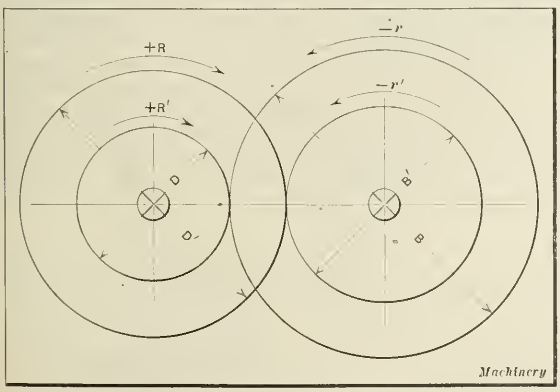


Fig. 8. Compound Gears in Fixed Bearings

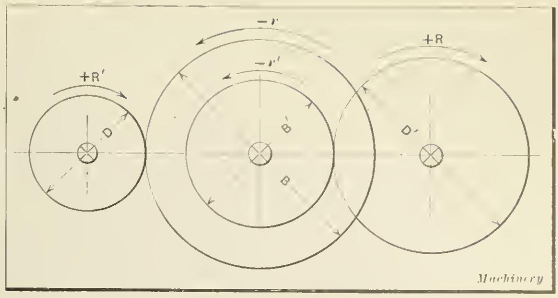


Fig. 9. Simple Gears in Fixed Bearings with Intermediate Compound Idler

Simple Internal Epicyclic Trains with Intermediate Gear

The interposition of an intermediate gear between a central gear and the internal gear, as shown in Figs. 5 and 6, forming the familiar "sun-and-planet" gear, is an arrangement that is frequently encountered and that well exemplifies the principles of epicyclic gear trains. In such arrangement, either the central gear or the embracing internal gear may be dead, but one must be stationary.

Considering the central gear as dead and the arm as driving, as shown in Fig. 5, the internal driven gear, if fixed so that it will have to revolve with and at the same speed as the driving arm, will make a revolution for each rotation of the arm and in the same direction. With the arm fixed, the rotary motion imparted to the internal gear during a revolution around the central gear is the same as that imparted to it by a revolution of the central gear in the same direction. The planetary idler reverses the direction of rotation and the rotary motion will be measured by that part of a complete revolution represented by the quotient of the diameter of the central gear divided by the diameter of the internal gear. The speed of the driven internal gear, the central gear being dead, is then equal to the speed of the driving arm multiplied by one plus the quotient of the diameter of the dead gear divided by that of the embracing internal gear.

By making the internal gear the driving member, instead of the arm, as shown in Fig. 6, the co-relationship of the rotary speeds of the effective members is quite different. Considered as fixed, that is, turning with and at the same speed as the internal gear, the arm will make a revolution for each revolution of the internal gear and in the same direction. Considering the internal gear, or the driving member, as fixed, the retarding influence of the rotating planetary idler can be ascertained from the reverse rotation of the central gear, which will produce the same effect upon the planetary idler as a forward revolution of the internal gear. The number of reverse turns of the central gear required for such result will be equal to the quotient of the diameter of the internal gear divided by that of the central gear. For each of these reverse revolutions of the central gear, the arm will be turned in the same direction for that part of a revolution measured by the reciprocal of the number of reverse turns of the central gear required

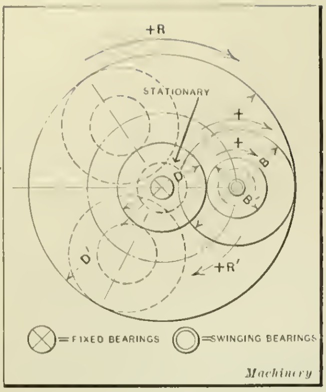


Fig. 11. Compound Internal Epicyclic Train

to actuate the planetary idler in the same manner as a forward revolution of the internal gear. This portion of an arm revolution will also be measured by the ratio of the rotary speed of the central gear to that of the internal gear, when the driving arm is fixed, so the retarding influence of the planetary idler is equal to this speed ratio multiplied by the portion of a reverse revolution of the arm made during a reverse revolution of the central gear. Simplified, the retarding influence of the planetary idler is equal to the rotary speed of the driven arm multiplied by the quotient of the diameter of the central gear divided by that of the internal gear. The rotary speed of the driving internal gear minus this measure of the retarding influence of the planetary idler is then equal to the speed of the driven member of the mechanism, the arm.

The sun-and-planet gear may also be arranged so that the driving member is the central gear and the internal gear the dead member. In such construction, the retarding influence of the planetary idler, per revolution of the arm, will be measured, not by the quotient of the diameter of the central gear divided by that of the internal gear, but by the quotient of the diameter of the internal gear divided by the diameter of the central gear. This gives a speed formula similar in form to that for the arrangement shown in Fig. 6, but with the diameter of the central gear substituted for that of the internal gear and that of the internal gear for that of the central gear.

If both the central and internal gears are free to revolve in any of the sun-and-planet gear arrangements, the effective members will revolve at the same speed. The intermediate gear, the planetary idler, will lock the effective members in relation to one another. The planetary idler, or idlers should there be a number of them as in most adaptations of this type of speed reducer, in rolling around the internal gear will tend to cause the central gear to revolve in the opposite direction, and in rolling about the central gear to cause the direction of rotation of the internal gear to be reversed, so that the whole mechanism will have to revolve as a unit about the central shaft.

Compound Gear Combinations

The foregoing arrangements cover all types of simple epicyclic gear trains; the more complicated arrangements involve the use of compound gear combinations. The arrangement of gears shown in Fig. 8 illustrates the principles of compound gearing in fixed bearings. More gears may be placed on the respective shafts in order to secure a greater speed ratio for the train, or there may be more than two shafts, as shown in Fig. 9, upon at least one of which a compound gear must be mounted without in any way affecting the general principle and the compound gear rule, which is: The ratio of the velocity of the driven gear to that of the driving gear is equal to the ratio between the continued product of the diameters of the driving gears to the continued product of the diameters of the driven gears. In a train with an odd number of compound gears, the direction of rotation of the effective driving and driven gears is the same, while if the number of compound gears is even, the directions of rotation are opposite; provided, of course, that other reversals in direction of rotation are not made by supplementary idlers.

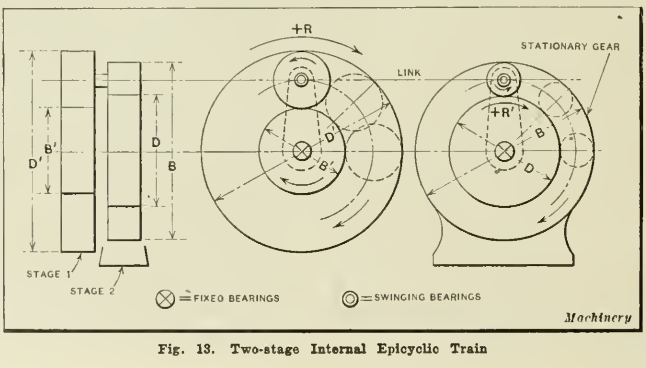


Fig. 13. Two-stage Internal Epicyclic Train

Compound Epicyclic Gear Trains

The arrangement of a compound gear on the swinging shaft meshing with simple dead and driven gears mounted on fixed bearings shown in Fig. 10 is the simplest variety of compound epicyclic train. The derivation of its speed formula will be given in detail. The dead gear, about the axis of which the driving arm revolves, is shown mounted on the same shaft as that carrying the driven gear in order that the rotation of the effective members may be concentric, which is the more practical arrangement, though not essential to the epicyclic principle; it is assumed that the pitch of all gears is the same. First, consider the driven gear fixed in the arm and the arm free to revolve, disregarding the meshing of the stationary gear with its mating gear. Under such conditions, the driven gear would revolve with the driving arm, making the same number of revolutions and in the same direction. Next, consider the driving arm fixed and the driven gear free to revolve. The motion (rotary) that will be imparted to the driven gear by a revolution of the driving arm is the same as will be imparted to it, with the driving arm fixed, by a revolution of the central gear in the reverse direction. Reversing the rotation of the central gear will also reverse the direction of rotation of the driven gear. As both the central gear and the driven one are mounted on the same shaft, the motion imparted to the driven gear by its rotation on its own axis through the agency of the compound gear on the swinging shaft is negative. This motion, considering the central gear as a driver, is equal to the product of the diameters of the driving gears by the speed of the driving arm divided by the product of the diameters of the driven gears. The speed of the driven gear is then equal to the sum of the positive motion due to its revolution with the driving arm and of the negative motion due to the agency of the compound gear, or is equal to the speed of the driving arm multiplied by one minus the quotient of the product of the diameters of the driving gears by the product of the diameters of the driven gears.

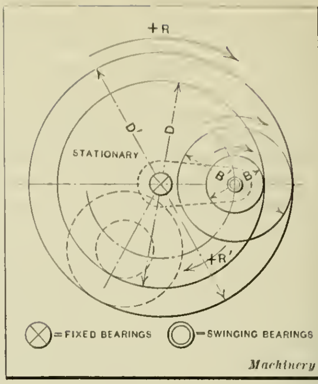


Fig. 12. Compound Double Internal Epicyclic Train

If the product of the diameters of the driving gears is less than that of the driven gears, as shown in Fig. 10, the direction of rotation for both the driving arm and the driven gear will be the same. If the products of the diameters are equal, the driven gear will not revolve, no matter what the speed of the driving arm may be. While should the product of the diameters of driving gears be greater than that of the driven gears, the driving arm and the driven gear will revolve in opposite directions.

Compound Internal Epicyclic Trains

The substitution of an internal gear for the externally meshing driven gear of the preceding arrangement, as shown in Fig. 11, simply reverses the direction of motion imparted to the driven

gear through the agency of the compound gear so that the rotary speed of the driven gear is equal to that of the driving arm multiplied by one plus the quotient of the product of the diameters of the driving gears divided by the product of the diameters of the driven gears. The direction of rotation of the driving arm is necessarily the same as that of the driven gear, for no reverse motions or retarding influences occur in this arrangement of epicyclic gearing. Making either the internal gear or the central gear the driving member and the arm the driven member of the combination alters the co-relationship of the speeds of the effective members in a manner analogous to the changes in the speed formulas for sun-and-planet gears when the arm is changed from the driving to the driven member in such gear combinations.

Still another modification of the simple compound epicyclic train is shown in Fig. 12, in which both the dead gear and the driven gear are of the internal type. With this arrangement of gearing, the rotary speed of the driving arm bears the same relationship to that of the driven gear as in the arrangement of a compound train of externally meshing gears. The motion of the driven gear, by virtue of its rotation with the driving arm, is positive, while the motion imparted to it through the agency of the compound idler is negative. When the diameter of the dead gear is less than that of the driven gear, in this variety of compound epicyclic train, the diameter of the section of the compound idler rolling with the stationary gear is also less than that of the section driving the driven internal gear. As a result, the product of the diameters of the driving gears is less than the product of the diameters of the driven gear and the driven gear revolves in the same direction as the driving arm. If the two internal gears are of the same size, unless of different pitch, there will be no motion of the driven gear; while if the dead gear is the larger of the internal gears and of the same pitch as the other, the direction of rotation of the driven gear will be opposite to that of the driving arm.

A modification of this general arrangement with two internal gears, whereby either of the internal gears becomes the driving member and the arm the driven member, affects the speed ratio of the combination in much the same way as converting the arm from a driving to a driven member in compound epicyclic trains with only one internal gear. The difference is that in the case of trains with two internal gears the influence of the compound idler is positive instead of negative.

Compound Epicyclic Trains with Gears of Different Pitch

The pitch of the gears is specified in the foregoing arrangements of compound epicyclic gear trains, as the compound gears in such mechanisms may have sections of different pitch, thereby securing speed ratios that could not be practically obtained in any other way. A change of pitch affects the speed ratio in the same manner as a variation in the diameter of the gears. In such instances, therefore, it is necessary to substitute the number of teeth in the gears for their diameters in the speed formulas. The examples of simple and compound epicyclic gear trains that have been considered cover the general types of epicyclic gearing, but these simple mechanisms may be still further compounded by additional gearing; simple epicyclic trains may be combined with compound epicyclic trains, etc., so that a great number of different epicyclic gear mechanisms can be evolved. They will all be based on the same general principles as those that have been described, however, and a clear conception of their action requires but an analytical study of the individual motions involved and the application of the general formulas that have been derived, which are listed in the accompanying table.

Notation for Formulas

Diameter, number of teeth, of dead gear .... D
Diameter, number of teeth, of driven gear .... D'
Diameter, number of teeth, of section of compound gear meshing with dead gear .... B
Diameter, number of teeth, of section of compound gear meshing with driven gear .... B'
Velocity, revolutions, of driven gear, or arm .... R
Velocity, revolutions, of driving gear, or arm .... R'

Two-stage, Internal Epicyclic Gear Reducer

An example of a more complex epicyclic gear train—a successful speed reducer—is shown in Fig. 13. This mechanism is made up of two stages, each of which is composed of a central gear, about which there is a comparatively large concentric internal gear, one slightly larger than the other but both of the same pitch, and between the central gears and their respective circumscribing internal gears is a compound plane-

GENERAL SPEED FORMULAS FOR EPICYCLIC GEAR TRAINS

Type of Train	Number of Gears	Formulas	Rotation R and R'	Form. No.
Simple	2	$R=R'\left(1+\frac{D}{D'}\right)$ $R'=\frac{RD'}{D'+D}$	Same	(1)
Simple, with idler and arm driving	3	$R=R'\left(1-\frac{D}{D'}\right)$ $R'=\frac{RD'}{D'-D}$	Same or opposite	(2)
Simple internal, with arm driving and pinion dead	2—1 internal	Same as Formula (2)	Same	....
Simple internal, with arm driving and no dead gears		Same as Formula (2)	Same	....
Simple internal, with idler and arm driving.....		Formula (1)	Same	....
Simple internal, with idler and internal gear driving, central gear being dead......	3	$R=\frac{R'D'}{D'+D}$ $R'=R\left(1+\frac{D}{D'}\right)$	Same	(3)
Simple internal, with idler and central gear driving, internal gear being dead......		$R=\frac{R'D}{D+D'}$ $R'=R\left(1+\frac{D'}{D}\right)$	Same	(4)
Compound........	4	$R=R'\left(1-\frac{DB'}{D'B}\right)$ $R'=\frac{RD'B}{D'B-DB'}$	Same or opposite	(5)
Compound internal, with arm driving	4—1 internal	$R=R'\left(1+\frac{DB'}{D'B}\right)$ $R'=\frac{RD'B}{D'B+DB'}$	Same	(6)
Compound internal, with internal gear driving and central gear dead		$R=\frac{R'D'B}{D'B+DB'}$ $R'=R\left(1+\frac{D'B}{DB'}\right)$	Same	(7)
Compound internal, with central gear driving, internal gear being dead	4—1 internal	$R=\frac{R'DB'}{DB'+D'B}$ $R'=R\left(1+\frac{DB'}{D'B}\right)$	Same	(8)
Compound internal, having two internal gears with arm driving		Same as Formula (5)		
Compound internal, having two internal gears, the larger internal gear driving.	4—2 internal	$R=\frac{R'D'B}{D'B-DB'}$ $R'=R\left(1-\frac{DB'}{D'B}\right)$	Same or opposite	(9)
Compound internal, having two internal gears, the smaller internal gear driving.....		$R=\frac{R'DB'}{DB'-D'B}$ $R'=R\left(1-\frac{D'B}{DB'}\right)$	Same	(10)

Machinery

tary idler. The internal gear of one of the stages is stationary, a dead gear, and encircles the driving gear of the combination, the arm being the driven member. The internal gear of the second stage is the driven member of the combination, while the central gear it circumscribes is active and rotates with and in the same direction as the driving gear of the first stage.

Stage 1 is obviously a simple internal epicyclic train in which the central gear is the driving member, the arm the driven member, and the internal gear the stationary, or dead, member. One revolution of the driving gear will cause the driven arm to make but a partial revolution, measured by the quotient of the diameter of the driving arm divided by the sum of the diameters of the driving gear and the stationary internal gear, according to Formula (4) in the table.

Stage 2 is also a simple internal epicyclic train but of a somewhat special nature, as there is no dead member. This adds a third motion to this stage, which affects the speed of the driven gear but is quite independent of the action of Stage 1; that is, the third motion is not apparent in Stage 1 but must be considered in Stage 2. Without this third motion, the speed of the driven gear, the arm of Stage 2 being the driving member for the second simple internal train, would be equal to the speed of the driving member multiplied by one plus the quotient of the diameter of the central gear divided by that of the internal gear, Formula (1), the direction of rotation being the same as that of the driving arm and of the driving gear in Stage 1. As the speed of the driving arm for Stage 2 is the same as the speed of the driven member of Stage 1, the speed of the driven gear of the combination, disregarding the third motion produced by the live central gear of Stage 2, would be equal to the product of the speed developed in Stage 2, in terms of the speed of the rotating arm, and the ratio of the speed of the driven arm to that of the driving gear of Stage 1. This speed ratio is equal to the diameter of the driving gear divided by the sum of the diameters of the driving and stationary gears. The third motion affecting the speed of the driven gear, that due to the revolution of the central gear in Stage 2, is a negative one, the central gear and the driven gear revolving in the same direction and the motion being transmitted between them through the agency of an intermediate gear. This retarding motion is measured, per revolution of the driving member of the combination, by the quotient of the diameter of the central gear (Stage 2) divided by that of the driven gear, so that the net speed of the driven gear is measured by the speed it would have had but for this retarding motion minus the reduction in speed due to the activity of the central gear. Expressed in algebraic form, the relationships between the driving and driven speeds of the mechanism are:

$$R = \frac{R'\,(DD' - B'B)}{D'\,(D + B)} \text{ and } R' = \frac{RD'\,(D + B)}{DD' - B'B}$$

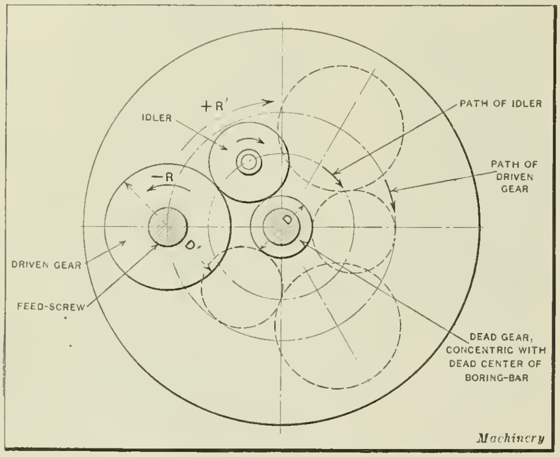


Fig. 14. Epicyclic Gear Train in Boring-bar

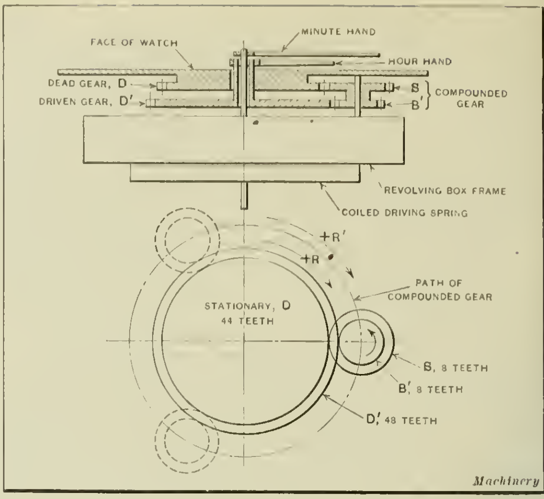


Fig. 15. Compound Epicyclic Train in Waterbury Watch

Obviously this two-stage, internal, epicyclic gear train speed reducer can be proportioned to develop a high speed ratio. Such a mechanism, having the stationary gear 24 inches in diameter, driven gear 24.2 inches, the driving gear 20 inches, and the central gear of the second stage 19.8 inches in diameter would have a speed ratio of 121 to 1. In this case the driving gear D is 20 inches, the driven gear D' is 24.2 inches, the stationary gear B is 24 inches, and the central gear B' is 19.8 inches diameter. Therefore, the speed of the driven gear, in terms of the speed of the driving gear is:

$$R = \frac{R'\,(20 \times 24.2 - 19.8 \times 24)}{24.2\,(20 + 24)} = \frac{8.8\,R'}{1064.8} = 0.0082644\,R'$$

The speed ratio is, therefore, $R' : R = 121 : 1$.

Epicyclic Gear Trains in Boring-Bars

Certain types of boring-bars use a simple epicyclic train by which the revolution of the bar on its dead center is employed to carry the feed-screw (within the bar) about a circular path concentric with the dead center of the tool, and in so doing impart the rotary motion to the screw required for the feed. For this construction a sliding type of head is essential, the driven gear of the epicyclic train being attached to the end of the feed-screw, as indicated in Fig. 14.

The epicyclic train is of the simple type with an idler, the function of the latter gear being to secure opposite directions of rotation for the boring-bar and the feed-screw. This necessitates making the driven gear of the train larger than the dead gear. In Fig. 14, the driven member is the gear at the end of the feed-screw, the driving member is the arm measured by the offset of the feed-screw from the dead center of the boring-bar, and the stationary gear is a dead gear concentric with the dead center of the boring-bar. Assigning a diameter of 5 inches to the dead gear and one of 10 inches to the driven gear at the end of the feed-screw, the boring-bar will make one revolution while the feed-screw makes but one-half

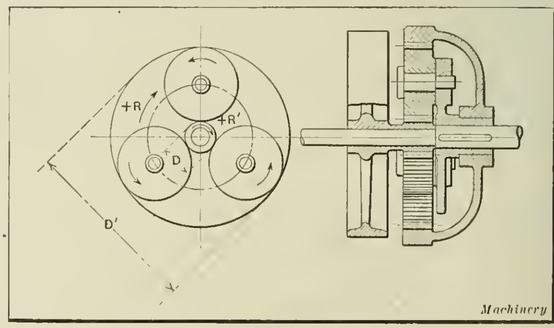


Fig. 16. Differential Back-gear

a revolution. This is shown by substituting in Formula (2) $D = 5$ inches, $D' = 10$ inches, $R' = 1$. With a feed-screw of 8 threads per inch, this would give a boring-bar feed of 1/16 inch per revolution.

Compound Epicyclic Gear Trains in Watches

One of the commonest examples of a compound epicyclic gear train is to be found in the mechanism that actuates the hands of certain watches; and this is one of particular interest, as the desired speed ratio is best secured by slightly altering the pitch of the compound gear. The change of pitch makes it possible for the double gear of individual gears to have the same number of teeth, as the two sections differ but slightly in diameter, and thus secure the same result as if the compound gear were made up of individual gears of the same pitch but a different number of teeth and the corresponding difference in diameter.

Fig. 15 illustrates diagrammatically the mechanism used in the Waterbury watch on a somewhat distorted scale in order to more clearly depict the construction. The minute hand is carried on the end of a shaft upon which is mounted a revolving box frame containing other mechanism essential to the operation of the watch but that does not constitute any part of the epicyclic gear train. This frame, which acts as the driving arm of the epicyclic train, is rotated by a coiled spring at the rate of one revolution per hour. Protruding from the box frame, near its circumference, is the shaft carrying the compound gear. One section of this compound gear engages a dead gear fastened to the face of the watch, and the other section meshes with a gear attached to the sleeve carrying the hour hand. This latter gear, which is the driven gear of the train, the dead gear, and the path of the compound pinion as it is carried by the box frame are all concentric, and the train is evidently of the simple compound type for which Formula (5) is applicable.

In the Waterbury watch, the compound gear is made up of what is equivalent to two individual gears of eight teeth each, but slightly differing pitch; the dead gear has forty-four teeth and the driven gear actuating the hour hand has forty-eight teeth. Substituting the number of teeth in the various gears for their respective diameters in Formula (5) the speed of the driven gear is found to be one-twelfth that of the driving member, or the revolving box frame. That is, the hour hand makes one-twelfth revolution while the minute hand circles the watch.

Differential Back-gearing

An example of the application of epicyclic gear trains to machine tools, which is probably their most familiar use, is the back-gearing of drilling machines and other light machine tools. Such a mechanism is shown in Fig. 16 and is of the sun-and-planet gear type for which the speed formula is that given as Formula (4). The driving member is the central gear and the large internal gear is stationary while the reducer is in operation. A differential gear in which the embracing internal gear is 18 inches in diameter and the central gear 3 inches will have a speed ratio of 7 to 1, according to Formula (4), where $D = 3$ and $D' = 18$ inches, the direction of rotation of the connecting shafts being the same. By locking the mechanism and liberating the internal gear, the two abutting shafts will revolve at the same speed and, of course, in the same direction.

* * *

The general experience is that severe vibration tends to tire workmen and make them irritable and inefficient. In one case where vibration occurred, a correspondent states that it was necessary for the company to take prompt measures to overcome it, as under certain conditions it was impossible for the employes to stand it for a very long time. This meant that if they had to work on a floor which was vibrating, they were far from 100 per cent efficient. In the case of women it seemed impossible for them to stand the vibration even temporarily on account of the nervous strain. It is believed that employes working under such conditions as were there present were not over two-thirds efficient.—*Extract from "The Effects of Vibration in Structures," published by the Aberthaw Construction Co., Boston, Mass.*

SLIPPAGE OF BELTS RUNNING AT HIGH SPEED

BY W. A. LAILER

One of the troubles encountered in belt-transmission practice, especially where the belts are run at high speed, is the slipping of the belt on the driven pulley, making it almost impossible to maintain proper speed ratios between the driver and the driven pulleys. The lost motion caused by the slipping of the belt results in the driven pulley being operated at a speed below that figured for it from the formulas or equations used for obtaining pulley speeds; and where the efficient operation of a machine is dependent on its running at the proper rate of speed, the uncertainty introduced is a serious matter. What makes the problem even more difficult is the fact that this slippage does not follow any fixed ratio or proportion, but varies for each particular set of conditions, and may even vary at different times under the same general operating conditions, because of weather, etc.

In general, two theories are advanced as to the cause of belt slippage: First, that it is due to an air cushion being drawn between the belt and the pulley; and second, that it is due to centrifugal action. The first theory is based on the assumption that the high speed of the belt causes air to be drawn in under it as it approaches the pulley, forming an incompressible air cushion between the belt and pulley surface on which the belt skims and slides instead of actually coming in contact with the tractive face of the pulley. Following the conclusions reached by this line of reasoning a number of methods have been devised for eliminating these so-called air-cushions between the belt surface and the pulley face. Probably the simplest method is the use of a pulley with holes in it to allow the immediate release of any air entrapped between the belt and the pulley. Another method is to place a small deflector near the under surface of the belt, just before it enters the pulley, so that any air pockets carried with the belt will be broken up and dispelled. This deflector may be made stationary where the belt passage is constant; or where vibrations are present, it may be held lightly against the inner surface of the belt by means of a light spring bracket. Still another method is to cut grooves in the surface of the pulley so that the air is forced into the grooves while contact is established between the elevated parts of the pulley face and the belt.

The theory of air cushioning is discounted by many on the ground that the tension pressure between the belt and pulley is so great as to make impossible the retaining of any film of air. Those who belittle the theory of air cushioning usually claim that the slippage in high-speed belts is due to centrifugal force, which causes the belt to stretch and tends to make it rise off the pulley face. It is admitted that the belt does come in contact with the pulley at frequent enough intervals to supply tractive power, but it is also momentarily thrown off the pulley face, thus making it appear as if it were riding on the air cushion. In support of this theory, it is pointed out that the lower the belt speed the lower will be the centrifugal force, and hence the less the belt will stretch. It has been found that with belts running up to 4500 or 4800 feet per minute no trouble from excessive slippage due to centrifugal action is encountered, but at higher speeds the force brought into play due to centrifugal action is sufficient to cause a considerable falling off in efficiency.

Another check of the correctness of this theory is the fact that the slipping of the belt can be eliminated by taking up any stretching due to centrifugal force that may occur after the pulley gets up to speed by drawing the pulley out to the belt, through the use of adjusting screws and sliding frames. It will be noted that when the belt is stopped and the centrifugal tension released, the driven pulley must be drawn back again to its former position, or the belt will span tightly between the two pulleys and will be subjected to great internal strain. This theory can be tested by mounting the driven pulley on a sliding frame with adjustable screws, as is the general practice in motor construction. Then after the belt is started, the stretch caused by centrifugal force may be taken up by adjusting the screws and drawing the pulley out

against the belt in its stretched position; but the operation must be reversed before the belt is stopped and centrifugal tension is released. Another remedy for this trouble would be to use a belt made of some material that will not stretch. Unfortunately no material that is strong and pliable enough to do the work has been found that will not also be subjected to this stretching action.

* * *

CHANGES IN MANUFACTURE

BY ERIC LEE[1]

It is interesting to note how both small and large results may be obtained from a change in manufacture. When the original lay-out was made, something may have been overlooked, and often one operation may be substituted for two or more others. But sometimes it is cheaper not to interfere with the original lay-out, as the changing over or making of new machines, jigs or fixtures will exceed the profit obtained.

When a new product is to be made, the operations are considered separately and collectively. All the apparatus for each operation is taken into account, the foremen of the shops are consulted, their opinions upon the routine of operations noted, and prices fixed before any permanent method of manufacture is adopted. But in all mechanical industries, whatever standard has been adopted, the only visible constant is change. However good a lay-out may be, it is only relative, and from time to time it has to be made flexible by a change in manufacture. Many factors must be taken into consideration, however, and a large profit must be shown before any radical change is made. Among the things to be considered are the amount of the product on the market and in the storehouses, the number likely to be returned for repair, and the interchangeability of the new part with parts formerly made; that is, it must be determined whether the parts changed in manufacture can be altered so as not to be noticeable in an article that has obtained a wide reputation, and whether the change will materially affect any other part of the mechanism. Changes of tools, gages, jigs and fixtures must also be carefully considered.

If the original lay-out was properly performed and each operation considered separately and collectively, it will be difficult, through a slight change in design, to bring about a new and proper sequence of operations. While a temporary change may prevent a lot going to the scrap pile through being milled small or splined too large, or for some similar reason, it is sometimes better to locate the origin of the defect, scrap the lot, and use such measures as will eliminate the cause. In large manufacturing concerns, when a change is necessary and the resulting profit is likely to be considerable, some plan should be devised whereby the manufacture of the gages, jigs, fixtures and machines used for the operation that is to be discarded will be automatically stopped until the necessary changes have been made upon the blueprints by some drafting-room official; and as these mechanical devices are made in various shops, it is essential that this plan works properly.

A change in manufacture does not always eliminate an operation; sometimes it may add one. There have been cases where two operations cost less than one. In one instance, where drilling and counterboring were done at a cost of 22 cents per hundred, by dividing this work into two operations and paying 10 cents a hundred for drilling and 8 cents a hundred for counterboring, a saving of 4 cents a hundred was accomplished. This gain was brought about by speeding up the drilling and letting the counterboring run at a more moderate speed. The workmen made just as much pay, but the cost of cutting tools was greatly diminished, as it was expensive to make the counterbore and drill in one piece, and when it broke both the drill and the counterbore had to be scrapped. When the drill and counterbore were made separately, they cost less and could be ground more easily; the work was also done more quickly, as several drills and counterbores were kept on hand.

It has been found expedient to make a change in a ring gage, when a lot of 10,000 has run small. However, with up-to-date methods of gaging it seems almost impossible to run over 500 parts small. Sometimes, when gages suffer excessive wear, as, for instance, thread gages, all gages are called in on Saturday, inspected on Sunday, and are ready for work the next day; this plan, however, is expensive, as it entails much overtime for gage-makers. Another method is to provide two sets of gages. One set is in the gage-room while the other is in the shop, and the sets are changed every week, so that those in use are continually being inspected.

Sometimes when a change of manufacture is necessary, the designer will visit the store-room and redesign some discarded machine at low cost. At other times, a designer will try to change over a machine that is quite inadequate for the operation necessary. In many cases, a new machine could have been built for one-half the cost required to change over an old one, just to prevent its being an eyesore to the master mechanic.

Often changes are suggested that a little consideration would prove inadvisable. A design was once made over for a slight change in manufacture, and a fixture costing $275 was built to take the place of a templet for laying out work. This templet was made from a piece of stiff brown paper, and when one piece of paper was worn out another was substituted. However, it was thought that by the aid of this new fixture women could be employed to do the work, which was extremely light. A trial showed that the new fixture quickly lost its shape, so it was found cheaper to discard it and go back to the old method.

[1]Address: 195 Bassett St., New Haven, Conn.

* * *

RESOLUTIONS ADOPTED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The American Society of Mechanical Engineers adopted three important resolutions at the Cincinnati meeting relating to war conditions, as follows:

Dissemination of Munitions Standards

Whereas, serious delays have been experienced in other countries and this country in the production of munitions work, and rejection and unnecessary loss to manufacturers, and its consequent shortage of labor and material due to lack of control of data and of standards of measurement; and

Whereas, Great Britain, Canada and France have found standardization of measurement of all war material for both army and navy imperatively necessary to obtain uniform and reliable results, and have constructed an efficient organization, which has proved successful in overcoming these difficulties; and

Whereas, increased efficiency of our manufacturers would be promoted by the establishment of proper standards of measurement; be it

Resolved, that the Congress be urged to appropriate sufficient funds for expenditure through the Munitions Board, or other agency, to provide standards and adequate means of calibration, distribution and supervision of such standards, including means for calibration of working and inspection standards in the different centers of munitions manufacture.

Also that provision be made in this appropriation for the establishment of a central office for the collection and dissemination of information on the methods of manufacturing munitions and other supplies.

Resolved, that the American Society of Mechanical Engineers indorse any effort tending to promote the ends outlined above, and in view of the imperative needs of the present situation, most strongly urge immediate action.

No Secrets in Munitions Work

Whereas, it is the patriotic duty of every manufacturer to facilitate and expedite the manufacture of munitions and other supplies for the army and navy; be it

Resolved, that an appeal be addressed to all manufacturers and engineers to cooperate in the dissemination of information and the interchange of data pertaining to methods of manufacture, system of organization, design of tools, operation of lay-outs and time studies, including what is generally known under the term "shop secrets," so far as they pertain to munitions manufacture.

Recognition of Munitions Workers

Whereas, it is necessary to obtain the patriotic cooperation of every man who can contribute to the furnishing of naval and military supplies; be it

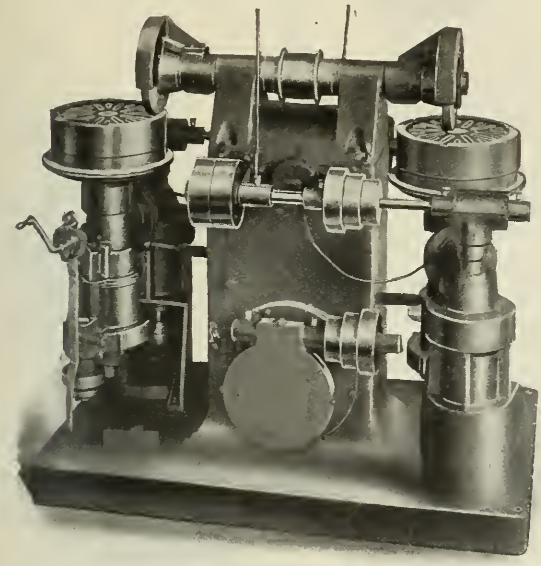
Resolved, that the American Society of Mechanical Engineers urge upon the government the necessity of indicating in some way the value and loyalty of men in service in industries whose occupation is essential to the production of war supplies.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

GLOBE ROTARY SURFACE GRINDER

The accompanying illustration shows a rotary surface grinder built by the Globe Machine & Stamping Co., Cleveland, Ohio, which is claimed to have the productive capacity



Duplex Rotary Surface Grinder built by Globe Machine & Stamping Co.

of two standard grinders, although requiring less attention from the operator. This grinder is really a double machine, so constructed that the mechanism of one chuck and grinding wheel can be operated as a unit entirely independently of the other. This feature permits the operator to prepare his work on the idle chuck and allows the grinding to continue without interruption. Both chucks can be operated simultaneously if so desired, thus enabling the operator to devote his attention to other work. The grinding wheel head is secured to the frame in a fixed position, affording a rigid construction and preventing the wheels from being thrown out of alignment.

There are no sliding surfaces on this machine, and all working parts are effectively protected from dust and abrasive grit. An automatic feed and stop is provided on the grinder, and by means of this device work can be fed to the grinding wheel from 0.0005 to 0.005 inch for each stroke of the machine. The stop can be set to release the feed at any point, and this relieves the operator from the necessity of concentrating his attention solely upon the grinding operation. Each operating unit is independently controlled, and all speeds, feeds, etc., have separate drives, thus making the grinder practically a double machine. Two 12-inch magnetic chucks are mounted on counterbalanced swinging arms with ball thrust bearings of large diameter. The swinging movement is caused by means of a cam and rocker arm of uniform motion, with means for adjusting the length and position of the stroke. There are three speeds for the revolving chucks and three for the work traverse. Six 3¾-inch piston rings can be ground simultaneously on each chuck, and the chucks can be set to grind either concave or convex work.

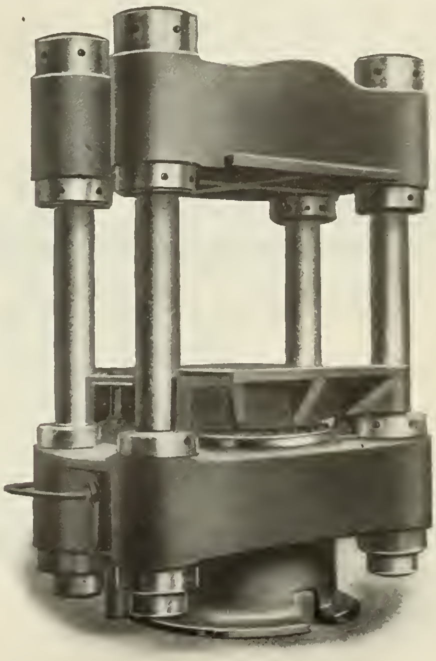
HYDRAULIC FORMING PRESS

Hydraulic pressure is being utilized more and more in forming various articles from sheet steel, steel plates, etc., because of its accurate and positive force. The press here shown was designed and built for steel plate and sheet forming operations. It has a pressure capacity of 1000 tons. The press has an unusually sturdy construction throughout, and is capable of performing heavy forming operations.

This press has an adjustable daylight space of 18 to 36 inches. To provide for this adjustable daylight, the upper ends of the strain-rods are threaded, thus permitting the maximum and minimum daylight to be obtained. The upper ends of the strain-rods are fitted with threaded forged nuts, while the lower ends are made with solid heads and split collars. Both the upper and lower strain-rod collars are threaded, the upper collars serving two purposes: first, to permit the head to be lowered, and, second, to take up all clearance so that the head can be set perfectly true for close work. The lower collars are threaded so that all clearance may be taken up.

The press is equipped with two auxiliary push-cylinders, the purpose of which is to hasten the return of the press platen and ram after the pressing operation. These push-cylinders are equipped with differential rams, the upper ends of which are smaller than the lower. This provides a shoulder on the rams in the cylinders and forms an area to take the water pressure for forcing the ram.

This press may be operated from either an independent pump or an accumulator system. The accumulator is the most satisfactory arrangement, especially where there are several presses being operated, as when the valves of all the presses are opened at one time, an unusual load occurs and the pumps are unable to care for it. The pressure may be allowed to remain on the auxiliary cylinders or they may be operated by means of double-acting operating valves. This press is of steel construction throughout, a large factor of safety being allowed in its design for the heavy pressure which it exerts. It has a pressing surface of 42 inches by 48 inches. This equipment is built by the Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio.



Forming Press of 1000 Tons Capacity built by Hydraulic Press Mfg. Co.

ELGIN AUTOMATIC CHUCK CLOSER

The Elgin Tool Works, Elgin, Ill., are now making an automatic chuck closing attachment to fit any of their bench lathe heads. These attachments may be put on or taken off quickly; they are of simple construction, work easily and rapidly, and are convenient where duplicate chucking operations are being performed. With one of these attachments the lathe does not have to be stopped for loosening or tightening the collet.

The Elgin automatic chuck closer consists of a draw-spindle, two sleeves, dogs, yoke and bracket. The draw-spindle is

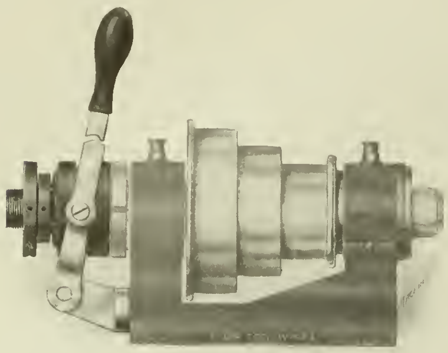


Fig. 1. Automatic Chuck Closer for Bench Lathes made by Elgin Tool Works

threaded on the rear end and fitted with two check-nuts which adjust the tension on the collet. An inner sleeve slips directly over the lathe spindle and is held in place by a set-screw, the point of which fits into a hole provided on the spindles of all Elgin bench lathes. This sleeve also carries the dogs, which are operated by the sleeve and yoke that open and close the collet. The bracket is held in place on the head by means of two screws, tapped holes for which will be found on all Elgin lathe heads.

This automatic chuck closer is so designed that it requires no extra fitting, but may be placed on any head, making use of the tapped holes provided for the indexing, dividing and other attachments. The attachment does not interfere with the ordinary use of the draw-spindle. Used in conjunction with this company's double tool-slide rest, it will be found convenient for manufacturing small duplicate parts. Fig. 2 shows another new product of the Elgin Tool Works, which is known as a No. 4 by 5 bench lathe. In the February, 1909, number of MACHINERY a description was published of a No. 4

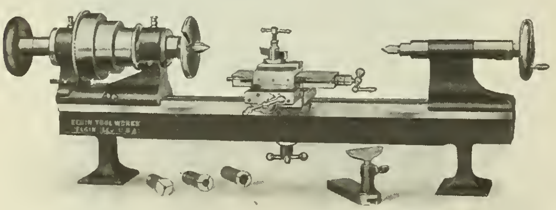


Fig. 2. No. 4 by 5 Bench Lathe built by Elgin Tool Works

bench lathe manufactured by this company, and the present machine is of similar design except that the parts subject to strain have been made considerably heavier to adapt the machine for more severe classes of service.

HARDY GRINDING ATTACHMENT

To provide for performing grinding operations on bench lathes, Charles Hardy, 1051 Boston Road, New York City, has developed a grinding attachment which is capable of handling both internal and external work. It will be seen that a graduated swivel is furnished for setting the attachment at the proper helix angle for thread grinding. The swivel is clamped in any desired position by means of a headless set-screw, which,

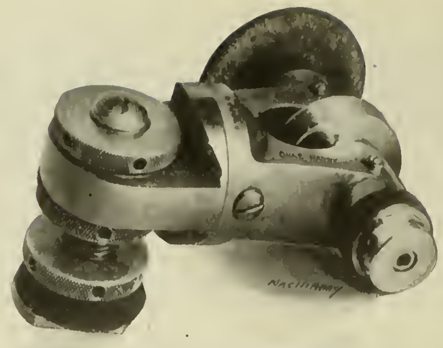


Fig. 1. Grinding Attachment for Bench Lathe built by Charles Hardy

in turn, operates a tapered half ring that is seated in an annular groove of corresponding taper. Application of pressure on the ring by this set-screw causes the latter to expand and bind firmly in the annular groove.

Vertical adjustment is also provided which enables the attachment to be raised or lowered according to requirements of different grinding operations. This vertical adjustment has a maximum range of one inch from the lowest to the highest position. The spindle has double tapered bearings of 5 and 50 degrees taper angle. Both spindle and bearings are hardened and ground, and the bearings are furnished with oil chambers to insure efficient lubrication. For internal grinding an extension spindle is used, which is furnished with a draw-

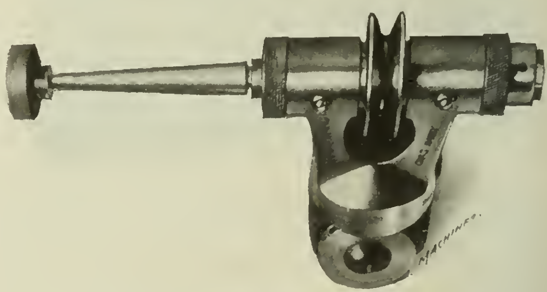


Fig. 2. Attachment shown in Fig. 1 equipped with Internal Grinding Spindle

back mechanism that holds it securely. The attachment may be driven at any required speed for the efficient operation of grinding wheels from 1/4 inch to 3 inches in diameter.

In addition to its use as a grinding attachment, this tool may be employed for the operation of fine end-mills. For this class of work it is held in a vertical position by means of an arm, and the swivel is employed to obtain any required angular

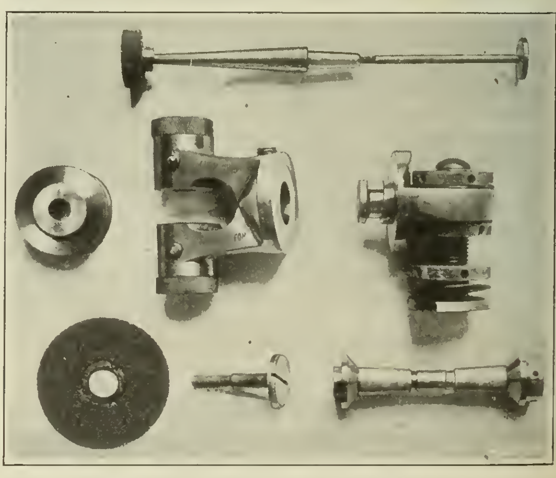


Fig. 3. Parts of Hardy Bench Lathe Grinding Attachment

setting. Used in this way, the tool will be found adaptable for many classes of work which may be conveniently done with small sized end-mills. A feature of the attachment is that it can be easily taken apart for cleaning or adjustment. This may be done in a few moments, and the only tools required are a small screwdriver and spanner wrench, which are included among the tools furnished with the attachment.

MAGNA TURRET TOOLPOST

The Magna Machine Co., 50 Church St., New York City, is now manufacturing the turret toolpost shown in the accompanying illustrations. This toolpost will fit any engine lathe, and one size is interchangeable between all lathes from 11 to 20 inches swing. An exceptionally large number of tools can be mounted in this toolpost, and they are always clear from the chuck and working material. The toolpost will finish a piece of work completely inside and outside, including threading and cutting-off operations. A sequence of operations can be performed at a single setting of the work and without the necessity of changing tools, so that considerable time will be saved where a number of operations must be performed.

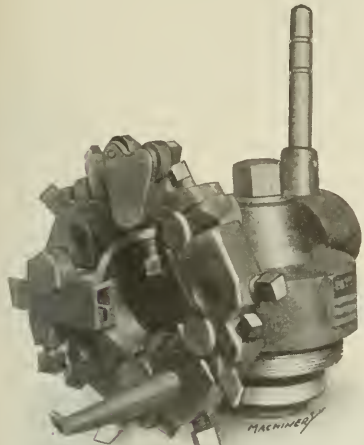


Fig. 1. Magna Turret Toolpost

This turret toolpost is equipped with a cutting-off blade in such a position that cutting off can be done close to the lathe chuck. All external cutting tools are independently adjusted, when necessary, by means of a set-screw. The toolpost is inserted in the tool slot of a compound rest, and a threaded sleeve provides a vertical adjustment of about ¾ inch to accommodate it for lathes of various swings. One set of tools is furnished as part of the equipment, consisting of a knurling tool, four ⅝-inch boring tools, four ⅜-inch square high-speed tool bits, and one ¾-inch high-speed cutting-off blade. The dimensions of the toolpost are 8½ inches long by 8 inches high by 6½ inches deep, and it weighs 18 pounds.

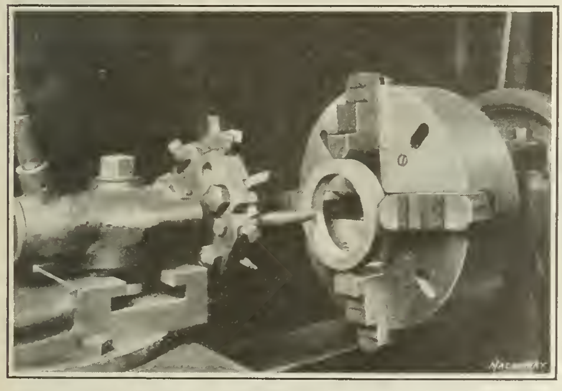


Fig. 2. Magna Turret Toolpost in Operation on Lathe

DETROIT PNEUMATIC CHUCKS

Figs. 1 and 2 show a milling fixture recently made by the Detroit Pneumatic Chuck Co., Flat Rock, Mich., to hold carbureter bodies. These bodies are first machined on turret lathes, in which they are held by air chucks while the first operations are performed. For milling, the fixture is strapped on the top of the milling machine table and is furnished with a two-jaw chuck with jaws made especially to fit the work. The cylinder is attached to a bracket at the opposite side of the chuck, making a compact construction. A valve is fastened on the end of the cylinder, with the supply pipe running from below, and all the operator has to do is to reach out his hand and draw the lever over; with an air pressure of 80 pounds per square inch, the operator throws between one and two tons' gripping pressure on the work. Owing to the use of this high holding pressure, it was necessary to make parts of the fixture of steel and further strengthen them by carbonizing.

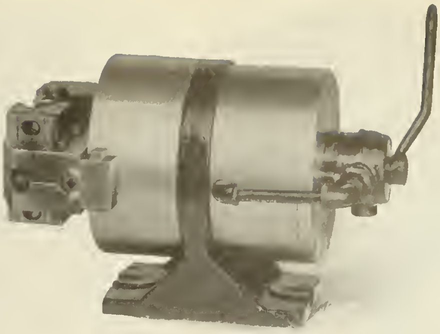


Fig. 1. Detroit Pneumatically Operated Milling Fixture for Carbureter Bodies

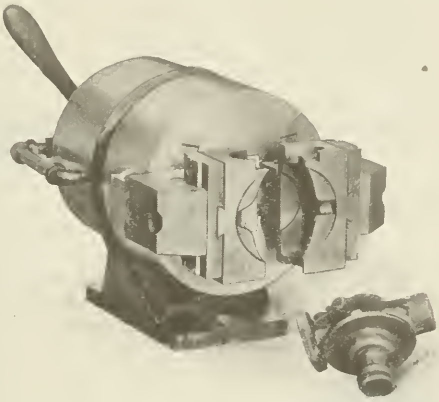


Fig. 2. Opposite Side of Carbureter Body Milling Fixture shown in Fig. 1

Figs. 3 and 4 show how a ring bevel gear for an automobile rear axle is held. Anyone familiar with the machining and grinding of a bevel gear will know the difficulties that are encountered. In this equipment the gear rests on four points

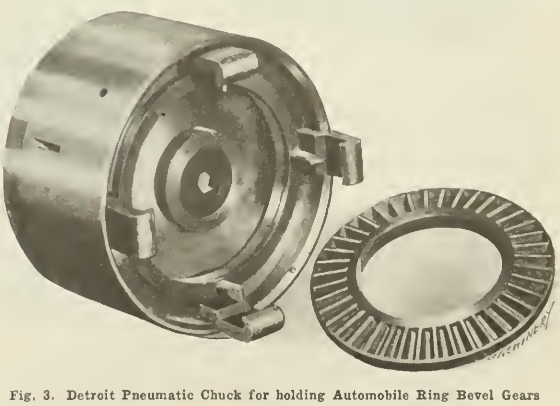


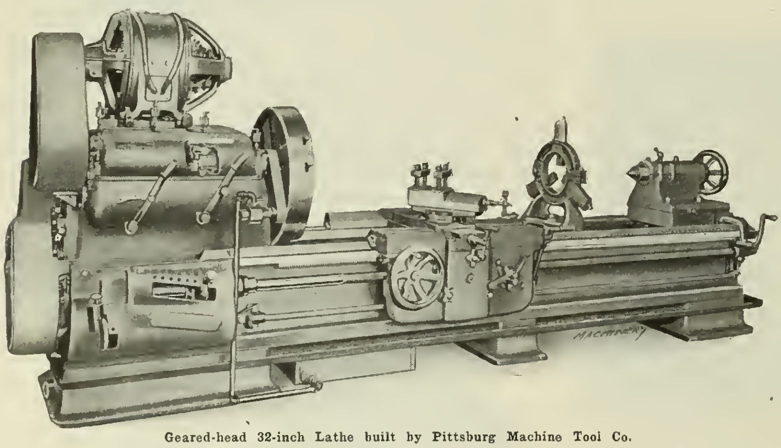
Fig. 3. Detroit Pneumatic Chuck for holding Automobile Ring Bevel Gears

Fig. 4. Detroit Pneumatic Chuck shown in Fig. 3, with Automobile Ring Bevel Gear Blank in Place

made to fit the gear teeth. It will be seen that there are four levers which come down and draw the blank up tight against these resting points; these levers are held on rocking arms on the inside and so constructed that if one should grip ahead of its mate, it stays still until the other lever on the opposite side touches the gear on the outside, and after so doing, the levers draw up and fasten the gear on its bearing points. There is no place where one point on the work is gripped harder than another, thus drawing the work out of shape. This fixture was made for machining the back side of the gear and boring the hole so that the center of the fixture is plugged up, but it can be made, if so desired, with a hole running through the entire spindle of the machine, so that the hole in the work can be water-ground and the chuck still be operated by the air cylinder.

PITTSBURG GEARED-HEAD LATHE

In the accompanying illustration is shown an all-geared-head 32-inch lathe which is a recent product of the Pittsburg Machine Tool Co., Braddock, Pa. These lathes are built in 32- and 36-inch swings, with any required length of bed. It will be apparent from the illustration that they are of extremely heavy construction, and all gearing is of steel, so that



Geared-head 32-inch Lathe built by Pittsburg Machine Tool Co.

these lathes are suitable for the heaviest classes of service. The geared head is furnished with twelve spindle speeds, and there are thirty-six available rates of feed. A new apron has been designed which is of exceptionally heavy and rigid construction. All gears are of steel and all studs in the apron are made of steel, hardened and finished by grinding. The spindle is made of hammered steel, and the ratio of the gearing in the head is 63.5 to 1. Tumbler gears and clutches are made of casehardened steel. These lathes are sold under a guarantee of accuracy of 0.001 inch per foot in the performance of facing and boring operations, and are offered to manufacturers who do accurate machining on heavy castings and forgings. An interlocking arrangement prevents the nut from being engaged with the lead-screw when the longitudinal feed is engaged.

INTERNATIONAL THREAD GRINDER

For truing the threads of thread gages and for similar work where it is required to correct distortion produced by hardening, the International Equipment Co., 1553 S. 58th St., Philadelphia, Pa., has placed on the market a grinding machine, which is shown in Fig. 1. It will be apparent to experienced mechanics that the field of usefulness of this machine includes all internal and external threaded work, as well as cylindrical grinding. This grinder is set up on the lathe after removing the toolpost, and grinding is done by means of a carborundum wheel, which runs at 5500 revolutions per minute. This wheel is first trued to coincide absolutely with the pitch thread to be ground, by means of a diamond set in the attachment shown—the diamond is carried in the ball shown adjacent to the periphery of the grinding wheel, and the wheel truing attachment is graduated to provide for setting it at any angle.

For example, when a U.S.S. thread gage is being ground the wheel is shaped 30 degrees on each side, making it conform

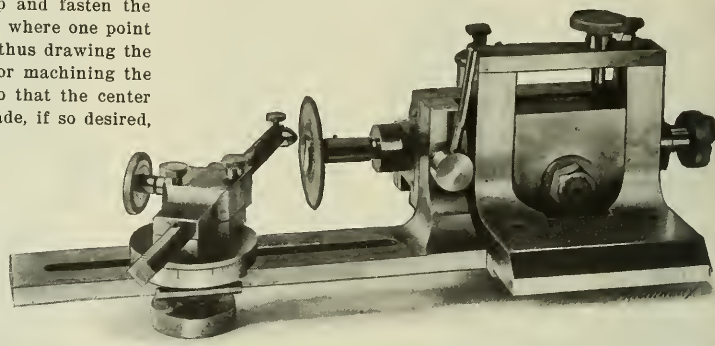


Fig. 1. International Thread Grinder for correcting Distortion of Thread Gages and other Threaded Work

to the exact form of the thread. For special Russian threads on gages which were recently ground on this machine, the wheel was trued 45 degrees on one side and 5 degrees on the other side. This grinder may be employed to true any thread, no matter what the requirements may be, and this applies to taps, hobs, etc., as well as thread gages. It is claimed that this machine is capable of converting any lathe into a cylindrical grinding machine, and that the construction is so rigid that it is impossible for vibration to spoil even the finest work.

Fig. 2 shows examples of an internal and external thread gage ground on this machine. The internal thread gage was cut off from round bar stock, turned, chased, hardened and ground in eight and one-half hours. The external gage is for use on large shell work, and attention is called to the fact that the plain surface grinding was also done on the International thread grinder. Fine taps, hobs, dies, worms and similar threaded parts are being turned out on this machine. The grinder is also used with relieving attachments for relieving taps after hardening.

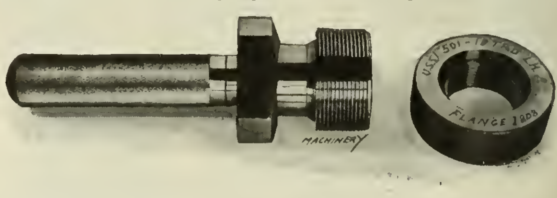


Fig. 2. Internal and External Thread Gages ground on International Thread Grinder

In operating this thread grinder, the spindle on which the grinding wheel revolves must be at all times in perfect alignment with the centers of the lathe. It is therefore adjustable to secure this condition; adjustment is also provided for determining the lead of the thread. A special fiber core is furnished in the end of the driving stud by means of which end play and vibration are taken up instead of being transmitted to the wheel. The driving shaft is independent of the main bearing shaft and allows the wheel perfect freedom of operation. The bronze bearing is indented with right- and left-hand, as well as straight, oil-grooves, which equalize the flow of oil and permit the spindle to run constantly in oil.

When grinding coarse threads the device is tipped sufficiently so that the heel of the wheel will not interfere with the course of the thread. Two oil-cups are furnished, one for the driving shaft and the other for the main bearing shaft. An ingenious method is provided for attaching and detaching the wheel dresser, which renders the operation practically instantaneous. This is accomplished by means of an interrupted screw provided with a handle. There is no lost motion in the rack diamond holder, because any lost motion is taken up by means of a spring pressure exerted upon the rack. This rack meshes with a pinion operated by means of a handwheel which feeds the diamond the required distance. The entire dressing attachment is movable back and forth by means of a releasing nut.

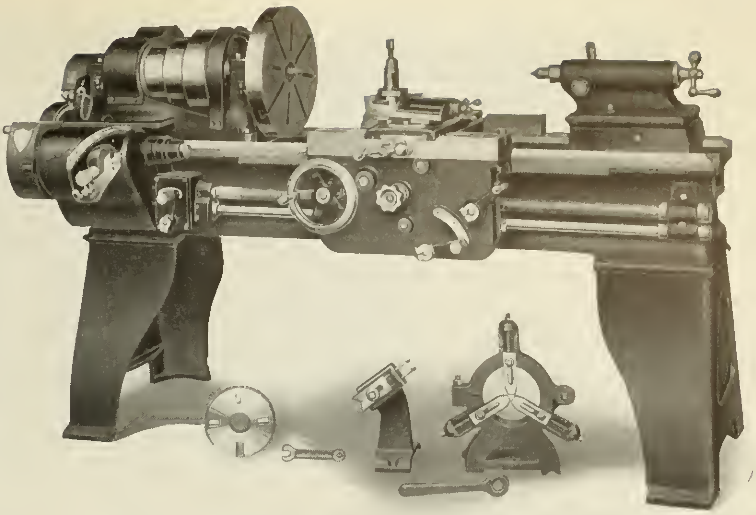


Fig. 2. Cone-driven 17-inch Lathe built by National Lathe Co.

NATIONAL LATHES

The National Lathe Co., 15 W. Second St., Cincinnati, Ohio, is now building the 18-inch geared-head lathe illustrated in Fig. 1. On the National geared-head lathe there are only twelve gears in the head. All the back-geared drive gears are five pitch and the direct geared drive gears are six pitch. All the gears are made of steel, and there are only two shafts besides the spindle. These shafts run in bronze journals in the bottom of the head. There are no journals suspended in the top of the head. This is said to insure perfect alignment and rigidity. The shafts are of 40-point carbon steel, ground to fit. The gears are cut with special cutters, giving them as perfect a mesh as possible.

The design has been worked out in such a way as to insure strength and long wearing qualities, and the simplicity of the design makes it possible for the operator to change speeds with great rapidity. With a two-speed countershaft a total of sixteen speed changes are obtainable, ranging from 12 to 330 R.P.M., or eight forward and eight reverse speeds. The stopping and starting lever is conveniently located so that the operator does not have to change his position when he is checking or calibrating a piece of work. When the clutch lever is shifted, all the gears in the head are stopped. It is so designed that only the gears that are working are in mesh, the gears not required to operate being thrown out of mesh. The advantages in this arrangement are obvious.

The drive is of the single-pulley type; the pulley is 12 inches in diameter, and runs at 330 R.P.M. It carries a 4-inch belt, which gives ample driving power. A friction clutch is mounted on the driving pulley shaft, and is operated instantaneously with a single lever. The countershaft clutch pulleys are 12 inches in diameter and run at 240 R.P.M. They carry a 4-inch belt. The spindle speeds range from 12 to 330 R.P.M. At no time do the gears drive at a greater speed than the driving pulley, and the greatest speed reduction is 28 to 1.

National Cone-driven Lathe

In Fig. 2 is shown a 17-inch engine lathe with double back gears and a three-step cone pulley, which is another recent product of the National Lathe Co. The bed of this machine is firmly braced for its entire length and designed to absorb vibration incident to heavy work. The headstock is also ribbed. The spindle is hollow and made of a special carbon steel and finished by grinding. The centers are No. 4 Morse taper, and the boxes are made of phosphor-bronze, with means of compensating for wear. A double-walled apron is provided, so that all important shafts and studs may have a rigid outboard bearing. Control of all feeds is within convenient reach of the operator, and an interlocking device makes it impossible to engage the lead-screw and feed-rod at the same time. The screw-cutting mechanism is of the quick-change gear type, and all available feeds are obtained by the movement of one lever. Speeds from 3 to 64 per inch are available on standard lathes, and from ½ to 15 millimeters on the screw-cutting lathe. The range of available feeds is from 0.006 to 0.128 inch per spindle revolution.

The lead-screw is 1 5/16 inch in diam-

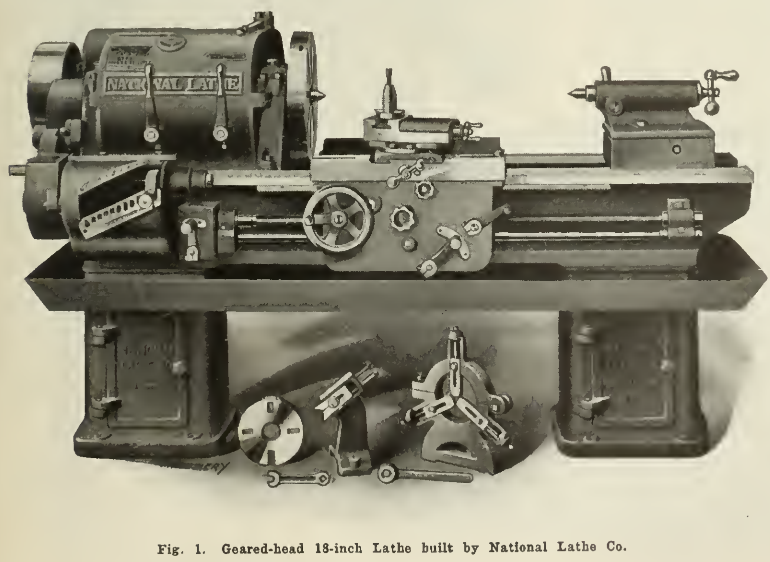


Fig. 1. Geared-head 18-inch Lathe built by National Lathe Co.

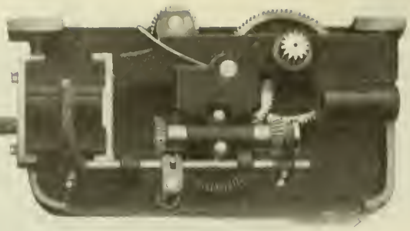


Fig. 3. Apron of National Geared-head Lathe shown in Fig. 1

eter, and is made of special carbon lead-screw stock. It is chased by means of standard and metric master lead-screws, either metric or standard pitch screws being furnished, as desired. In chasing threads, the apron half-nuts engage at the proper point, thus guarding against error and saving time. The feed-rod is gear-driven and enables the operator to obtain a large range of feeds, from the coarsest to the finest. The compound rest is rigidly constructed and fitted with full length taper gibs having end adjusting screws. The swivel is made completely circular, is graduated in degrees, and firmly clamped to the cross-slide. A tailstock of the National Lathe Co.'s offset type allows the compound rest to be placed parallel with the bed. The tailstock is provided with set-over screws for taper turning operations. Provision is made for firmly locking the carriage for cross-feed work, and the carriage is gibbed to the bed at both the front and back; it has a wide bearing for the slide-rest, with a large vee at the front and back.

HARRIS AUTOMATIC MULTIPLE-PLUNGER PRESS

For the rapid automatic production of stamped, perforated and embossed sheet metal parts, the H. E. Harris Engineering Co., 1041-1055 Broad St., Bridgeport, Conn., has developed the machine illustrated and described herewith. It is a multiple-plunger press especially adapted for the manufacture of eyelets, snap fasteners, pencil tips, primers, percussion caps, thimbles, buttons, ferrules, automobile grease and oil-cups, fuse caps, boxes and covers for medicines and toilet articles; in fact, these machines can be used for the manufacture of almost any part that can be produced from sheet metal by several punch press operations. Machines of this type are supplied for doing both large and small work. These machines are very rapid in operation, producing from 35,000 to 80,000 parts per day of ten hours, allowing time for repairs, setting up, sharpening tools, oiling, replenishing the stock, and other legitimate causes of delay or stoppage. This large variation in output covers all classes of work, the output depending upon the kind of material used, its thickness, the depth to which it has to be drawn and other factors directly due to the nature of the work. The number of revolutions per minute at which the cam-shaft should run (or strokes of the plungers per minute) varies from 65 on heavy, deep-drawn work to 150 on light, shallow work.

Automatic Operations Performed

This machine will automatically cut a blank from sheet metal and carry the work along for the successive operations under other plungers, performing such operations as piercing, forming, drawing, trimming, light stamping or embossing, etc., and completing the part without manual handling. The basic principle of the machine has been used for forty-five years, and, in fact, most of the manufactured articles mentioned are made by older forms of this machine. The common trade name for a machine of this kind is "eyelet machine." In the new design there are improvements which were developed and added in 1916 and 1917. The frame is offset at the left-hand side, and provision is made for an extra die and for a double punch to be carried by the last plunger. In this way the Harris automatic multiple-plunger press will perform one more operation than the number of plungers. This is a distinctive feature of the machine. On all other machines, the number of operations is the same as the number of plungers. This makes it unnecessary to follow the general practice of providing one more plunger than is actually needed, for if it becomes advisable to add an additional operation, such as stamping a name or trademark, or any other operation which becomes desirable after first planning, the means for taking care of it in the machine are thus provided. The popularity which this machine has attained is due to the fact that all the operations are simultaneous; that is, with each revolution of the cam-shaft, each of the plungers performs an operation on the parts going through the press. The speed of operation and methods of performing the work do away entirely with the necessity of annealing parts between operations.

Adapting the Machine for Different Work

The weight of the machine, the throw of the cam and other details are arranged to suit the parts to be manufactured in the press; likewise, the number of plungers is varied to suit the number of operations required. The machine consists of a heavy main frame carrying a number of press plungers, which, in turn, carry the different punches for blanking, embossing, piercing, drawing, etc. The plungers are operated by a cam-shaft that determines the timing and throw. The bolster fitted on the bottom part of the main frame holds the different dies to suit the punches and carries the transfer slide. The plungers are returned to their upward position after operating upon the part, by the same shaft but with a separate set of cams. This is done by the adjustable horizontal members shown above the cam-shaft, which may be seen between the cam-shaft and the upper cross member of the frame, and connected to the plungers by means of the vertical lifting rods at the back. From the cam-shaft is geared a vertical crankshaft, which operates the transfer slide from right to left. This slide carries the work along from the first plunger at the right-hand side to the second plunger, and from there to the third plunger, and so on, there being a piece under each plunger at each stroke of the press. The stock is passed underneath the first plunger from a reel shown on the front of the machine, by means of a roll feed on the back, and the blank is punched out in the first operation.

Determination of Size

The size of the machine is determined by the depth of the parts to be drawn or embossed, and the diameter or width of

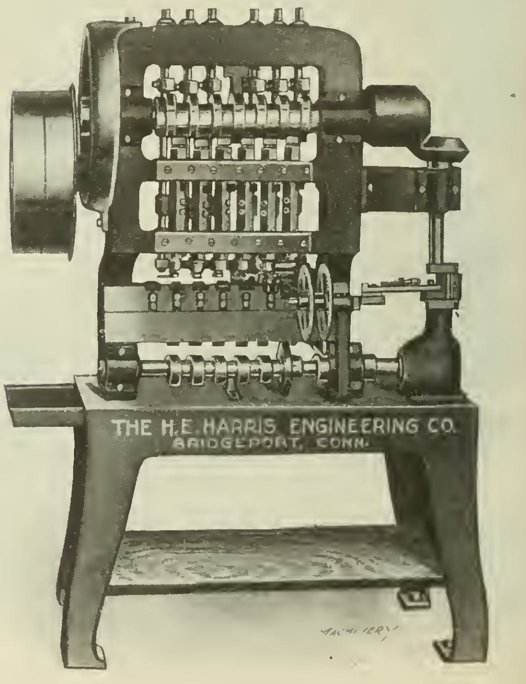


Fig. 1. Automatic Multiple-plunger Press built by H. E. Harris Engineering Co.

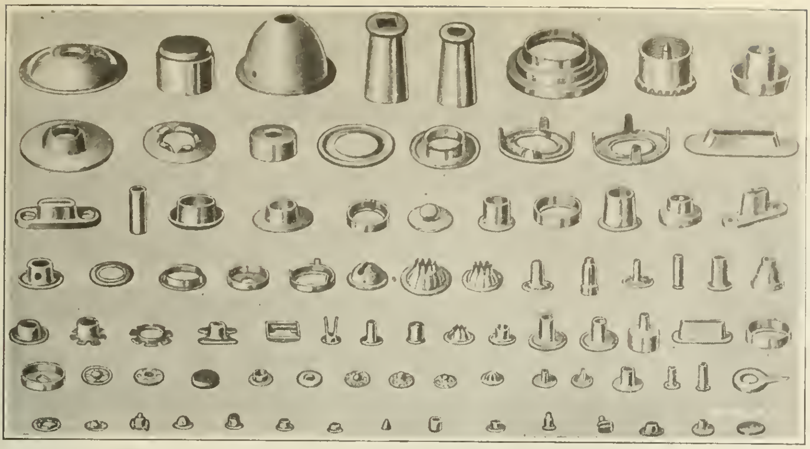


Fig. 2. Examples of Work done on Harris Multiple-plunger Presses

the blank. These machines are built with from three to twelve plungers, although these extremes are rarely used, from four to seven plungers being most generally employed; these, with the provision before stated for an additional operation, cover the entire range usually required from these machines. In manufacturing parts, the machines operate as follows: The metal, which is in strip form, coiled, is placed on the reel in front, passes through a lubricating pad and through a stripper over the blanking die to a feed roll mechanism in the back. This mechanism is operated by an intermittent ratchet, timed so as to coordinate with the operation of the press. While the strip stock is at rest in this position, the first plunger blanks out the piece and carries it through the die to a pocket in the transfer slide, a reel at the back reeling up the scrap stock after it leaves the feed rolls. The transfer slide moves from right to left, by the action of the vertical crankshaft, the movement being equal to the center distances between the plungers. This action carries the blanked piece in the pocket in the transfer slide, under the second plunger, which carries the forming punch, and the second operation is performed by the punch in the second plunger, drawing the blanked piece through the transfer slide and into the first forming die. The transfer slide now moves back from left to right into its first position, so that it can move again from right to left, carrying the second blanked piece from the first plunger to the second position, and at the same time carrying the cupped piece from the second position to the third position.

This operation is repeated at each stroke of the press, until work has been carried along to the last plunger, when it is ejected and carried through a tube into a box or pan. The work is returned from the dies (with the exception of the first one) to the transfer slide, where it is dropped into a pocket by vertical ejector plungers operated by the lower cam-shaft, which is geared to operate in synchronism with the upper cam-shaft through the medium of bevel gears. This will be seen in the illustration at the right of the machine. These lower plungers push the work up out of the die at the proper time into the fingers of the transfer slide. The transfer slide is fitted with these carriers or fingers for each station except the first. They take hold of the piece like the thumb and index finger of a person's hand.

Service

The machine is thus fully automatic in its operation, the operator only having to keep the stock reel supplied with stock and remove the boxes of finished work and small piercings, if any, replacing them with empty boxes. One attendant can take care of a dozen or more machines. The cams on the main cam-shaft at the top of the machine are made of tool steel, hardened to the proper temper, and operate upon hardened bumpers which are adjustably fitted to the upper end of the plunger, to control the setting of the tools. The upper and lower cam-shafts and the crankshaft are also made from tool steel, forged before machining. The multiple plungers are machined from tool steel, ground perfectly square and true, and are fitted with the utmost accuracy of spacing, alignment, and with smoothly fitted sliding surfaces to the frame of the machine.

The dimensions of the machines most generally used for the usual run of eyelet and fastener work are as follows: number of plungers, four, six and seven, with provision for five, seven and eight operations; movement of plungers, 1 3/8 inch; distance between plungers, 2 1/2 inches; maximum diameter of part, 1 1/4 inch; and maximum depth of draw, 9/16 inch. For machines with the following numbers of plungers the floor space and net weight are as follows: Four plungers, net weight, 2000 pounds; floor space, 40 inches by 52 inches. Six plungers, net weight, 2215 pounds; floor space, 40 inches by 58 inches. Seven plungers, net weight, 2375 pounds; floor space, 40 inches by 64 inches. Fig. 3 illustrates how the machines should be arranged to permit one attendant to care for a dozen or more.

LANGELIER BENCH TAPPING MACHINE

A vertical tapping machine, built in bench and floor types with a capacity for tapping holes up to 1/4 inch in diameter in brass and up to 3/16 inch in diameter in steel, has recently been placed on the market by the Langelier Mfg. Co., Providence, R. I. This machine embodies several interesting features in its design, among which the following are worthy of special mention: An automatic reversing mechanism causes the tapping spindle to reverse its direction of rotation instantly at a predetermined depth, without depending in any way upon the resistance of the tap to effect the reversal. This feature is specially advantageous when tapping thin stock with fine taps, or for blind tapping. The reverse is effected by adjusting a depth stop. These adjustments may be made very quickly and simply.

So effective is this automatic reverse that, on tests, ten steel pieces, 3/16 inch thick, were tapped complete in one minute, by a 3/16-inch tap operating at 800 revolutions per minute.

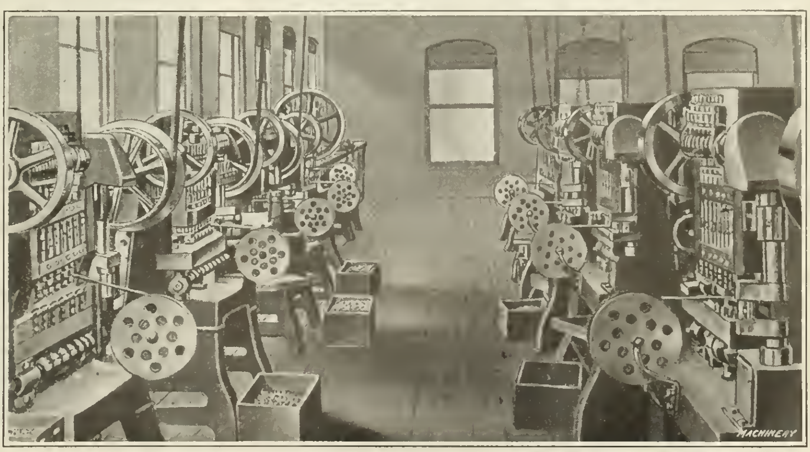
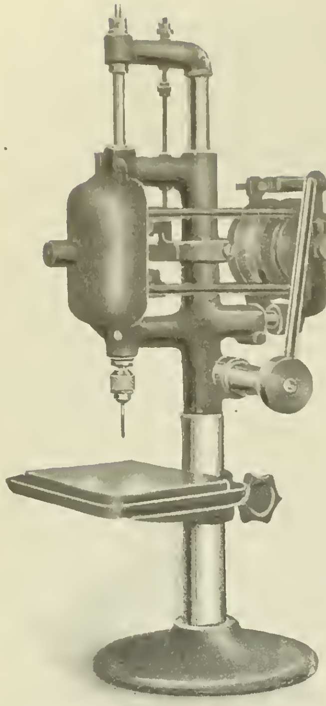


Fig. 3. Arrangement which enables One Operator to attend to Twelve or More Presses



Vertical Tapping Machine built by Langelier Mfg. Co.

Correspondingly higher production is obtainable in brass or with smaller taps. The spindle is floating, with all unnecessary weight and load removed, and is double-splined for correct balance at high rotative speeds. It is driven into the work in much the same manner as the spindle of the Langelier sensitive high-speed drilling machine, securing marked reduction of tap breakage, especially when fine taps are used. The spindle is mounted and carried in a feed yoke actuated by a hand-feed lever, and is entirely independent of the reverse mechanism, which is mounted on the machine column.

The tapping spindle may be fed down by depressing a foot-treadle provided for the purpose, and further feed is accomplished by continuing the pressure upon the foot-treadle or by lowering the hand-feed lever. The construction employed throughout relieves the spindle of all load beyond that of its chuck and tap. Ample driving power is delivered to the tapping spindle. The drive is transmitted to the machine by a 1-inch belt on 4½-inch diameter tight and loose pulleys. These pulleys are mounted on a common horizontal shaft, which also carries one bracket at the back of the machine column. This shaft also carries one idler and one tight pulley, grooved for a ⅜-inch diameter round, endless belt. The bracket is adjustable backward and forward, to maintain the proper tension for the round belt, which is looped over the forward and reverse pulleys by the over and under method.

A clutch mounted between the spindle driving pulleys, actuated by the snap fork shown, engages either the forward or the reverse pulleys. The depth stop on the yoke governs the time of the throw, and a belt shipper for the tight and loose pulleys is equipped with a snap catch which holds the belt positively on the desired pulley. With this belt shipper there is no possibility of the belt trailing from one pulley partly onto the next. The table, adjustable vertically and with radial movement, is of ample proportions to hold all ordinary sizes of jigs for the work done on this machine. The working face of the table is planed true and square with the spindle and has an oil rim on four sides. For tapping large quantities of parts, where the pieces are to be clamped or jigged in a stationary fixture and the holes to be tapped are not likely to come all exactly in the center of the work, an auxiliary flexible extension spindle is furnished, which is gripped by the chuck on the regular machine tapping spindle, and this permits the tap readily finding its own center and materially reduces tap breakage.

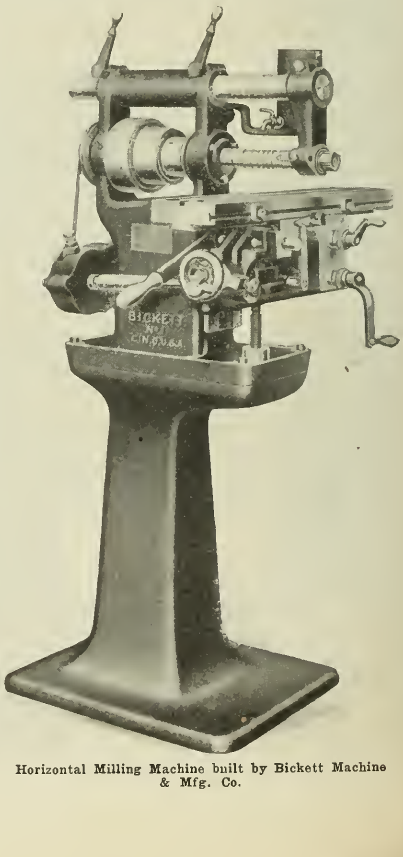
The principal dimensions of the machine are as follows: height, 31 inches; size of table with oil rim, 6 1/2 by 9 inches; distance from chuck to table, 0 to 7 3/4 inches; distance from spindle to column, 3 7/16 inches; feed of spindle, 3 1/8 inches; speed based on 3/16-inch tap, 800 revolutions per minute; size of tight and loose pulleys, 4 1/2 inches by 1 1/8 inch; net weight of machine, 240 pounds; and bench space occupied, 15 1/2 by 10 inches.

BICKETT HORIZONTAL MILLING MACHINE

In the accompanying illustration is shown a No. 1 horizontal milling machine arranged for power and hand feed, which is a recent product of the Bickett Machine & Mfg. Co., 1118 Richmond St., Cincinnati, Ohio. It will be apparent from the illustration that this machine is of sturdy construction. In addition to its use as a manufacturing machine, it is suitable for use in jobbing machine shops, as it is adapted for both light and fairly heavy milling. Such operations as end-milling, keyseating, oil-grooving, face-milling, splining, T-slotting, gear-cutting, straddle-milling, and many similar operations can be performed. The longitudinal feed of the table is effected by a gear and rack which provide a rapid movement by means of a hand-lever, while the power feed is transmitted through a series of worms and worm-wheels.

The spindle is made of crucible steel finished by grinding and mounted in Gurney ball bearings. At the front end there is a No. 9 B. & S. taper hole for the cutter-arbor, and the hole extending through the spindle is ⅞ inch in diameter. Six spindle speeds are obtainable, and the machine may be run at 2500 revolutions per minute for continuous operation. Reversible power feed is provided for the longitudinal movement of the table. This mechanism is geared to feed 0.003, 0.006 and 0.009 inch per revolution of the spindle. The drive is by a one-inch leather belt running on three-step cone pulleys and thence through a set of tumbler gears and a universal driving shaft to a worm and wheel under the table. An automatic trip releases this worm at the end of the cut and the feed of the table can be readily reversed. The power feed can be changed to hand feed, and the hand feed is arranged to operate either by means of a geared lever or a handwheel. The knee is of box-type construction, accurately scraped and aligned and held to the column by a substantial adjustable gib. It is raised and lowered by means of an Acme thread elevating screw.

Among the important dimensions of the machine the following may be mentioned: diameter of hole through spindle, ⅞ inch; distance from center of spindle to bottom of arbor support arm, 5 1/32 inches; size of arbor, 9 inches long by 1 inch in diameter; diameter of arbor spacing collars, 1½ inch; maximum distance from face of column to arbor support bracket, 11½ inches; diameter of cone pulley steps, 3, 4½ and 6 inches; face width of cone pulley steps, 2¼ inches; width of driving belt, 2 inches; size of table, 24 by 5½ inches; size of T-slot, ½ inch wide; maximum longitudinal feed, 18 inches; maximum transverse feed, 5 inches; maximum vertical feed, 5 inches; height of machine without pedestal, 25 inches; and base, 9½ by 18 inches.

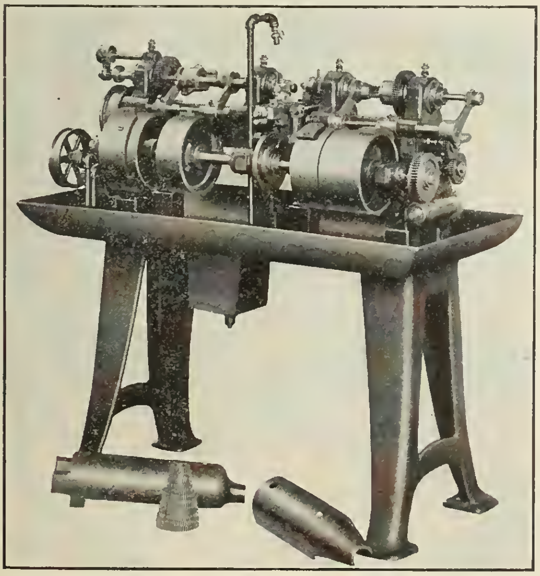


Horizontal Milling Machine built by Bickett Machine & Mfg. Co.

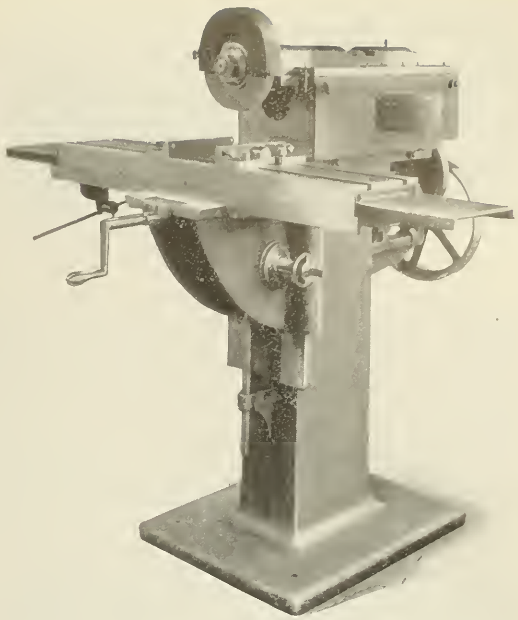
DETROIT AUTOMATIC PIN MACHINE

One of the recent products of the Detroit Tool Co., Detroit, Mich., is a full automatic screw machine of unusual design, which is styled a "pin machine." This machine is so constructed that it can only be used for cutting-off and turning operations, and at the present time it is built to take stock up to 3/8 inch in diameter; but it is the intention later to bring out a 5/8-inch machine of the same design. Pieces made on this machine are finished on both ends, making it unnecessary to perform a subsequent burring operation. These machines are rapid and accurate in operation, holding work within close limits. They can be used for making any small pieces from steel or brass which do not have to be threaded or drilled, and can also be fitted up to take care of pieces on which a rolled thread is required. Reference to the accompanying illustration will show that this machine has both a head- and tail-spindle. The stock is fed through the head-spindle in the usual way, and after coming in contact with the feed stop, it is gripped by the tail-spindle, which revolves at the same speed as the head-spindle, both being geared to the same driving shaft. The tail-spindle holds the work rigidly until the piece is cut off.

Owing to the fact that work is held in both spindles, it cannot chatter during the cutting-off and forming operations. This is the means of greatly increasing rates of production, because more pieces can be cut off for each grinding of the tools and the feed of the tools per revolution can be increased. The cross-slides are arranged to work independently of each other, enabling the front and back tools to be used at the same time. Fourteen change-gears are supplied with each machine, which allows the timing of the cams to be arranged with a minimum of lost motion. Driving belts for the machine and the pump are located at one end of the machine, where they are away from the cutting oil. The cam-shaft is located at the rear, where it is accessible for changing cams, and it can be thrown in and out of motion at any time by means of a clutch lever located at the front of the machine. A special feature of this machine is the construction of the spindle bearings, which are lined with phosphor-bronze to provide for employing the highest practicable spindle speeds in turning brass. The spindle bearings are made to fit a tapered steel sleeve to provide for taking up wear, this construction enabling each bearing to be adjusted and replaced without disturbing the alignment of the spindle. Ample oiling facilities are provided, and all exposed gears are protected by guards. Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York City, will have the United States sales agency for this machine.



Automatic Pin Machine made by Detroit Tool Co.



Improved Design of "Hartford" Surface Grinder

"HARTFORD" SURFACE GRINDER

The National Machine Co., Hartford, Conn., has brought out an improved design of surface grinder. This machine, like the preceding model (described in MACHINERY, September, 1915), is a horizontal traversing-wheel type, intended for such work as finishing the flat surfaces of dies, punches and other hardened parts. The grinding wheel is carried by a heavy ram or slide, which is gibbed to the stationary head. The ram and wheel has a maximum traversing movement of 12 inches, and the motion may be reduced in accordance with the width of the work by adjusting the crank stud in its slot. The position of the ram may be varied by adjusting the ram stud, to bring the wheel in the right location relative to the work.

The platen or work-table may be adjusted vertically or laterally, and it has an automatic lengthwise feeding movement in either direction. The maximum feeding motion is 1/16 inch for each complete stroke of the ram. This motion, which occurs when the wheel has completed its stroke, may be reduced any required amount for obtaining a fine finish. The saddle carrying the table is dovetailed and gibbed to the top of the knee, which is dovetailed and gibbed to the face of the column or frame. The knee may be locked in position by means of a binder screw. The elevating screw is equipped with a graduated dial reading to thousandths of an inch.

The spindle runs in phosphor-bronze bearings, and it is a steel forging having a diameter in the bearings of 1½ inch. The wheel hood has a hinged front, so that the wheel is accessible. Work may be held on the machine table either by adjustable clamps furnished with the machine or by regular machine vises, special holding fixtures, or magnetic chucks. The work-table measures 8 by 37 inches, and it has a longitudinal movement of 30 inches, a traversing movement of 7 inches, and a vertical movement of 14 inches. The maximum distance from the center of the spindle to the table is 16 inches. The water attachment consists of a special table, pump and tank, with the necessary piping and valves.

HOUSTON, STANWOOD & GAMBLE LATHE APRON

In an ideal lathe apron design, ample strength should be provided to move the carriage along on its ways under any rate of feed and depth of cut which the headstock is capable of pulling. The accompanying illustrations show a lathe apron recently developed by the Houston, Stanwood & Gamble Co., of

Fig. 1. Improved Lathe Apron recently developed by Houston, Stanwood & Gamble Co.

Cincinnati, Ohio, which possesses features giving it ample driving power, strength and durability. All gears are made of steel to afford ample strength to withstand unexpected and unusual strains imposed upon the gearing in aprons on large lathes on which heavy turning and boring operations are performed.

Figs. 1 and 2 show front views of this lathe apron, and it will be noticed that use is made of a positive toothed clutch in place of the usual friction clutch. Disks in the initial drive are connected with a shearing pin, as is clearly shown. It is claimed that the positive clutch does not slip, and owing to the slight pressure required to hold the clutch closed, is easily released. With this positive feed clutch there should be a weak point to protect the feed mechanism from breakage in case the carriage were accidentally fed against the tailstock, headstock, steadyrest or other obstruction. A shearing pin,

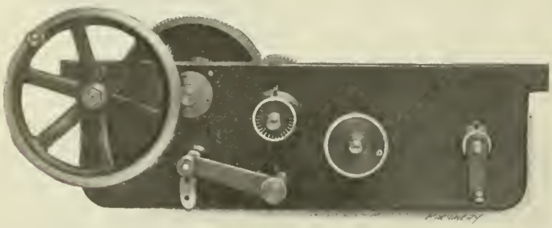


Fig. 2. Houston, Stanwood & Gamble Lathe Apron partially disassembled

to which reference has been made, provides such a weak point in the train of mechanism. It will also be noted that the rack pinion can be withdrawn from the rack for thread cutting and that the nut for the lead-screw is opened and closed in the usual manner. The customary reverse lever for shifting double bevel gears is provided, and the clutch for cross-feed is attached to the carriage. This clutch is not shown, but it is of the positive toothed type. Attention is called to the big reduction from handwheel to gear in the lathe, which insures that the carriage will be easily moved by hand.

Fig. 3 shows the back of the apron, and here attention is called to the broad-faced, coarse feed-rack pinion. There is an outer bearing for the rack pinion, that is, this pinion is not overhung. The large bevel gear also has an outer bearing, although this is hidden from view. A capillary wick oiling system of lubrication for the bearings is furnished in the rear plate of the apron. The Houston, Stanwood & Gamble Co. employs this apron, with slight modifications according to size, on all its standard engine lathes built in sizes from 30 to 60 inches swing.

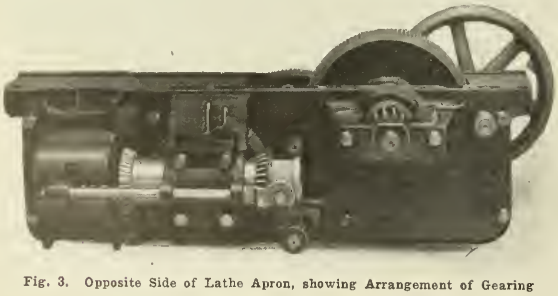


Fig. 3. Opposite Side of Lathe Apron, showing Arrangement of Gearing

RELIANCE ELECTRIC MOTOR

It has been the experience of some electric motor manufacturers that their business is largely divided into two groups. In one of these the service is severe, while in the other only a moderate service demand is made of the motor. The latter type of service is by far the more general, and many manufacturers have specialized in the construction of motors adapted for moderate service. To meet the demand for a rugged heavy-duty general-service motor, the Reliance Electric & Engineering Co., 1056 Ivanhoe Rd., Cleveland, Ohio, has developed a Type T machine, which is illustrated and described herewith. Machinery builders and users have experienced difficulty in mounting motors on their machines,

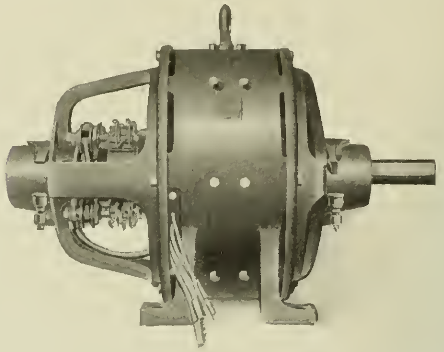


Fig. 1. Reliance Type T Heavy-duty Electric Motor

and to overcome this the new Reliance motor has been provided with heavy feet cast integral with the motor frame, wide ribs being carried up from the feet to the frame so as to give effective support. The motor frame has four laminated main poles which are securely fastened to the frame by cap-screws. The flat section at the pole tip provides a surface against which the coil can press snugly without danger of wear. The field coils are insulated and provided with protective features to meet hard service conditions. Double cotton covered wire is used for the commutating coils, which are wound in a form, dipped in insulating varnish and baked. They are assembled in press board and fiber spools of the same kind that are used for the main field coils.

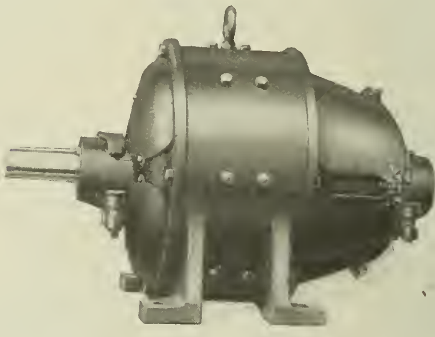


Fig. 2. Opposite Side of Reliance Motor of Fully Enclosed Dustproof Type

The bearings are cast-iron shells babbitted with metal containing over 70 per cent tin and only a trace of lead. Babbitt liners are locked in place by depressions in the cast-iron shells. In addition to the "oil throws" on the armature shaft, other precautions are taken to keep the oil in its proper place. Spiral oil-grooves insure proper distribution of the oil, and the bearing is shouldered in the end bracket and held against rotation by a large dowel screw under the oil-hole cover. When desired, split bearings may be supplied at the pinion end to provide for taking out the armature without removing the pinion. All armature cores are built up of electrical steel punchings insulated with core plate varnish. These punchings are mounted on a cast-iron spider and securely keyed to it. To insure tight cores, the laminations

are pressed together under five to ten tons pressure and securely held between two substantial end flanges. The shaft is made of forged high-carbon steel and finished to size by grinding. Double cotton covered wire used for the armature coils is wound on a form and dipped in insulating varnish, after which it is baked. The commutator is mounted on an extension of the armature spider and forced on under approximately four to five tons pressure, provision against rotation being provided by a round key. The commutator is of the cap-screw type on which the screw heads are accessible from the outside. These and other features of the Type T Reliance motors adapt them for those classes of heavy service for which they have been especially designed and built.

BICKNELL-THOMAS THREAD LEAD INDICATOR

This tool fills the demand for a simple but accurate device for testing the lead of both external and internal screw threads. The accompanying illustrations clearly show the

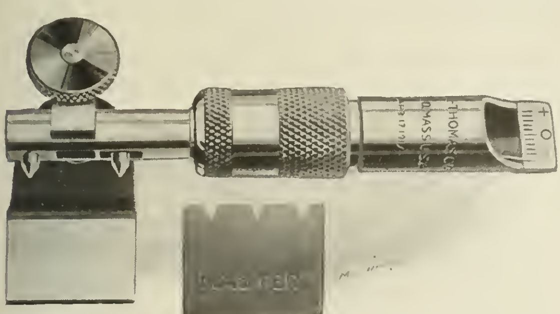


Fig. 1. Thread Lead Indicator and "Master" made by Bicknell-Thomas Co.

construction and method of using the instrument for measuring the lead on the screw and inside the tapped hole. In use, the tool is held in one hand, preferably the left, and the screw is pressed against the two points, which are spaced ¼, ½ or 1 inch apart, as desired. If the lead of the thread is normal the indicator needle will register zero; if the lead is short the needle will show on the minus side; if long, on the plus side. Each line of the graduation represents 0.001 inch.

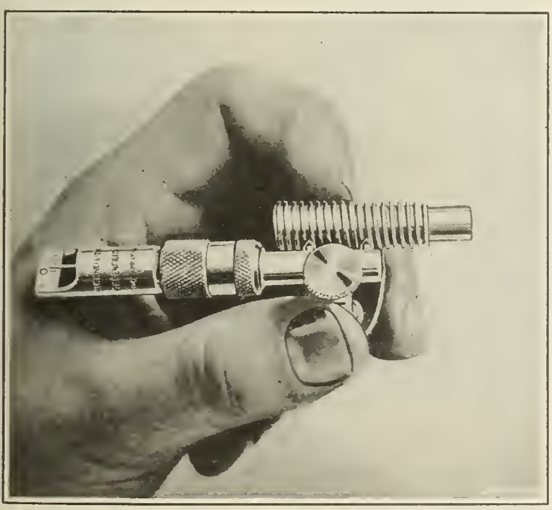


Fig. 2. Thread Lead Indicator in Use testing an External Thread

The table on which the screw rests in testing is adjustable to accommodate screws of any diameter. For internal measuring, the table is removed merely by loosening the thumbscrew and drawing it off. The end of the instrument containing the point is small enough so that tapped holes as small as ½ inch in diameter can be tested and, of course, from that

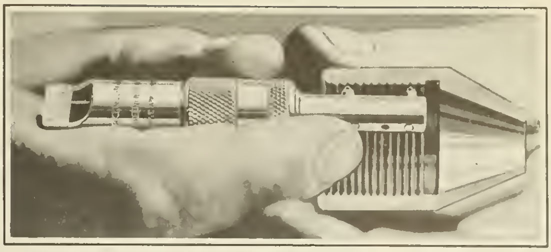


Fig. 3. Thread Lead Indicator in Use testing an Internal Thread

up to any size. This is a feature which is not found on any other lead tester and is of the utmost importance in making sure that the lead of the thread on both the screw and in the tapped hole are the same. A master is furnished with each gage so that the operator may be sure at all times that the needle point is on zero when the gaging points are spaced correctly. If it is necessary to test threads with odd pitches, as 13 threads to the inch, a master can be furnished to which the indicating point can be adjusted. This tool is one of the latest products of the Bicknell-Thomas Co., Greenfield, Mass.

HISEY-WOLF ELECTRIC GRINDERS

The Hisey-Wolf Machine Co., Cincinnati, Ohio, is now building a line of portable electric surface grinders. These are made in twenty different styles having capacities of one-quarter, one-half, one, two and three horsepower. To meet the requirements of different shops, grinders may be obtained with direct-current motor, alternating-current motor, or the so-called "universal" motor suitable for operation on either alternating or direct current. The direct-current motor is of the compound-wound type and operates at a constant uniform

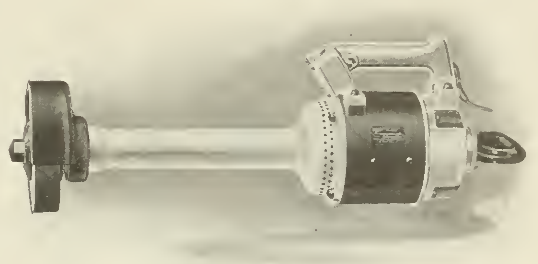


Fig. 1. Hisey-Wolf Portable Electric Grinder with Long Spindle and Guarded Wheel

speed. It is provided with forced ventilation for continuous service at capacity and will not run hot. The alternating-current motor is of the squirrel cage induction type and is regularly supplied for sixty-cycle, single, two- or three-phase circuits. For operating from any lamp socket on the lighting circuit, single-phase machines are required. Two- or three-phase machines are employed for operation on corresponding power circuit lines and cannot be operated from lamp socket connections. If one phase of the line of a two- or three-phase system is equipped with lamp socket connections, a single-phase grinder can be operated from it. The universal motors are primarily designed for operation on twenty-five-cycle, single-phase, alternating current with effective grinding speeds not obtainable with the induction type alternating-current motors at this low frequency. These universal motors will operate equally well on either direct current or single-

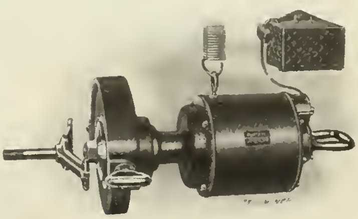


Fig. 2. Hisey-Wolf Portable Electric Grinder with Removable Handle in Line with Spindle

phase alternating current up to sixty cycles. The motor is designed for operation from lamp sockets.

Aside from the different types of motors furnished with these grinders, the design of the different machines comprising the line is essentially the same. S. K. F. ball bearings are used throughout, and they are so mounted that grinders can be operated with the shafts in any position. The machines with extended spindles are equipped with center bearing supports, the bearing nearest the grinding wheel being designed to take all working strains and stresses. The bearings are completely enclosed to protect them from dust and grit, and where necessary felt protector washers are provided. Provision for efficient lubrication is one of the important features embodied in these portable grinders. The bearings are filled with a semi-fluid grease which provides proper lubrication for a period of several months. Each machine is fitted with a quick-acting switch of a type well suited to the current and size of grinder on which it is used. The switch is conveniently located in the motor frame and can be operated without requiring the operator to lose his grip on the handle. All switches are completely enclosed to insure protection at all times, regardless of the position of the grinder.

The spindles used in these grinding machines are made of steel and accurately ground to size. Extended spindle grinders are made with a two-piece shaft mounted in a double set of ball bearings. The handles are mounted according to the way experience has proved to be best adapted for each size and style of machine. Grinders of two- and three-horsepower capacity are designed with handles suitable for operation by one or two workmen. The wheel guards are made of steel to insure adequate protection, and they are adjustable so that they can be placed at a convenient angle. The grinding wheels regularly furnished on these machines are of a grade and grain which experience has shown to be well adapted for each size and type of machine.

OAKLEY CUTTER AND TOOL GRINDER

The Oakley Machine Tool Co., Cincinnati, Ohio, is now building a No. 2 cutter and tool grinder, which will rapidly

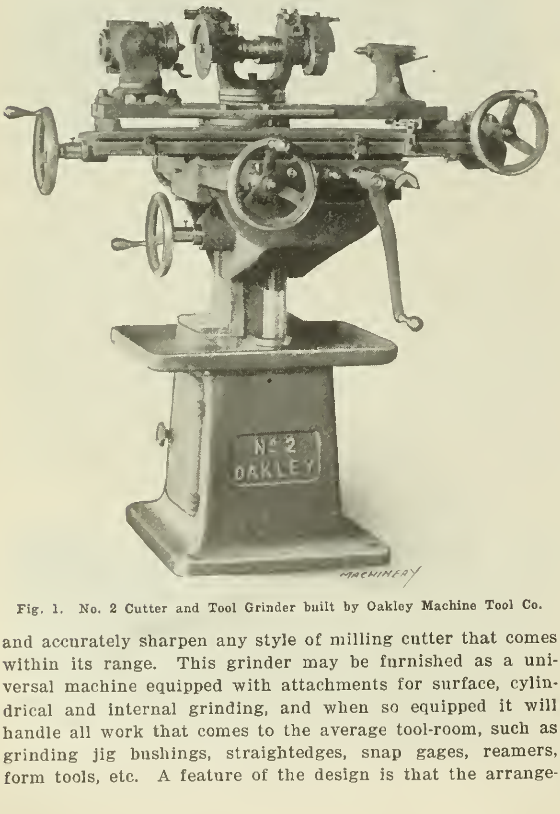


Fig. 1. No. 2 Cutter and Tool Grinder built by Oakley Machine Tool Co.

and accurately sharpen any style of milling cutter that comes within its range. This grinder may be furnished as a universal machine equipped with attachments for surface, cylindrical and internal grinding, and when so equipped it will handle all work that comes to the average tool-room, such as grinding jig bushings, straightedges, snap gages, reamers, form tools, etc. A feature of the design is that the arrange-

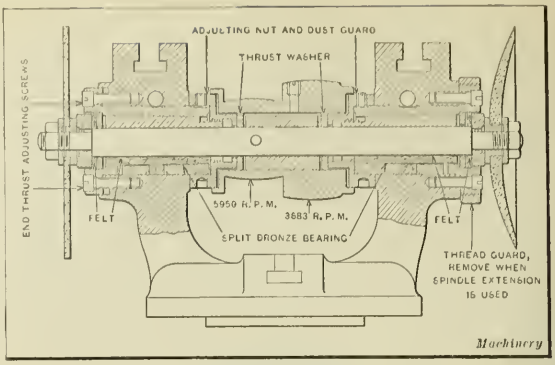


Fig. 2. Sectional View through Wheel-head

ment of handwheels and levers gives unusual convenience of operation. The base has a heavy pyramid construction, affording a solid bearing on the floor. Means are provided for securely bolting the column to the base, and a dovetail bearing is provided on the column to support the knee. A swivel motion of 180 degrees each way is provided for the wheel-head on the column, and the massive construction absorbs vibration.

Dustproof tapered bronze bearings, which are adjustable for wear, insure accurate running of the wheel-spindle. The knee has broad vees, spaced 16 inches apart, and a box form of construction closed at top and bottom affords maximum resistance to all torsional and bending strains. Adjustable taper gibs compensate for wear on the column and insure long life for the machine. The saddle extension bearings completely protect the knee vees from dust in all positions. The table slide has one narrow dovetail guide and one flat way, and is provided with a full length adjustable taper gib. The table is supported in the middle and at both ends, and carries two scales reading in degrees and inches of taper per foot. A fine-pitch screw is used for setting over the table for handling taper work. A coarse table feed used especially for cutter grinding is operated from either side of the machine by a clutch lever, power being transmitted through a rack and pinion. Fine table feed is operated from either side of the machine by a handwheel through a screw and half-nuts. This screw is provided with a micrometer dial and can be used for bringing the work up to the wheel while the cross-feed is used for feeding the work across the grinding wheel. Provision is made to gear up the screw with the spindle of the index head when grinding spiral fluted hobs, the arrangement being similar to that used on the universal milling machine.

The principal dimensions of this machine are as follows: longitudinal movement, 17 inches; vertical movement, 10½ inches; cross movement, 9 inches; swing of universal head over table, 10 inches; swing of universal head right angle, 16 inches; size of table, 5¼ by 33¾ inches; width of T-slots, ⅝ inch; amount of swivel, 270 degrees; taper adjustment, 2 inches per foot; distance from center of spindle to table, 0 to 10½ inches; number of hand feed changes, 2; swing of work centers, 10 inches; maximum distance between centers, 20

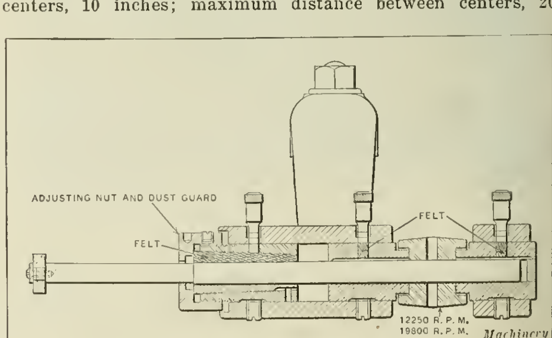


Fig. 3. Sectional View of Internal Grinding Attachment

inches; number of wheel speeds, 2; range of wheel speeds, 3683 to 5950 revolutions per minute; swivel of wheel-head, 180 degrees either way; capacity for handling face mills, up to 16 inches in diameter; capacity for handling form cutters, up to 7½ inches in diameter; capacity for handling saws on table, up to 48 inches in diameter; diameter of countershaft tight and loose pulleys, 6 inches; width of driving belt, 2½ inches; speed of countershaft, 850 revolutions per minute; and floor space occupied by machine, 49 by 68 inches.

WRIGHT CAGELESS ROLLER BEARING

Difficulty experienced with roller bearings having tapered rollers through the tendency of the wedge-like rollers to slip endwise was overcome by the late William Hamilton Wright through decreasing the cone angle of the races below a certain critical value. The value of the so-called "angle of repose" may only be determined by experiment and depends upon the nature of the surfaces in contact with each other. It still remained to determine a practical value for the angle of inclination of the axis of the roller in relation to the main axis about which general rotation takes place. These are principles involved in the construction of the full series cageless roller bearing manufactured by the Wright Roller Bearing Co., 1420 Chestnut St., Philadelphia, Pa.

The static elements are best considered by reference to Fig. 3, in which is shown a cross-section of a Wright bearing taken through a major or full diameter. It is necessary to determine whether or not the tapered conical roller when acted upon by the forces due to rotation of the bearing under load is subject to any tendency to slip endwise, and if so, whether the value of the resultant force is relatively large or negligible. Such a bearing in use is subjected to two principal load forces, which in the case of a wheel bearing are a dead weight carried upon a wheel, producing a radial load, and end thrust due to the resistance of the vehicle wheel to the side swinging of the body of the vehicle. A general case is shown in this illustration, wherein the direction of the radial load is indicated by the downward pointing arrow and the direction of a moderate thrust load is indicated by the upward pointing arrow, each of these lines representing not any solitary force acting from above due to downward pressure of the axle, or from below due to upward reaction of the hub of the wheel, but rather the resultant of all downward acting forces and all upward reacting forces on the conical roller.

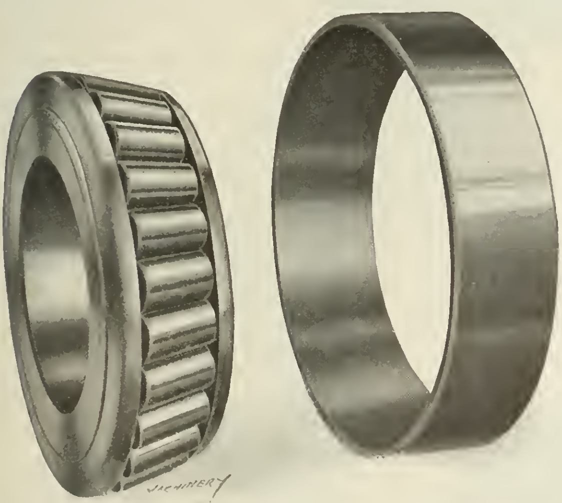


Fig. 1. Wright Cageless Roller Bearing, showing "Full Series" of Rollers

If these two resultants take directions such that a line passing through the intersection of the two lines forms an angle of less than 180 degrees on the side toward the apex of the conical roller, they are bound to have a resultant *T* which is a thrust tending to produce a slipping of the roller in the direction indicated. Whether slipping will occur depends upon whether or not the value of force *T* exceeds the value of the opposing friction due to pressure upon the roller in its position between the two raceways. The value of the opposing friction is relatively much greater than is commonly supposed, and in a bearing of this kind under load no one of the several rollers in the load zone can be driven out of position except by a relatively great force.

Fig. 2. Wright Cageless Roller Bearing assembled

In a properly designed roller bearing, the necessary force required to produce end slip is never present unless the direct horizontal side thrust has a value greater than 50 per cent of the direct radial load. However, in order to insure positive security, the rollers ride about the inner raceway between flanges which limit the movement of any roller in the direction of its own axis. In the general case, if the angle formed by the resultant of the lines representing the two forces as shown in the diagram is less than 180 degrees on the side corresponding to the bases of the cones, the final resultant *T* will have a negative value, or will act in a manner tending to produce end slip of the roller in the direction of its apex, or as of a driven wedge. In everyday operation the actual case lies between the two conditions illustrated.

A most important consideration of design is now to be noted, namely, that the width of tread between the shoulders is greater than the length of tread of the roll. Herein lies the condition for the perfect freedom of rotation of this type of bearing. It should be obvious to the average reader that the tendency of the roller shown in the diagram is to react under pressure against the inner tread by sliding to the right, while its tendency to react against pressure due to the outer tread is by sliding to the left. The manner in which these two tendencies counteract each other is best considered if the bearing is now treated as respecting kinetic conditions.

When rotating, it is found that the conical rollers, under the play of forces whose resultants never take the same direction very long at a time, tend to "weave" slightly from side to side in their position between the treads, and if a moderate amount of clearance is allowed in limited width of inner tread, freedom of the rollers is assured. Even though they may, for an instant, under an extremely heavy side thrust, move endwise far enough to make contact with the opposing shoulder in one direction, they instantly and automatically free themselves as they pass out of the load zone of the bearing into the upper part of the bearing. An advantage of the "free-race" bearing is

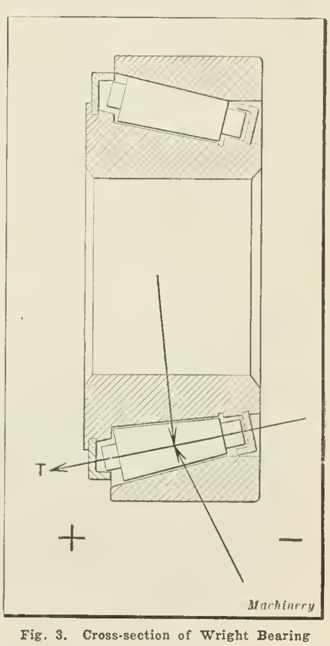


Fig. 3. Cross-section of Wright Bearing

here demonstrated, namely, that although a severe thrust may occasion conditions wherein friction between rollers and the opposing shoulder tends to produce temporary misalignment of the rollers, if they are left free they will right themselves.

Two remaining points of interest may be touched upon, first as to how alignment is maintained, and second as to what the friction is between adjacent rollers, the surfaces of which are moving in opposite directions. If anyone will take a lead pencil and place it inside the outer ring, commonly known as the "cup" of a taper roller bearing, it will readily be perceived that in any other position than with its axis in the proper alignment there are forces tending always to produce proper alignment due to the geometrical characteristics of the conical interior surface. Upon the point regarding opposite rotation of adjacent rollers, it should be noted that a total clearance approximating about one-third the diameter of a roller is provided for the entire "full-series" in the raceway. Contact could not exist between all rollers unless all the clearance is maintained at one point.

AJAX FORGING MACHINE

The first seven-inch forging machine built by the Ajax Mfg. Co., Cleveland, Ohio, which was placed on the market in 1911, was similar in appearance and construction to the present machine, except that it was much lighter and had a more limited capacity. Since that time several seven-inch machines have been built, notably special machines for the production of large annular rings, bevel gears, etc. These special machines are different from the standard only in that they have a single toggle operating the moving die in place of the double toggle used in standard machines. These machines have a narrower die slide, and consequently they are about ten inches shorter than the standard type of machine.

The accompanying illustrations show the new seven-inch Ajax upsetting and forging machine, which is said to be the largest and most powerful forging machine built. The bed plate casting is of steel, cast in one piece, and weighs approximately 60 tons. The complete machine, with its regular equipment, weighs nearly 100 tons. When stripped of all accessory equipment, gear, flywheel and other parts, which can be removed without entirely dismantling the machine, the weight just comes within the capacity of a 150,000-pound ordnance gun truck car. The length of the bed plate is 21 feet, and the width, 9 feet, 6 inches, which is practically the limit of width which may be shipped over railroad lines.

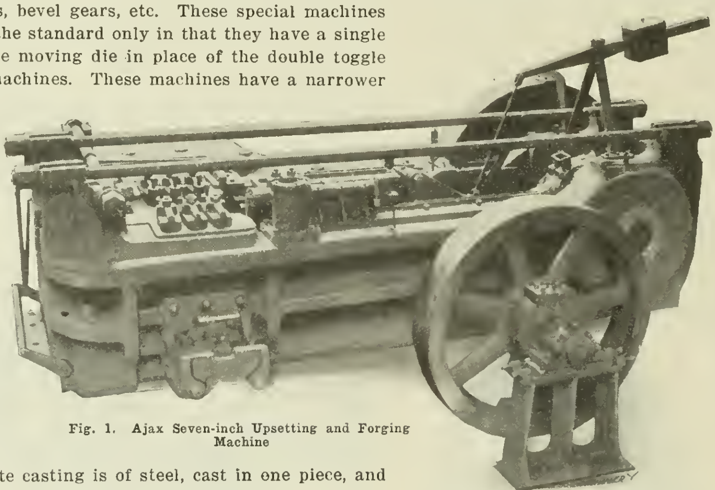


Fig. 1. Ajax Seven-inch Upsetting and Forging Machine

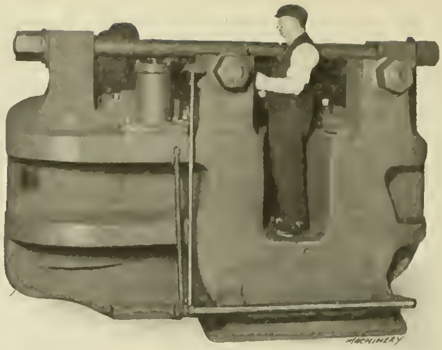


Fig. 3. End View of Ajax Forging Machine

This new machine is built along the lines of the standard Ajax upsetting and forging machines of all sizes. The crankshaft housings are continuous, being bored large enough to take the throw of the crank. The bronze-bushed bearings are pressed into the bed from each side, forming solid bearings for the crankshaft. The momentum of the crankshaft and pitman are utilized in this machine, as the clutch mechanism is located between the main slide and the pitman. As this clutch can only pick up the main slide and start it in motion at the end of the stroke, the action is very easy, and a minimum of power is used in starting the operating parts of the machine. Side motion of the die is operated through a set of knuckles from the main slide in such a way that the dies are closed when the heading tool is about half way forward, and remain closed until the heading tool comes back to the same point. This insures the heading tool being free from the forging before the grip is released. Liners may be used in the die to provide for the use of smaller blocks when light work is being done on the machine.

The production of forgings on this machine is determined largely by the efficiency with which the material is handled between the furnace and the forging machine, and also by the heating capacity of the furnace. One automobile company has produced 540 large bevel gears in eight hours, the method used being to upset on the end of a solid bar, then push the bar back, and leave the ring in the dies. This produces forgings of this type without waste of material, except for a few inches at the end of the bar that cannot be gripped in the dies.

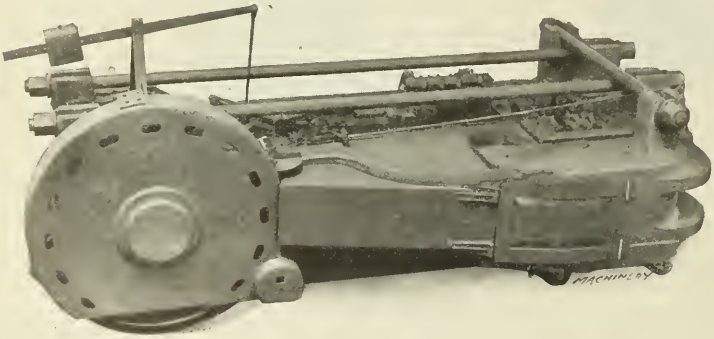


Fig. 2. Opposite Side of Ajax Forging Machine shown in Fig. 1

AUTOMATIC TAPPING AND DRILLING MACHINE

W. H. Simmons & Co., 208-212 Lawrence St., Cincinnati, Ohio, are now building the "Cinti" automatic tapping and drilling machine shown in the accompanying illustrations. The clutch and reversing mechanism of this machine can be set to run the tap to any desired depth and reverse automatically; after the tap clears the work, the spindle also stops automatically. The clutch, as well as other contact points, is made of hardened steel to afford ample durability. A lead for any desired pitch of thread is used on the spindle, and 16, 18, 20 and 24 thread leads are standard equipment. The

belt tightening device is operated by a knob on the right side of the column near the base, and the belts can be adjusted to any desired tension. Bronze bearings are furnished throughout this machine, and the lower pulleys are provided with bronze bushings.

The principal dimensions of the machine are as follows: capacity for drilling or tapping to the center of a 12-inch circle; maximum distance from spindle to table, 10½ inches; vertical adjustment of spindle. 3¼ inches; vertical adjustment of table, 5 inches; diameter of spindle in sleeve, 13/16 inch; diameter of table, 10 inches; diameter of cone pulley steps, 3½ to 7 inches; width of driving belt, 1½ inch; size of tight and loose pulleys, 7 by 1¾ inch; tapping capacity in cast iron, up to ⅜ inch in diameter; drilling capacity in cast iron, up to ½ inch in diameter; speed of tight and loose pulleys, 300 revolutions per minute; and available spindle speeds, 150, 250, 390 and 600 revolutions per minute.

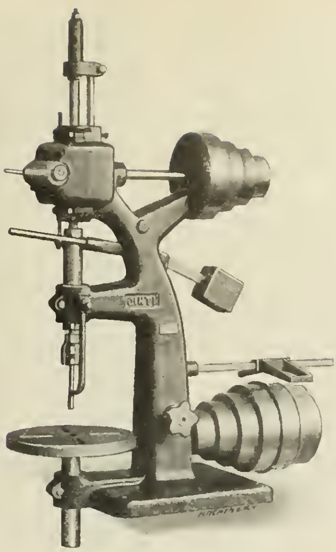


Fig. 1. "Cinti" Automatic Tapping and Drilling Machine built by W. H. Simmons & Co.

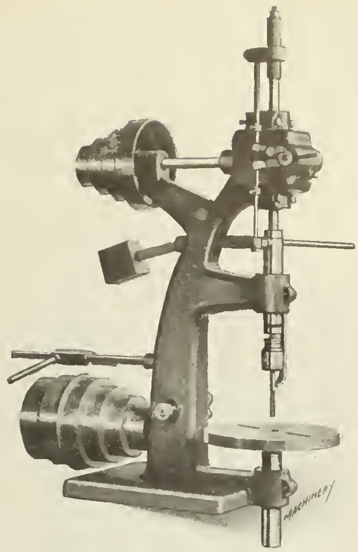


Fig. 2. Opposite Side of "Cinti" Automatic Tapping and Drilling Machine shown in Fig. 1

SUPERIOR MOTOR-DRIVEN MILLING MACHINE

The Superior Machine & Engineering Co., 51-53 Fort St., Detroit, Mich., has recently applied motor drive to its hand milling machine. The machine is shown in Fig. 1, and Fig. 2 illustrates a section through the speed gear-box with a sliding gear and transposing gears on the end of the shafts for varying the spindle speeds. The lower pulley near the bottom of the column, the pulley on the end of the spindle and the upper pulley on the swinging arm are made interchangeable, and in combination with the two-speed gear-box and transposing gears, twelve spindle speeds are obtainable, having a range of from approximately 150 to 1035 revolutions per minute.

Reference to Fig. 2 will show that the large sprocket wheel is keyed to the hollow shaft, which is the main driving shaft. The quill gear is also keyed to this shaft and drives the sliding gear on shaft A. Gears B and C are transposing gears, and either one can be used on shaft D, which runs in bronze bearings at each end of the hollow shaft. The hollow shaft, to which the large sprocket wheel is keyed, and pulley shaft D both run in the same direction. The chains and sprockets are entirely covered, which will be apparent by referring to the view of the machine shown in Fig. 1.

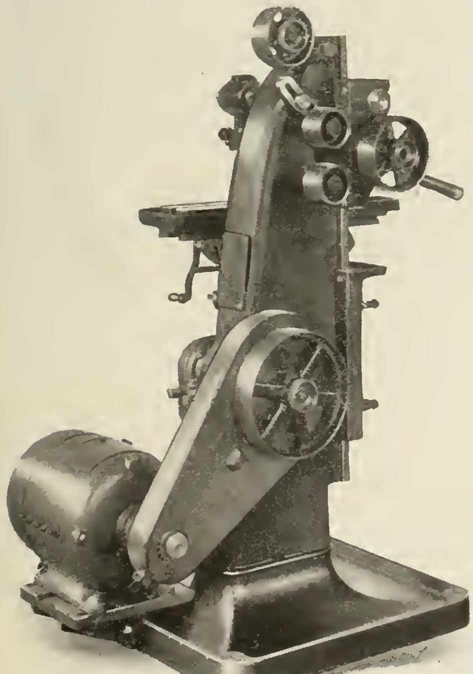


Fig. 1. Superior Hand Milling Machine equipped with Motor Drive

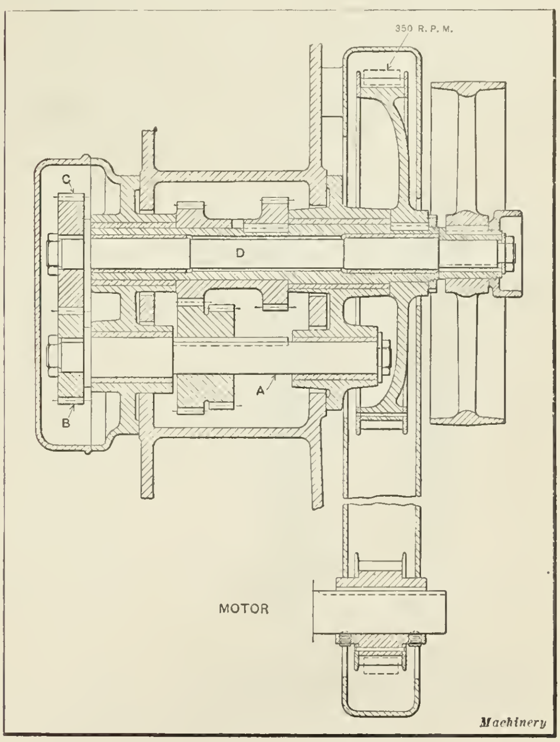


Fig. 2. Section through Speed Gear-box for varying Spindle Speeds

SCHOENERT REAMERS AND TAPS

Carl Schoenert & Sons, Inc., 631-633 S. 20th St., Newark, N. J., is now manufacturing the reamers and taps here shown. Fig. 1 shows a number of sizes of the reamer for which the following advantages are claimed: First, a perfectly smooth

and exactly cylindrical hole is reamed, it being impossible for these tools to leave any chatter marks, as they are guided by the full length of the tool at the opposite side from the cutting edge; after being reamed, the hole appears perfectly polished. Second, the reamer can be easily sharpened on an ordinary grinding wheel without requiring the use of a special attachment. The cutting edge is simply held against the grinding wheel and ground to the shape of the wheel, which is said to make a good cutting edge. Schoenert reamers are made with straight and taper shanks and in various sizes. The central hole in the reamer facilitates lubrication and provides chip room, as the chips tend to crowd into the hole in the tool, where they give no trouble.

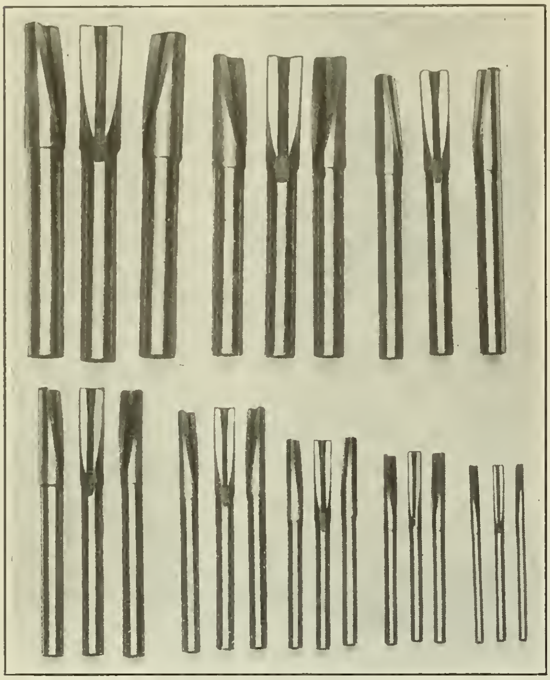


Fig. 1. A Number of Sizes of Reamers made by Carl Schoenert & Sons, Inc.

This reamer usually makes a hole of exactly the size of the tool, cutting as close as 0.0001 inch to size. It cuts the material the same as a lathe tool will cut it, but never digs in. The chips have the same shape and appearance as those produced from a lathe tool, and the cutting clearance is more than on any standard reamer. The reamer may be used either right or left, as there are cutting edges on both sides. If the right-hand side is worn off, it may be used left-handed. However, the grinding takes only a little time, and so there is no occasion for not keeping the reamer properly sharpened. Fig. 2 shows a close view of two of the reamers and some of the chips produced by them.

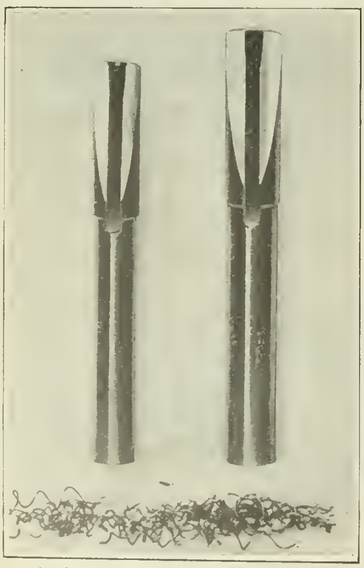


Fig. 2. Close View of Schoenert Reamers and Chips made by them

The same general form of construction is employed in the Schoenert taps, three of which are illustrated in Fig. 3. They have much more clearance than the ordinary tap and cut the chips out the same as the reamer does. These taps are said to be especially valuable for use where lubrication is important. The hole through the center of the tap gives the lubricant a chance to flow freely to the work. Owing to the spiral on the tap, the cutting edges also work better than would the straight cutting edge on the regular tap.

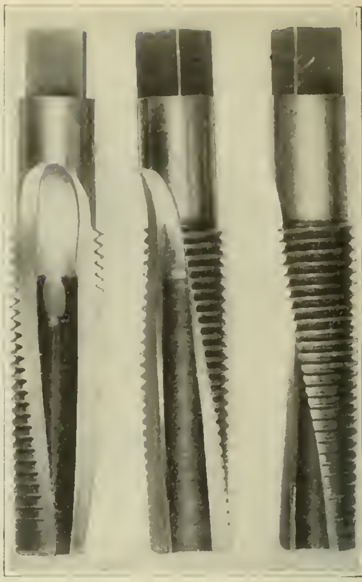


Fig. 3. Schoenert Taps made on Same Principle as Reamers shown in Figs. 1 and 2

G. E. DYNAMIC BRAKING CONTROL FOR CRANE HOISTS

The General Electric Co., Schenectady, N. Y., has recently brought out an automatic device, which can be added to its standard Type B drum controller and thus make a serviceable semi-magnetic dynamic braking control for crane hoist service. The additional equipment consists of: a panel for wall mounting, which contains a direct-current contactor and current limit relay; and an extra resistance, which is inserted in the circuit during the acceleration and deceleration period. A dynamic braking, manually operated, drum type controller is more severe on the commutator of a direct-current series motor than is a plain reversing manual controller, because when lowering, the motor is connected similarly to a shunt-wound motor and does not have the inherent protection of the series field. In many installations, where the service is severe, a semi-magnetic equipment will materi-

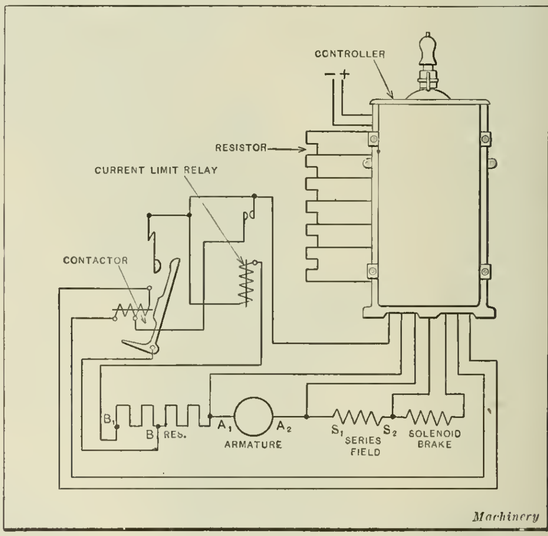


Diagram showing Principle of G. E. Dynamic Braking Control for Crane Hoists

ally assist commutation. This equipment is useful also where the service is not quite severe enough to justify the expense of a full magnetic equipment.

The connections, when used with the dynamic braking controller, are shown in the accompanying diagram. The extra resistance BB_1 is to be added to the resistance regularly furnished with this controller. With the new arrangement this block of resistance would be so high that it would be impossible to damage the motor, no matter how quickly the controller was thrown on and off. The contactor and relay simply insert and cut out this resistance when accelerating and decelerating in such a manner as to give practically the same speed characteristics on the motor as would be obtained with a standard controller and at the same time prevent abusive currents. This device protects the commutator from severe arcing, and protects the controller fingers and segments from severe burning. It enables the motor to run at a higher lowering speed for a given severity and condition of service, provided extra resistors are used to weaken the motor field.

NEW MACHINERY AND TOOLS NOTES

Magnetic Chuck Fixtures: Lawson & Co., 90 West St., New York City. Three magnetic chuck fixtures for holding small or irregular shaped pieces on an ordinary magnetic chuck. These comprise a set of parallels, a V-block, and a protractor block with a V-shaped top.

Radius Gage: Moss-Ochs Co., 3387 E. 116th St., Cleveland, Ohio. A universal radius gage for determining the accuracy of concave or convex surfaces of tools and dies from 1/8 to 1 inch radius. This gage does not have separate leaves for concave and convex surfaces, but has a convex surface on one side and a concave surface on the other.

Radial Drilling Machine: Canedy-Otto Mfg. Co., Chicago Heights, Ill. A radial drilling machine built in two models, one of which has power feed and the other hand feed. Both of these models are built with either a 2½- or 3½-foot arm. Four changes of speed are provided by four-step cone pulleys, and the spindle and feed drives are operated through bevel gears at the top of the column.

Angle-plates: Simplex Tool Co., Woonsocket, R. I. Angle-plates intended for the use of toolmakers. These plates can be used on a bench lathe faceplate, grinder, on the bench or in other ways. Both the inside and outside faces of the plate are ground, and tapped holes are provided in one side and plain holes in the other side of the angle. The plates are made of hardened steel and ground all over.

Thread Milling Fixture for Shells: Hall Gas Engine Co., Inc., Bridesburg, Philadelphia, Pa. A fixture for threading shrapnel and high-explosive shells, which is designed for use on a lathe or milling machine. This attachment is adapted for producing either internal or external threads in brass, aluminum, steel and other metals. The attachment can also be employed for threading many other classes of work besides shells.

Tool-room Lathe: Cleveland Machinery & Supply Co., Cleveland, Ohio. A 12-inch tool-room lathe, the design of which includes the following features: a geared headstock, a gear-box arranged for cutting either U. S. standard or metric threads without the use of translating gears, and a relieving attachment for angular, straight or taper relieving operations. The bed is made unusually heavy to adapt the machine for heavy work.

Disk Grinders: Guy G. Townsend, Winchendon, Mass. A line of heavy-duty disk grinders which replaces the line of lighter machines of similar design formerly manufactured by this machine builder. The tables are constructed with adjustable gibs, and the head swing shaft bearings are adjustable. Abrasive wheels are mounted in steel disks, and hoods serve both for safety and for the additional purpose of carrying away abrasive dust.

Crank-case Reamer: Taft-Peirce Mfg. Co., Woonsocket, R. I. A tool known as the "Mantell" adjustable reamer. A parallel movement of the reamer blades is secured by means of inclined planes or wedges which fit into the slot at each end. The blades are set in the reamer at opposite angles, two in one direction and four in the other, but so arranged that the advantage of uneven spacing is obtained. It is possible to caliper any pair of blades at any point.

Drill, Tool and Toolpost Grinder: Universal Electric Co., Inc., 5 Oliver St., Newark, N. J. A machine known as a universal drill, tool and toolpost grinder, which is driven by a ¼-horsepower motor. This machine may be supported on a stand for use as a tool or drill grinder, or it may be lifted from the stand and supported in the toolpost by means of a suitable shank. The stand is equipped with a table rest for grinding tools and a V-rest for sharpening drills. The motor is supplied for either direct or alternating currents.

Multiple Drill Head: Nelson-Blanck Mfg. Co., Detroit, Mich. A line of adjustable multiple-spindle drill heads. An adapter at the top of the head is separable, so that a change may be quickly made. The driving shank is square and slides in a square hole in the driving gear, thus allowing different sized tapers to be used without taking apart the entire head. A ball thrust bearing is provided for the driving shank, and the driving gear runs in S.K.F. ball bearings. These heads are built in four styles to take drills with No. 0 straight and Nos. 1, 2 and 3 Morse taper shanks.

Continuous Milling Attachment: Mann Corporation, Kankakee, Ill. An attachment known as the "Manco" continuous miller, which is self-contained and can be mounted on any drilling machine of suitable size. Drive is transmitted through a universal joint. This outfit will handle a variety of work usually done on plain or hand milling machines. The work-table is 13¼ inches in diameter, has both hand and power feed, and carries a series of pieces; as it rotates, it carries the work to a milling cutter mounted on a 1¼-inch arbor supported by a steel column.

Dynamic Balancing Machine: Carlson-Wenstrom Co., Richmond St. and Erie Ave., Philadelphia, Pa. A dynamic balancing machine of similar design to that formerly built by the Dynamic Balancing Machine Co. of Philadelphia. Rights to manufacture this machine under the Akimoff patents have been acquired by the Carlson-Wenstrom Co., and certain changes have been made in the design of the machine. The most important of these is the greater convenience of operation through provision of handwheels for making all adjustments while the machine is running. This is claimed to be the means of doubling the capacity.

Precision Lathe and Grinder: Ideal Machine & Tool Co., 128 Opera Place, Cincinnati, Ohio. A combination precision lathe and grinder, which swings 7 inches and is made with beds of various lengths, the shortest of which takes work up to 12 inches between centers. A compound slide-rest is used which will give a longitudinal feed of 3 inches at one setting, and the cross-feed also has a maximum movement of 3 inches. A 4- by 6-inch table with T-slots, which is adjustable to any angle, is mounted on a bracket at the rear and has a vertical movement of 4½ inches. This table is used for holding work while grinding.

Drilling Machine: Colburn Machine Tool Co., Franklin, Pa. A heavy-duty drilling machine that is constructed on the unit principle. The machines are provided with one, two, three or four spindles. The drive is through a constant-speed belt to the main driving shaft. Two mechanical speed changes are provided, which are operated in conjunction with an arrangement for changing gears which makes it possible to obtain forty different speeds ranging from 74 to 508 revolutions per minute. Thirty-six changes of feed are available, covering a range of from 0.005 to 0.153 inch per revolution of the spindle. These changes are obtained by means of a worm feed handwheel. An automatic tripping mechanism is furnished to disengage the feed at any desired point.

Back-geared Lathe: Giddings & Lewis Mfg. Co., Fond du Lac, Wis. An 18-inch double back-geared lathe, driven by a three-step cone pulley. The bed of this machine has a large V-bearing at the front and a flat surface at the rear for the carriage, while there is a second smaller vee for lining up the headstock and tailstock. Back-gear ratios are 9 to 1 and 3 to 1. The spindle is made of a carbon steel forging, which is ground to size, and the spindle runs in self-oiling phosphor-bronze bearings. The lead-screw is made of carbon steel with a four-pitch Acme thread. Eight changes of feed are furnished by the standard gear-box, while a special change-gear box, which is interchangeable with the standard box, gives forty changes. Screws with metric pitches may be cut by using a pair of gears running on idlers on the quadrant stand.

Disk Grinder: Charles R. Carpenter Machine Co., Robbinsdale, Minn. This machine is known as a disk flat surface grinder, and the following are noteworthy features of its design: Angular adjustment of the universal table is controlled by means of a clamping handle located immediately below the table. This arrangement works in connection with a graduated table top and protractor blade to provide for instantaneously placing the table in position for accurately grinding plain or compound angles. Clamping handles are provided for the table arms, allowing them to be quickly clamped or released to oscillate in the usual manner. The table two-way thrust collar is enclosed within the table arm, thus making both bearings absolutely dustproof. At the disk ends of the table arm bearings dust shields are provided to prevent the table studs from becoming charged with grit. The machine arbors are turned and ground, and supported in two split bronze bearings, which are adjustable for wear. This machine is equipped with two 18-inch disks, and weighs 1700 pounds.

ACCURACY TESTS IN MANUFACTURING THE TILTED TURRET

BY J. W. BARBOUR[1]

The Wood Turret Machine Co., Brazil, Ind., in assembling its tilted turret lathe, employs several interesting methods and tests to insure the accurate alignment of the turret holes and the spindle. After the machine bed is thoroughly seasoned and finish-planed, it is sent to the hand scraping department, where the ways are scraped and spotted to a heavy surface plate; the bed is then set up on a specially equipped boring mill and bored for the spindle bearings. The bearings are next placed in position, after which the machine is returned to the erection department, where the bearings are scraped to the spindle. The initial test is then made to determine the alignment of the spindle with the ways. A telescoping fixture is used for this purpose and readings are made at all positions on the ways, both for lateral and for horizontal alignment.

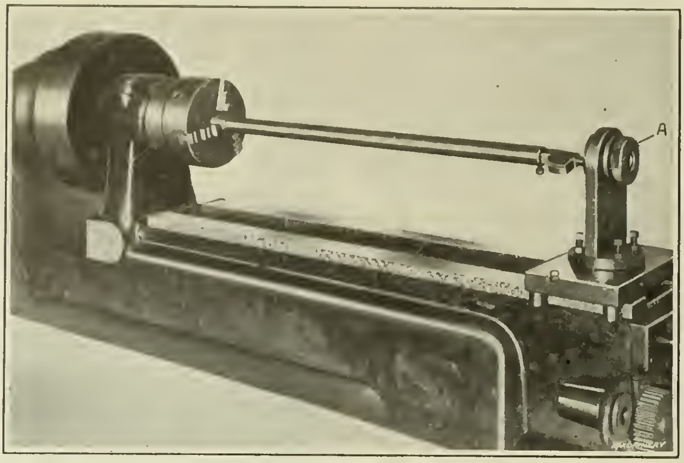


Fig. 1. Testing Alignment of Spindle with Ways

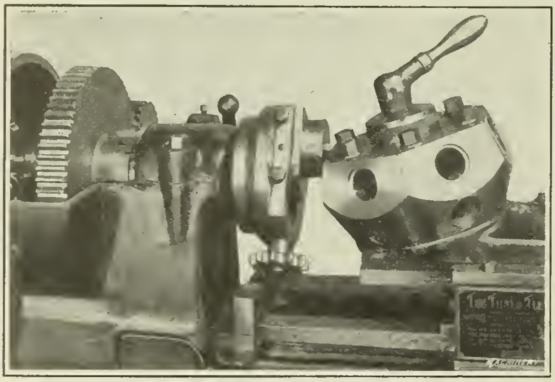


Fig. 2. Special Tool facing Turret True with Spindle

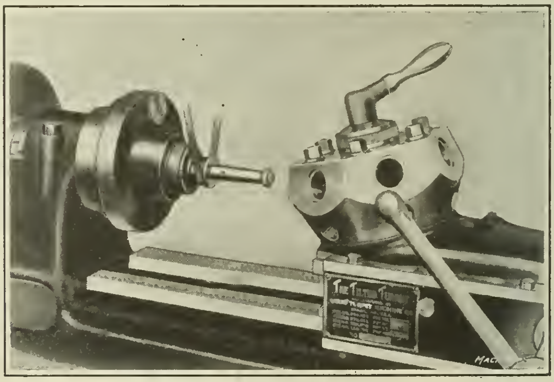


Fig. 3. Grinding Turret Holes in Perfect Alignment with Spindle

In Fig. 1 is shown the final test for alignment of the spindle with the ways. The bar holding the indicator is slipped back through the spindle until the indicator comes up near the chuck, and the fixture *B* is moved along the ways until the indicator enters the hole of the hardened and ground bushing *A*. Then, while the spindle is revolving, the bushing *A* is adjusted so that the indicator points to zero during the complete revolution of the spindle. The fixture *B* is then moved to the end of the ways, as shown, the adjustment of bushing *A* remaining unchanged. After the bar that holds the indicator is moved through the spindle until the end of the indicator enters bushing *A*, the spindle is revolved, and if the indicator points to zero for a complete revolution, as it did at the chuck, the alignment of the spindle with the ways is perfect. It requires from three to four hours to obtain a satisfactory bearing.

The saddle slide and turret head are assembled as a complete unit. After all the surfaces on these parts have been scraped to heavy surface plates, this unit is placed in position on the ways of the bed, and a crank fixture, which moves the slide the full length of its travel, is attached to the rear end of the slide, as shown in Fig. 4. This fixture is driven from the lineshaft, and indexes the turret at the rate of forty complete strokes per minute. As it is run for a period of six hours, the entire indexing mechanism is limbered up and tendency to spring in any of the surfaces is overcome. Before this operation, the slide and saddle are hand-scraped to each other, so that moving the slide and the saddle and revolving the head mechanically brings the slide to a good seated bearing and also causes the locking pin to seat itself perfectly in the locking bushing before the holes in the turret head are finished. Any defects will thus be discovered before the machine is completed.

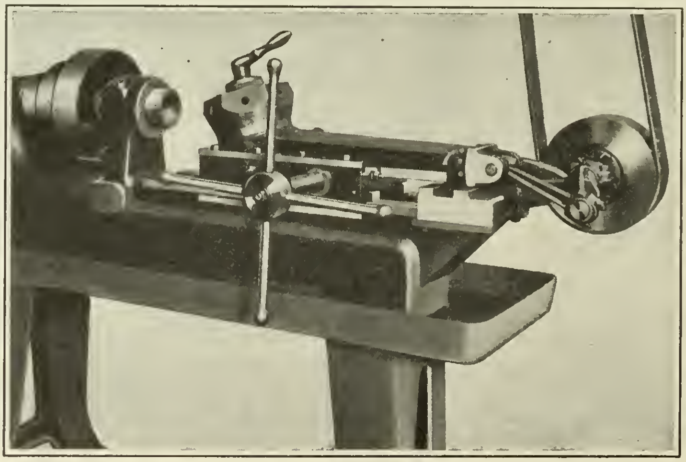


Fig. 4. Turret Head attached to Fixture that revolves Head and moves Slide and Saddle

The turret head is next bored to within 0.010 inch of size from its own spindle; then the tooling surfaces are machined by the special star-feed facing fixture shown in Fig. 2, which is also mounted on the spindle. This tool machines each face of the turret head at right angles with the hole

[1] Sales Engineer, Wood Turret Machine Co., Brazil, Ind.

and true with the spindle. This insures perfect alignment with any tools that may be bolted to the head.

The next operation, which is probably the most interesting, is that of grinding the turret holes by means of the specially designed grinder shown in Fig. 3. A motor is mounted over the front bearing, on a stand that is clamped to the ways, and the grinding fixture is inserted in the end of the spindle. Each turret lathe has the holes in the turret head ground from its own spindle, which insures perfect alignment of the holes and the spindle, and avoids trouble from non-alignment commonly encountered when the holes are reamed. All holes are ground the same size with this attachment. The adjustment of the grinder is very sensitive, and it can be easily set to the smallest fraction of an inch. This fixture is of the planetary type and operates on the same principle as the Heald grinder; it is adjustable for different sizes of holes, and duplicate grinding can be done within very close limits. This permits of absolute accuracy in sizing the turret holes and eliminates the bell-mouth tendency that often follows the use of boring-bars and reamers.

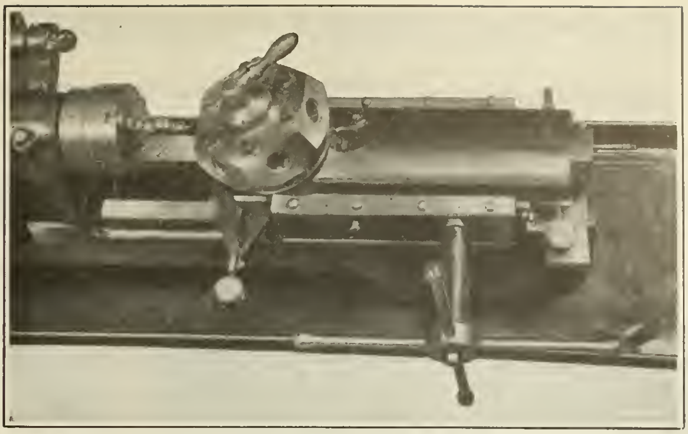


Fig. 5. Making Final Alignment Tests

Following this operation, the machine is ready for the final inspection. The head, slide and saddle are taken down and thoroughly cleaned to remove foreign substance. They are then reassembled and an indicator is placed at each end of the slide, to test both the vertical and the horizontal alignment; another indicator is held in the chuck of the machine to test the holes in the head, as shown in Fig. 5. Readings are then taken over the full length of travel of the slide on the tooling face of the turret, in the front and back of the turret holes, and on a plug extending six inches out of the turret hole. The work is held to within 0.001 inch limits. If there is any inaccuracy, it is found by this inspection before the machine is shipped.

Allowance is made for inaccuracies that may develop after extended use of the tilted turret. The turret slide is furnished with taper gibs, which are fitted the whole length of the saddle on each side and provide a means of adjusting the slide sideways. The saddle is gibbed to the outer edges of the bed by flat gibs throughout its entire length, and it has a supplementary taper base, by means of which the turret holes can be adjusted to maintain their exact height in relation to the center of the spindle.

* * *

U. S. ARMY MOTORIZED FIELD BATTERY

The United States Army has developed what is believed to be the first completely motorized field battery of medium caliber guns in the world. The work has been in charge of Major Lucian B. Moody, who has been assisted by the tractor standards committee of the Society of Automobile Engineers.

European armies have reduced greatly the number of horses in artillery use, but it has not been possible to eliminate them in hauling certain of the smaller and medium types of ordnance because of the lack of a proper tractor combination of speed and power. The big creeping type tractors capable of handling the heaviest guns have been unable to make the occasional bursts of speed necessary for getting the light field guns into position and using the minimum of space that conditions on the firing line frequently make vital.

The new creeping, or self-track-laying, type of small or medium size tractor developed by the American Army is built without the steering arrangement in front, and while possessing relatively as much power as the type now used in Europe, is capable of turning within its own length by simply reversing or stopping one of the creeper drivers while the other side continues to move ahead. The development in this type of tractors powerful enough to haul the heaviest guns will make them available for making the sharp turns and corners and fitting into the inconvenient spaces for which horses have so far had to be used at the front. The experiments have proceeded far enough to justify plans for the successive motorization of all American artillery units except the smallest calibers required to move at very high speed over bad ground.

From a scientific and military standpoint, the tractor is much more efficient than the horse. It lasts longer, is capable of performing more work in a day, and costs less for repairs and fuel than the expense of upkeep of the horse. A tractor can, if necessary, be used 24 hours a day, while the horse has to stop for rest, sleep and feeding, and can seldom be worked more than ten or twelve hours a day at the most.—*The Official Bulletin.*

* * *

A MACHINIST WITH STEEL HANDS

For some time the nations at war have sought artificial arms and hands that will enable cripples to resume their former occupations with little disadvantage. The need of effective devices of this sort is felt not only by war cripples, but by the many who have lost their members in industrial pursuits. Andrew Gawley, an employe of the Fisher Motor Co., Orillia, Ontario, has steel hands to replace the hands he lost some years ago through contact with a circular saw, which were made to his own design. These are said to be very effective indeed. Mr. Gawley is now employed in the tool crib of the Fisher Motor Co., and he can pick up pieces of varying sizes and weights with confidence and ease. He keeps track of the printed forms of all material that goes out and attends to the general duties of his position. Before entering the tool crib, Mr. Gawley worked on a drilling machine. His steel hands are so strong that when drilling shell adapters weighing forty-five pounds each, he was able to lift an adapter on and off the machine table with one hand, being the only man who could handle the pieces in this way. Yet the steel hands are so well under control that he can write a legible hand, pick up a fragile cup by the handle, dress himself, light a lamp, and do many other things that would seem impossible of accomplishment by an artificial member.

* * *

MARINE ENGINEERS NEEDED

The United States Shipping Board is seeking the name and address of every man in the United States who can qualify, with or without special training, for a position as an engineer officer on an American merchant ship. The merchant marine will need within eighteen months 5000 additional engineers in all grades. To start in training those not yet qualified to secure United States inspection papers, the government will open on July 2 a chain of free schools in marine engineering, at some of the best known technical colleges in the country, for which marine engineers of all grades, oilers and water tenders, also stationary engineers, are eligible. The duration of term is one month. After passing examinations of steamboat inspection service, students will have opportunity for further training under service conditions until wanted on ships of the new merchant marine.

MACHINERY'S MOTION PICTURE ON ITS TRAVELS

The mechanical world is evincing great interest in MACHINERY'S motion picture, which shows in detail every operation in the machining of a 9.2-inch high-explosive British howitzer shell. The picture was first shown at the joint session of the American Society of Mechanical Engineers and the National Machine Tool Builders' Association, Hotel Sinton, Cincinnati, Ohio, May 22, and was again shown in the same place May 24 to a large audience comprising mechanical executives of Cincinnati.

Requests for exhibitions of the film have come in from all over the country, and it will be shown in the chief industrial centers as soon as arrangements can be made. Wherever it has been shown, the audiences, being chiefly men familiar with mechanical practice, have been greatly interested and have plied with questions Chester L. Lucas, associate editor of MACHINERY, who presents the picture and gives a preliminary lecture on the different types of shells used by the warring nations, the characteristics of each, and other points of particular interest in connection with the picture.

We quote from Mr. Lucas' notes of recent exhibitions:

Pittsburg, Pa.—On June 4 the picture was shown at the Carnegie Institute Lecture Hall under the auspices of the Engineering Society of Western Pennsylvania. This was a special meeting called for the purpose and invited guests were present.

Cleveland, Ohio.—On June 5 the Cleveland Engineering Society called a special meeting at the Chamber of Commerce Auditorium, to which were invited the members of the Cleveland Engineering Society, Chamber of Commerce, Cleveland Advertising Club, West Side Chamber of Industry, City Club and the Superintendents and Foremans Club. While in Cleveland, the 9.2-inch shell was shown at the recruiting station, and as this was registration day, it aroused considerable interest and helped the recruiting work.

Buffalo, N. Y.—The Engineering Society of Buffalo called a special meeting at the ballroom of the Iroquois Hotel on Wednesday evening, June 6. Here several hundred members of the local society and other engineering men of Buffalo gave close attention to the preliminary lecture and the moving picture film. The meeting was preceded by a banquet, which was well attended.

Rochester, N. Y.—On Friday, June 8, the annual meeting of the Rochester Engineering Society was held, at which the lecture and moving picture were given. Owing to the fact that considerable shell work has been done in Rochester, more than ordinary interest was displayed in the film.

At the time of writing this notice—June 23—arrangements have been made to show the picture at various points in New England, and audiences comprising several thousand mechanical executives will probably see the picture between June 23 and 30.

* * *

WIRE STRAIGHTENERS—CORRECTION

The illustrations Figs. 4, 5, 6, 9, 10 and 11 of the article "Wire Straighteners" in the June, 1917, number showed straighteners made by the F. B. Shuster Co., New Haven, Conn. The statement in the description of Fig. 9 to the effect that the upper rolls are mounted in an equalizing block, and the lower rolls are fixed, is incorrect. The rolls are independently adjustable.

PERSONALS

Walter F. Sheehan has been appointed general manager of the Globe Motor Truck Co., St. Louis, Mo.

Henry Prentiss of Henry Prentiss & Co., Inc., New York City, has been elected president of the Machinery Club of New York.

R. E. Uptegraff has taken a position as chief engineer in the transformer department of the Packard Electric Co., Warren, Ohio.

C. T. Schaefer has been engaged by the Globe Motor Truck Co., St. Louis, Mo., as chief engineer. He was formerly chief engineer of the Mogul Truck Co.

M. M. Moore, formerly with the machine tool department of Gaston, Williams & Wigmore, Inc., New York City, is now employed in the sales department of John W. Thorne & Co., Inc., 165 Broadway, New York City.

Major Fred. H. Moody, mechanical editor of the *Railway and Marine World*, Toronto, Canada, and formerly associate editor of MACHINERY, is recovering from a shell wound in the arm received "somewhere in France."

Robert R. Keith, for the past five years in charge of the Sheffield plant of the Fairbanks-Morse Co. at Three Rivers, Mich., has taken a position as plant manager of the Holt Mfg. Co., Peoria, Ill., manufacturer of the "Caterpillar" gas tractor.

J. B. Ennis, who has been chief mechanical engineer of the American Locomotive Co. since 1912, has been appointed vice-president of the company in charge of engineering. Mr. Ennis has been with the American Locomotive Co. since its incorporation in 1901, prior to which he was with the Rogers Locomotive Works and the Schenectady Locomotive Works.

Alfred Spangenberg has resigned his position as assistant superintendent of the machine shop of the S. L. Moore & Son Corporation, Elizabeth, N. J., and is now superintendent of the ordnance shop of the Mead, Morrison Mfg. Co., East Boston, Mass. Mr. Spangenberg was for about twelve years with the Pond Works of the Niles-Bement-Pond Co., at Plainfield, N. J.

Morris R. Machol, sales manager of the Speco Manufacturing Corporation, New York City, read a paper, "Spark Gaps in Series with Spark Plugs," at the tenth annual convention of the National Gas Engine Association in Chicago, June 7. The paper described a spark gap device that eliminates many of the faults of spark plugs due to carbon, defective insulation, etc.

Robert Wuest, who for many years was the commissioner of the National Metal Trades Association, has joined the Travelers Insurance Co., Hartford, Conn., as a specialist in group insurance, with headquarters in Cincinnati. Mr. Wuest traveled extensively following his resignation as commissioner of the National Metal Trades Association. During his sojourn in Great Britain and Germany he gave a great deal of study to social insurance.

Lawrence Allison of Kansas City, Mo., a graduate of the Kansas College of Engineering, who has had ten years' experience in building airplanes with the Curtiss Co., the Standard Co. and the Burgess Co., has been made chief engineer of the Lawson Aircraft Co., Green Bay, Wis., a new concern recently organized by Alfred W. Lawson. John Carisi of Brooklyn has been appointed factory superintendent, and Lee Wallace, chief designer.

A. E. Martell, who until recently was connected with the Southwark Foundry & Machine Co., Philadelphia, Pa., builder of the Southwark-Harris Diesel type oil engine, is now associated with Leonard B. Harris, consulting engineer and architect, with offices at 411 Walnut St., Philadelphia, Pa. Mr. Martell, besides being an oil engine specialist, has had a broad experience in the design of automatic machinery, jigs, tools and fixtures for quantity production.

Ainslie A. Gray and Charles L. Benjamin, well-known advertising managers, have joined forces and will maintain offices at 301-302 Transportation Bldg., Chicago, and 608 S. Dearborn St., Chicago, where they will act as advertising counsel to manufacturers of electrical, mechanical, chemical and kindred products; they will analyze and report upon problems of manufacture and distribution and will supervise the preparation of advertising copy for trade papers, catalogues, booklets, etc.

A reunion in honor of the eighty-fifth birthday of Amos Whitney, of Hartford, Conn., one of the founders of the Pratt & Whitney Co. and secretary and treasurer of the Whitney Mfg. Co., was held at the Farmington Country Club, June 20. An informal dinner was given at the club. Among those present were George Bardons, George A. Bates, George M. Bond, W. J. Belcher, W. H. Carter, W. L. Cheney, William Corey, William Coffey, Charles Church, Charles Davis, George F. Echols, A. W. Foote, James W. Greene, B. M. W. Hanson, Herbert Hastings, W. H. Honiss, Frank Harrington, John Johnston, J. N. Lapointe, W. A. Lorenz, Thomas Mannix, C. E. Randles, George Reynolds, John Reynolds, L. E. Rhodes, Ambrose Swasey, Charles W. Sponsel, W. W. Totman, C. F. Tucker, W. R. Warner, C. E. Whitney, George O. Whitney, Fred A. West, Fravel Woodworth.

OBITUARIES

A. Vanderbeek, proprietor of the Vanderbeek Tool Works, Hartford, Conn., whose death took place on May 9 last, was in the wholesale grocery business in Newark, N. J., many years ago. He retired from that business and took up the manufacture of a milling machine which he worked at for a number of years, meantime moving to Hartford, Conn. The milling machine was not a commercial success, and he then took up the manufacture of universal joints and handy vises, which he continued up to the time of his death. The business has now been taken over by the Ainslee Machine & Tool Works, Hartford, Conn., who will continue it.

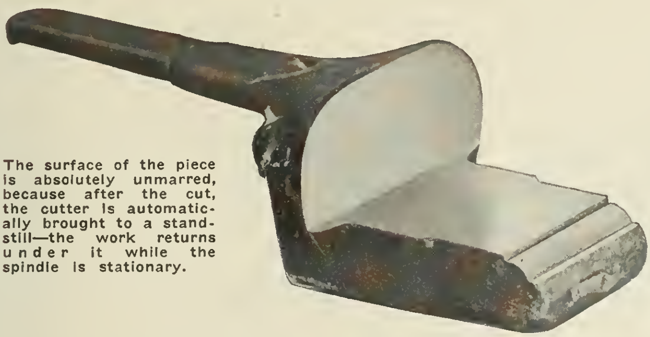
CINCINNATI AUTOMATIC MILLERS

With Intermittent Feed and Automatic Spindle Stop For Manufacturing

RIFLE AND MACHINE GUN COMPONENTS

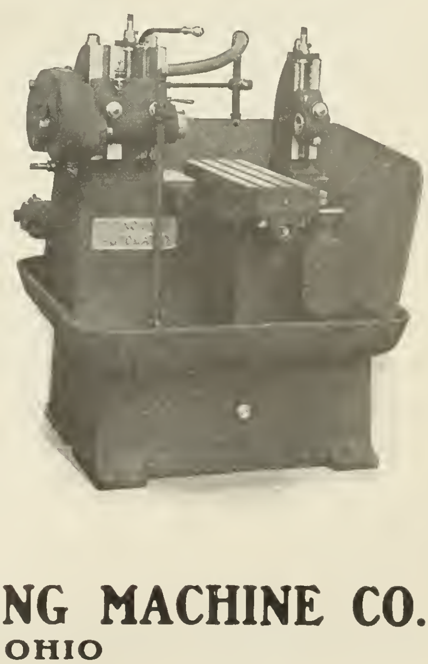
and Similar Parts in Quantities

The surface of the piece is absolutely unmarred, because after the cut, the cutter is automatically brought to a standstill—the work returns under it while the spindle is stationary.



They have the intermittent feeding feature, which has proven so successful on our earlier machines, with this addition — after the cut is taken the spindle is stopped automatically so that the work returns beneath it while the cutter is stationary—no danger of marring the surface of the work because of a revolving cutter.

Consider, too, the advantage of this from the standpoint of safety. The operator removes the finished piece and chucks a new one while the cutter is stationary. He can't get caught by a swiftly revolving although idle cutter. After he chucks the new piece, he moves one lever—and immediately both the spindle and feed movements start again.



This is one improvement on the Cincinnati Automatic. There are others equally vital. Do you wonder this new machine has already made a place for itself in the esteem of a number of big munitions shops?

For manufacturing parts in quantities it offers exceptional advantages.

Bulletin containing details will be sent you upon request.

THE CINCINNATI MILLING MACHINE CO.
CINCINNATI, OHIO

COMING EVENTS

July 26—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

August 30-September 1—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Museum of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

September 27-29—Informal congress and reunion of American and Canadian engineers and architects of Norwegian birth or descent in Chicago at Chicago Norske Klub, 2346 N. Kedzie Blvd., Logan Square, Chicago, Ill.

SOCIETIES, SCHOOLS AND COLLEGES

Melbourne Technical School, Workingmen's College, Melbourne, Australia. Prospectus for 1917, containing admission requirements, calendar, outline of courses, etc.

Committee for Men Blinded in Battle, 111 E. 59th St., New York City, has issued a report of its work in France during the past two years. The report gives an account of some of the remarkable work that has been accomplished in training the blind to take up useful work. Some of the things that have been taught, besides Braille, are typewriting, stenography, commercial courses, languages, music, handicrafts, modeling, sports, games, etc.

Cleveland Engineering Society, Cleveland, Ohio, has issued a publication named "The Conquerors," which is offered as a contribution to the work of the committee on cooperation. It aims to give credit to the engineer for services to society in conquering the forces of nature and bending them to the service of man. The following articles appear: "Peacefulness and Greatness of the Earliest Engineers," by George H. Johnson; "Making Homes in the Desert," by F. H. Newell; "Public Water Supply," by George W. Fuller; "Transportation," by A. W. Johnston; "Some Notable Masonry Bridges," by Henry S. Jacoby; "Measurement of Steam Flow by the United States Geological Survey," by John C. Hoyt; "Recent Developments in Naval Architecture," by Charles F. Gross. The price of the publication is 25 cents.

NEW BOOKS AND PAMPHLETS

Summary of Report on Workmen's Compensation Acts in the United States. 8 pages, 6 by 9 inches. Published by the National Industrial Conference Board, Boston, Mass.

The Embrittling Action of Sodium Hydroxide on Soft Steel. By S. W. Parr. 57 pages, 6 by 9 inches; illustrated. Published by the University of Illinois, Urbana, Ill., as Bulletin 94 of the Engineering Experiment Station. Price, 30 cents.

Magnetic and Other Properties of Iron-Aluminum Alloys Melted in Vacuo. By Trygve D. Yensen and Walter A. Gatward. 54 pages, 6 by 9 inches; 19 illustrations. Published by the University of Illinois, Urbana, Ill., as Bulletin 95 of the Engineering Experiment Station. Price, 75 cents.

Foreign Commerce and Navigation of the United States for the Year Ending June 30, 1916. 950 pages, 9 by 11½ inches. Published by the Department of Commerce, Washington, D. C.

This volume gives the total values of imports and exports of merchandise, gold and silver, and the tonnage of vessels entered and cleared for each year from 1912 to 1916. Various grouping arrangements are made so as to make the book of the greatest statistical value possible.

Examples in Battery Engineering. By F. E. Austin. 90 pages, 4¾ by 7½ inches; 39 illustrations. Published by Prof. F. E. Austin, Hanover, N. H. Price, $1.25.

The general and increasing use of primary and storage cells makes this work on battery engineering of general value to engineers and others concerned with problems of battery design and maintenance. The work is divided into sixteen lessons that were used in the author's classes. The lessons are accompanied by examples and problems which illustrate the principles explained.

Statistical Abstract of the United States, 1916. 773 pages, 6 by 9 inches. Published by the Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C. Price, 50 cents.

The American statistics cover such subjects as agriculture, forestry and fisheries; manufacturing and mines; internal communication and transportation; merchant marine and shipping; foreign commerce; consumption estimates; prices; money, banking and insurance. Commercial, financial and monetary statistics of the principal countries of the world are included.

Compressed Air—Theory and Computations. By Elmo G. Harris. 192 pages, 6 by 9 inches; 32 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $2.

This excellent work, which was first published in 1910, now appears in the second edition. It gives in comparatively few pages many formulas and a large amount of technical data on compressed air engineering. The author very truly states in his introduction that compressed air is a manufactured product of considerably greater value than the things used and consumed in its manufacture, yet in much of the practice in using compressed air, little attention is given to its efficient use. The user is likely to tolerate waste of compressed air that should be checked to save the coal pile. The work deals with fundamental formulas, measurement of air, friction in air pipes, air compressors, special applications of compressed air, air-lift pumps, receivers and storage of compressed air, fans, centrifugal or turbo-air compressors and rotary blowers.

How to Lay Out Turret Lathe Tools. 135 pages, 6 by 9 inches; 114 illustrations. Published by Alfred Herbert, Ltd., Coventry, England. Price, 2s., 6d. (60 cents).

This book is a handbook for those who design tools for use on turret lathes and automatic turning machines. It is a practical book, intended primarily, of course, for the convenience of people using the Alfred Herbert machines, but also containing many suggestions of value to tool designers who are laying out tools for turret lathes of any make. As stated in the preface of the book, the success of a lay-out of tools for turret lathe practice is dependent on the sound judgment of the designer, which, in turn, can only be based on past experience and familiarity with the best shop practice. It has, therefore, been the intention in this book to lay down the broad principles of design and practice, which, if adhered to, will enable anyone with a fair amount of shop experience to undertake this work with reasonable assurance of success. The book is divided into twenty-five chapters, each taking up some specific phase of the problem of laying out tools for the most effective use of turret lathes.

Shop Expense Analysis and Control. By Nicholas Thiel Ficker. 240 pages, 6 by 9 inches. Published by the Engineering Magazine Co., New York City. Price, $3.

The author states that according to the latest figures furnished by the Federal Trade Commission, only 10 per cent of the 250,000 or more manufacturing plants in the United States have adequate cost finding methods in operation; 40 per cent estimate their costs, and 50 per cent have no basis whatever of knowing what their costs are. The need of a more general understanding of the principles of cost keeping and the establishment of better methods of keeping cost is obvious. The work contains twelve chapters with the following heads: Establishing the Unit of Time as a Basis of Distribution; The Two Main Divisions—Machine Expense and Material Expense; Classification and Interpretation of General Ledger Accounts Pertaining to Production; Distributing Manufacturing Expense to Production Centers and Segregating Power Expense; The Standardization of Rent Expense Distribution; Depreciation, Insurance, Taxes and Interest—Tool, Material and Special Department Expense; The Machine Unit System; Current Variation Ratios for Adjusting Current Costs; Organization; Waste in Manufacturing; Graphic Determination of Costs; and Standard Reports.

Getting the Most Out of Business. By E. St. Elmo Lewis. 515 pages, 5¾ by 8½ inches. Published by the Ronald Press Co., New York City. Price, $2.50.

This interesting work might be called a philosophical treatise on the art of living and doing, and we recommend it to anyone in or out of business who has red blood in his veins as well worth reading. The work is so extensive that in giving a notion of the contents we are confined to a statement of the chapter titles, which are as follows: Thought as a Business Asset; Efficiency and Its Applications; Efficiency and Its Problems; Efficiency and Its Standards; Some Business Policies; Psychology and Common Sense; Efficiency and Common Sense; Doers and Thinkers; The Rule of Thumb; The Rules of Efficiency; The Work of Efficiency; The New Gospel of Commercial Efficiency; The Gift of Perception; Seen on the Way; Those Who Lead; The Religion of Loyalty; Loyalty to Plan and Purpose; Loyalty to Ideals; The N. C. R. School; Standard Practice Instructions; The Sales Manual; Extension of the School Plan; The One-man Fallacy; Rational Business Methods; Scientific Principles Applied to Business; The Executive Organization; The Line and Staff System; Individuality; The Efficient Individuality; According to the Rules; The Basis of Discipline; Discipline for Growth; The Essentials of Discipline; The Basis of Wages; The Wage Plan; Educated Democracy; The Law of Service; The Debt to Society.

Mechanical Equipment of Buildings, Vol. II.—Power Plants and Refrigeration. By Louis A. Harding and Arthur C. Willard. 759 pages, 6¾ by 9 inches; illustrated. Published by John Wiley & Sons, Inc., New York City. Price, $5.

This extensive work is a reference book for building engineers and architects, and is the second part of the treatise, though complete in itself. In order to make Vol. II complete, the chapters on heat, water, steam, air, fuels and combustion, and parts of two other chapters were reprinted from Vol. I. The contents are: Physical Units and the Measurement of Heat; Water, Steam and Air; Fuels and Combustion; Boilers and Rules for Construction; Mechanical Stokers; Superheaters and Economizers; Chimneys for Power Boilers; Mechanical Draft; Feed-water Heaters and Feed-water Purification; Steam Engines; Steam Turbines; Pumps; Steam Condensers; Cooling Ponds and Towers; Pipe, Fittings, Valves, Coverings and Accessories; Power Plant Piping; Arrangement of Steam Power Plants; Coal and Ash Handling Machinery; Isolated Power Plant Data; Cost of Steam and Gas Power Equipment; Units Employed in Refrigeration Practice; Heat Transmission and Construction of Cold Storage Walls; Heat Transmission of Piping as Used in Refrigeration Practice; Methods of Producing Artificial Refrigeration; Cold Air Machines; Compression Machines; Vacuum Machines; Ammonia Condensers; Brine Circulating System; The Ammonia Absorption Machine; Ice Manufacturing Plants. A great amount of tabular matter is included, much of which is especially valuable to refrigerating engineers.

Stobbs' Wire and Sheet Gage Tables and Metal Calculator. By Thomas Stobbs. 95 pages, 4¾ by 7¼ inches. Published by Spon & Chamberlain, New York City. Price, $1.25.

The author states that the tables were compiled to supply a long-felt want by merchants, manufacturers and those connected with the wire, sheet steel and other metal industries. Inasmuch as the metric system is coming more and more into use in England, the author has selected the tenths and hundredths of a millimeter as units, giving the equivalents in decimals of an inch. The work includes: Examples of Calculation for Wide Sheets, Sheet Steel, Circular Plates, Steel Sections; Multipliers for Finding the Net Weight of Rolled Metals; Millimeter Gage with Equivalents in Decimals of an Inch, in Imperial Standard Wire Gage; Stubs and Birmingham Gage, Tenths of a Millimeter and Fractions of an Inch; Imperial Standard Wire Gage, with Equivalents in Decimals of an Inch and in Millimeters; Stubs and Birmingham Wire Gage, with Equivalents in Decimals of an Inch and in Millimeters; Brown & Sharpe's (American) Wire Gage, with Equivalents in Decimals of an Inch and in Millimeters; Whitworth's Decimal Wire Gage, with Equivalents in Millimeters, Nearest Number in Stubs Gage; Needle Wire Gage, with Equivalents in Decimals of an Inch and Millimeters; Music Wire Gage, with Equivalents in Decimals of an Inch, and Nearest Size in Imperial Standard Wire Gage and Stubs Gage; French Wire Paris (P) Gage, with Equivalents in Millimeters and Decimals of an Inch; Japy Wire Gage, with Equivalents in Millimeters and Decimals of an Inch; German Millimeter Wire Gage, with Equivalents in Decimals of an Inch and Nearest Imperial Standard Wire Gage and Stubs Gage; Lancashire Pinion Wire Gage (Letter and Number), with Equivalents in Decimals of an Inch and in Millimeters; Norton's Spindle Sizes, with Equivalents in Decimals and Fractions of an Inch and in Millimeters; Whitworth's Standard Sizes Hexagon Bolts and Nuts, with Equivalents in Decimals of an Inch and in Millimeters; Tables of Ship Plates; Weights of Square, Round, Hexagon, Octagon, Three-square and Half-round Metals, Round Metal Wire, Metal Cubes, Balls and Disks, etc. The limits of space will not permit extending this list of contents, but, needless to say, the book is comprehensive and valuable to all needing an authoritative set of gage tables in English, metric and foreign sizes.

NEW CATALOGUES AND CIRCULARS

Stow Mfg. Co., Binghamton, N. Y. Circular illustrating Stow grinders, flexible shafts, portable drills, etc.

Reliance Electric & Engineering Co., 1056 Ivanhoe Rd., Cleveland, Ohio. Bulletin 2014 of Type T heavy-duty Reliance motors for direct current.

National Lathe Co., 15 W. 2nd St., Cincinnati, Ohio. Circular of the 17-inch, quick-change, double back-geared, three-step cone pulley "National" engine lathe.

Link-Belt Co., Chicago, Ill. Booklet entitled "Blue Diamond Coal Co.'s Tipple," describing the installation made at Cardiff, Ky., by the Link-Belt Co.

Taylor Machine Co., 7804 Carnegie Ave., Cleveland, Ohio. Circular of "Atlas" 20-inch double back-geared lathes, built in 8-, 10- or 12-foot lengths of beds, or longer to order.

Link-Belt Co., Chicago, Ill. Booklet entitled "The Ideal Drive for Grain Elevators," illustrating typical applications of Link-Belt silent chain in new and old grain elevators.

Wright Mfg. Co., Lisbon, Ohio. Catalogue 8 of Wright steel hoists, hand cranes and steel trolleys. Wright high-speed steel chain hoists vary in capacity from ¼ to 30 tons.

Prest-O-Lite Co., Inc., 837 Speedway, Indianapolis, Ind. Catalogue of apparatus for oxy-acetylene welding and cutting. This apparatus is designed for use with high-pressure gases only.

Link-Belt Co., Chicago, Ill. Catalogue 270, illustrating and describing Link-Belt wagon and truck loaders for loading and screening such material as coal, stone, sand, foundry refuse, etc.

David A. Wright, 568 Washington Blvd., Chicago, Ill. Circular of the Pratt & Wright No. 1½ screw machine, having an automatic chuck capacity of 13/16-inch round, 19/32-inch square and 23/32-inch hexagon.

U. S. Electrical Mfg. Co., Los Angeles, Cal. Circular of electric grinding and buffing motors using one-, two- or three-phase current, 110 to 440 volts, and operating at speeds from 1800 to 3600 revolutions per minute.

Dodge Sales & Engineering Co., Mishawaka, Ind. Catalogue C 17A of power transmission machinery, comprising shafting, hangers, pulleys, clutches, collars, couplings, countershafts, pillow blocks, step bearings, floor stands, belt tighteners, binder frames, etc.

Metalwood Mfg. Co., Detroit, Mich. Circular B-50 of Metalwood banding presses for pressing in copper rotating bands on high-explosive shells. These presses are built in two sizes, one for banding 3- to 6-inch shells and the other for banding 7- to 10-inch shells.

Link-Belt Co., Chicago, Ill. Booklet entitled "Increasing Profits by Saving Expense in the Handling and Storing of Coal and Ashes." The publication is profusely illustrated with line engravings and halftones showing up-to-date coal and ash handling equipment.

Montgomery & Co., Inc., 104 Fulton St., New York City. "Odds and Ends" No. 7, containing latest prices of the line of tools, supplies and machinery carried by this company, which includes vises, tool chests, drills, gages, faceplates, centers, angle-plates, punches, screws, snips, files, etc.

Steel-Art Tool Co., Elgin, Ill. Circular of the "Satco" quick-change, keyless drill chuck, made in five sizes, having capacities from 0 to 5/8 inch, inclusive; also circulars of the "Satco" adjustable boring- and turning-bar and bar-holder, improved hollow drill, and hollow end-mill with receding center.

Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich. Bulletin 3-A on Hoskins pyrometers, high-resistance type. These pyrometers are fitted with Hoskins base metal thermo-couples, made of "Chromel," the characteristic of which is a practically straight-line relation between the temperature rise and the milli-voltage.

Sprague Electric Works of General Electric Co., 527 W. 34th St., New York City. Bulletin 48700 A, descriptive of Sprague electric monorail hoists, cage-controlled, and illustrating installations of monorail hoists in various plants. Tables of ratings and weights of monorail hoists for direct and alternating current are included.

Colburn Machine Tool Co., Franklin, Pa. Circular of the No. 2 Colburn manufacturing heavy-duty drilling machine, 20-inch swing, having capacity to drive 1 1/4-inch high-speed drills through steel. The circular illustrates details and shows the machines in gangs of four spindles; two- and three-spindle gangs are also furnished.

Metalwood Mfg. Co., Detroit, Mich. Circular B-49, illustrating the Metalwood No. 87 internal pressure physical test press, designed primarily for testing high-explosive shells, but which can also be used for general laboratory and experimental work. An internal hydraulic pressure of 16,500 pounds per square inch is developed.

Greenfield Tap & Die Corporation, Greenfield, Mass. Catalogue containing a detailed description of the "Acorn" die and holder, for which the advantages of strength, accuracy, speed, adaptability and high quality of work are claimed. The catalogue is illustrated with views that show clearly the construction of the die and its use.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa. Pamphlet entitled "The Application of Ball Bearings to the Airplane," by W. L. Batt, mechanical engineer. The pamphlet briefly reviews the development of ball bearings and illustrates several applications of Hess-Bright radial and thrust bearings to airplane propellers.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa. Pamphlet entitled "Hess-Bright Ball Bearings—How to Apply Them," by H. Wickland. Applications of radial ball bearings are illustrated and the conditions to be observed are discussed. The pamphlet should be useful to all designers applying ball bearings in machine design.

De Laval Steam Turbine Co., Trenton, N. J. Catalogue entitled "Progress in Water Works Pumps," which treats of the development and advantages of steam-turbine-driven centrifugal pumps for city water supply, and illustrates installations in fifteen of the principal cities in this country and Canada, including thirty-four units, aggregating 999,000,000 gallons per day capacity.

Union Switch & Signal Co., Swissvale, Pa. Bulletin 87 on the forge plant which has recently been equipped with heavy steam drop-hammers for making forgings for automobiles, tractors, aeroplanes, etc. The fire in February that destroyed the company's main shop did not reach the building occupied by the forge, foundry or power house; hence the capacity to make forgings has not been affected.

Cleveland Twist Drill Co., Cleveland, Ohio, has issued an announcement of sets of "Ezy-out" screw extractors ranging from No. 1, the smallest, to No. 12, the largest. The smaller sizes of these extractors are put up in sets, the tool-room set comprising Nos. 1 to 5, inclusive; the utility set is made up of Nos. 4, 5 and 6; and the heavy shop set of Nos. 6, 7, 8 and 9; Nos. 10, 11 and 12 are sold singly.

Landis Machine Co., Waynesboro, Pa. Catalogue 23 of pipe and nipple threading machines, pipe threading and cutting machines and chaser grinders. The characteristics of the Landis die are illustrated and described, and data are included of clearances, etc., useful to toolmakers who maintain Landis machines in service. The Landis pipe machines are furnished in single- and double-spindle combinations, belt- and motor-driven.

International Machine Tool Co., Indianapolis, Ind. Catalogue of "Libby" turret lathes, a line of heavy-duty turret lathes, capable of forming, facing, turning and boring chucked pieces up to 20 inches in diameter and bar work up to 7 1/4 inches in diameter. These machines are described at length, the various parts being illustrated in detail. A table of condensed data, giving dimensions, feeds, speeds, etc., of the different sizes of "Libby" lathes, is included.

T. C. M. Mfg. Co., Hunterdon and First Sts., Harrison, N. J. Catalogue of Morris Thomson semi-automatic thread milling machine, made in five sizes or styles. Type 12-E has a capacity of 12 inches diameter by 42 inches long; Type 6-C, capacity 6 inches diameter by 34 inches long; Type 2-D, capacity 2 inches diameter by 9 inches long; Type 3-B, single-purpose for milling threads in base ends and noses of 3-inch shells; Type 1-A, capacity 1 1/4 inch diameter by 36 inches long, or 2 inches diameter by 9 inches long.

Lincoln Electric Co., Cleveland, Ohio. Pamphlet on "Electric Arc Welding," reviewing the various methods of welding and dealing with electric arc welding in particular. The pamphlet is profusely illustrated and contains valuable data and suggestions for welding engineers and operators. The possibilities of reclaiming defective steel castings are shown convincingly. Examples of broken gray iron and malleable castings, broken locomotive frames, cracked boiler sheets, leaky rivets, broken cross-heads and other characteristic railway repair work are given, with data on labor, material and current cost and costs of other methods. Equipments suitable for various classes of electric arc welding are illustrated.

Gardner Machine Co., Beloit, Wis. Catalogue of grinding and polishing machinery, accessories and supplies, comprising disk grinders for metals, disk grinders for pattern shops, disk grinder accessories, ring wheel grinders, band finishing machines, polishing and buffing lathes, ring wheel chucks, fixtures for disk grinders, abrasive disks, cloth and paper, wheel cement and disk grinder grease. The development of the disk grinding machine during the past ten years has been rapid, and it is now regarded as indispensable for many operations, having achieved the position of a high-grade machine tool in manufacturing establishments. The catalogue illustrates an extensive line of disk grinding machines, belt- and motor-driven, with one and two spindles provided with either plain or ball bearings to take radial and thrust loads. An extensive line of patternmakers' disk grinders and attachments is shown; also polishing lathes provided with ball bearings.

TRADE NOTES

L. S. Starrett Co., Athol, Mass., will appear prominently in the large electric display of the Rice Leaders of the World Association in New York City.

Westinghouse Electric & Mfg. Co. and the Westinghouse Machine Co. were merged by vote at the annual meeting of the stockholders in East Pittsburg, June 13.

Van Dorn Electric Tool Co., Cleveland, Ohio, has opened a branch office at 524 Wells Bldg., Milwaukee, Wis., under the management of James Gibbons, formerly manager of the company's Baltimore office.

Union Switch & Signal Co., Swissvale, Pa., is installing 5000-pound steam drop-hammers which will largely increase the facilities for forging automobile axles, large gear blanks, crankshafts and cam-shafts.

Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass., combined a flag raising with a "Liberty" bond sale May 25, at which time 173 employes subscribed to a total of approximately $30,000 worth.

Axelson Machine Co., Los Angeles, Cal., has moved to its new factory, comprising seven large and spacious buildings, up to date in all particulars. The concern is one of the largest manufacturers on the Pacific coast.

Driggs-Seabury Ordnance Co., Sharon, Pa., has acquired all the property and assets of the Savage Arms Co., Utica, N. Y., and has changed its name to the Savage Arms Corporation. The offices of the corporation are at 50 Church St., New York City.

Inter-State Machine Products Co., Inc., Rochester, N. Y., has opened an automatic screw machine department for handling outside work, and has installed a number of new four-spindle automatic screw machines. The department is expected to be running July 1.

Manufacturers' Equipment Co., Chicago, Ill., maker of air chucks, air cylinders and other labor-saving devices, has opened an office in New York City at 30 Church St., with E. J. Chamberlin in charge. The New York office was opened in order to give better service to the company's customers in the East.

Twentieth Century Brass Works, Minneapolis, Minn., are erecting a brick building, 65 by 66 feet, two stories and basement, at 518 Fifth Ave., S., which will be occupied about July 1. Considerable equipment will be installed. The company operates a brass, bronze and aluminum foundry, machine shop for brass finishing and special manufacturing.

Foster Machine Co., Elkhart, Ind., manufacturer of turret lathes and tool equipment, is erecting additions to the plant that will increase the floor area 100,000 square feet. The company expects to make other additions soon to provide facilities for the new line of turret lathes. The plant is up to date, being equipped with modern machinery throughout. Oskar Kylin is the chief engineer.

Navy Department, Bureau of Yards and Docks, Washington, D. C., has called for sealed proposals to specification No. 2362 for power plant equipment at the Naval Training Station, Newport, R. I., the early completion of which is of the utmost urgency. Bids are requested for furnishing and installing turbo alternators, condensers, pumps, exciters, boilers, stokers, draft fans and piping.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., granted another advance in wages to its employes May 16, amounting to 10 per cent, making a total increase in a period of two years of about 40 per cent. The company has also subscribed for a number of Liberty bonds, which it offers to its employes, permitting them to pay for them in small monthly or semi-monthly installments.

Vanadium-Alloys Steel Co., Latrobe, Pa., with sales offices in Pittsburg, Pa., has purchased $100,000 worth of Liberty bonds, and will also purchase all the bonds subscribed for by its employes, permitting payment on easy terms covering a period of approximately one year. No interest charge will be made, and upon final payment the bonds will be delivered to the employes with all coupons attached.

McMeehan Engineering Staff, East Providence, R. I., is an organization composed of several production men and designers who have held, or are holding responsible positions with reputable machinery concerns. The company proposes to render engineering service by making designs, drawings, working out details and specializing in the design of automatic and special machinery, jigs, fixtures and production tools.

Chicago Flexible Shaft Co., Chicago, Ill., manufacturer of flexible shaft machinery, gas and oil furnaces, has built a one-story plant with saw-tooth roof about 490 feet long and 300 feet wide at 12th St. and 50th Ave., and expects to occupy it in the month of July. The interior will be arranged by departments, so as to facilitate the economical handling of the various products. The floor is of concrete construction throughout.

Detroit Pneumatic Chuck Co., Flat Rock, Mich., has been reorganized with increased capital. The new officers are Floyd Bryant, president; George Case, vice-president; and George Bunte, secretary, treasurer and general manager. J. A. Olson is superintendent. This company has an up-to-date plant and is bringing out a full line of pneumatic equipment—chucks, mandrels and special tools. The company reports a rapidly growing business.

James H. Matthews & Co., 3942-3946 Forbes St., Pittsburg, Pa., gave its third annual outing and picnic to its employes and friends, at Homestead Park, June 9. The athletic events took up the forenoon, and after the picnic dinner a hotly contested ball game was played, following which was dancing. The event was enjoyable, and profitable in the sense that it brought about personal contact and acquaintance not to be realized in ordinary business relations.

Nicholson File Co., Providence, R. I., manufacturer of files, announces that it will participate in an electric display which is now being erected in New York City overlooking Times Square. This display will be unique. The emblem of the Rice Leaders of the World Association will be represented on the mammoth structure and the names and individual selling points of the members, including the Nicholson File Co., will appear on the display in brilliant electric letters.

Henry & Wright Mfg. Co., Hartford, Conn., manufacturer of automatic drilling machines, has made a contract with the Travelers Insurance Co. to provide $1000 life insurance on the group plan for all its employes. More than one hundred men profit by this at the outset, and many more will be included when they have completed three months' service. The plan went into effect June 1. The certificates not only provide $1000 life insurance, but also contain the usual disability clause.

American Machine Tool Engineering Works, 4854-4858 W. Kinzie St., Chicago, Ill., have taken over the entire "Neat" lathe business of the National Engineering & Tool Works, Oak Park, Ill., and will continue to manufacture this lathe under its trademark "Amtew." Frank W. Hack, general works manager, organized the National Engineering & Tool Works, and was formerly its president. He resigned January 1 and organized the American Machine Tool Engineering Works. A number of improvements are being made in the lathe.

General Electric Co., Schenectady, N. Y., has moved its New York City offices from 30 Church St. to the Equitable Bldg., 120 Broadway. The entire twentieth floor of the building has been especially arranged and furnished for the company. In the quarter century since the company was formed, its business has increased from about $10,000,000 in gross sales the first year of its organization to gross orders of over $167,000,000 during the twenty-fifth year, and its sales offices have naturally increased in number and importance. The offices in New York City are the largest and most important among its district offices.

Driver-Harris Wire Co., Harrison, N. J., has changed its name to the Driver-Harris Co. The former name did not comprehensively designate the products of the concern, which comprise not only wire but also alloys and pure metals in the form of strips, rods, sheets and castings. The company also manufactures flexible heater cords and wire rope. It has issued in bulletin form a new catalogue covering the complete line of products, with the exception of resistance materials, which are covered in the regular resistance catalogue. The new bulletins include monel metal, pure nickel, wire rope, heater cord, cold-rolled steel strip, brass, bronze and phosphor-bronze wire and "Nichrome" castings.

American Steel Export Co., Woolworth Bldg., New York City, has for over a year been devoting much energy to the upbuilding of its corps of representatives. Thirty have been established in the trade centers of the world, and others will be added as new territories are taken up for development. F. H. Tackaberry has been appointed traveling representative with the title of general agent. He was recently associated with the Ordnance Engineering Corporation of New York City and has held important executive positions in the Industrial Underwriters Inc., the Locke Steel Belt Co., etc. Mr. Tackaberry's first trip will be to South America, Brazil being his immediate objective and Rio de Janeiro his first base of operation.

Buffalo Forge Co., Buffalo, N. Y., has received an order from the National Acme Co., Cleveland, Ohio, for the installation of heating and ventilating equipment which will be the largest of its kind in a building under one roof, heated and ventilated by the fan system. The equipment consists of four "Carrier" Type A air washers with automatic control and fresh and return air dampers; four "Niagara" conoidal supply fans, two of which deliver 100,000 cubic feet of air per minute each and two 95,000 cubic feet of air per minute each; four exhaust fans, two of which will handle 70,000 cubic feet of air each and two 50,000 cubic feet of air per minute each; ten "Baby" conoidal fans; about 27,000 feet of "Vento" and four 12- by 14-inch steam engines for driving the fans.

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THE INDUSTRIAL PRESS, Publishers, 140-148 Lafayette Street, New York City

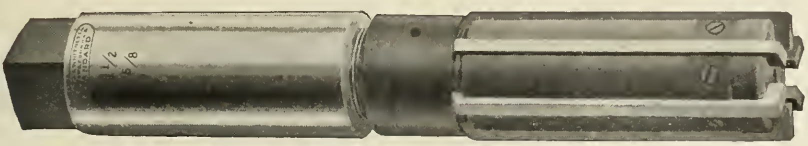
TOOLS

PRATT & WHITNEY

Precision Machine Tools, Small Tools, Standards and Gauges

The most modern manufacturing facilities backed by broad experience enable us to meet all present-day machine tool requirements, and obtain unequaled stability, power, refinement and accuracy for our various products.

P. & W. ADJUSTABLE BLADE REAMERS



These reamers have eccentric relief and can be set to size without regrinding. They are unexcelled for design, and simplicity and ease of adjustment. The eccentrically relieved blades are stronger than others, do not chatter, and produce a smoother hole. The hand, shell and fluted chucking reamers have interchangeable nuts, screws and wrenches. The bottom of a hole can readily be faced. By a simple adjustment of the blades the reamer can easily be set to size without regrinding.

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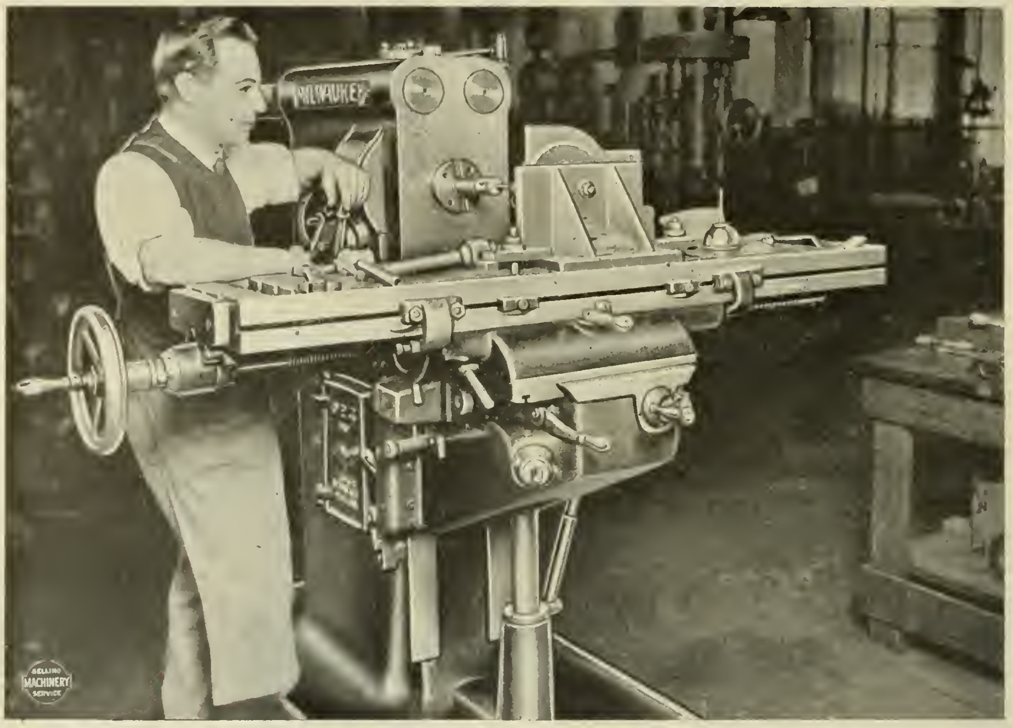


Milwaukee Milling Machines

for the finest of Machine and Tool Work

The illustration shows a Milwaukee Milling Machine in the modern factory of the Hartford Special Machine Co. This company has quite a number of Milwaukee Milling Machines which were installed about a year and a half ago when the new shop was built on the outskirts of Hartford.

The Hartford Special Machine Co. does special machine and tool work and the Milwaukee Milling Machines are called upon to do the difficult work.

These machines have performed all kinds of milling work since they have been in operation. They have done work requiring extreme rigidity and have met every requirement. They have done work requiring extreme alignment and accuracy and have proven themselves equal to every demand.

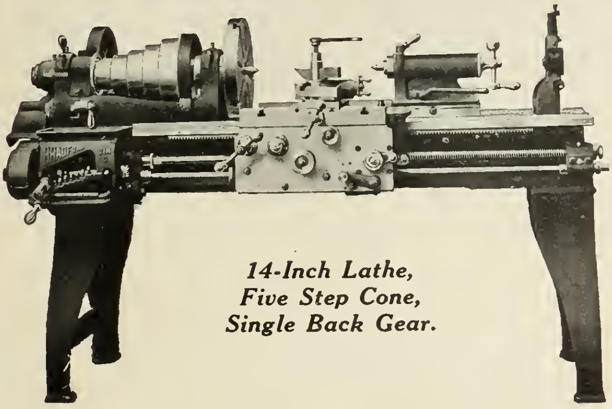
Milwaukee Milling Machines embody many features of design and construction. The double overarm—flanged spindle, reverse for which is self contained in the machine—solid top, box section knee—automatic flooded lubrication—cutter lubricating system an integral part of the machine—all combining for increased production, quality of output, low upkeep and ease of operation.

Catalogue No. 20 sent on request.

KEARNEY & TRECKER CO., MILWAUKEE, WIS. U.S.A.

For Easy Manipulation and Smooth Turning—

A Bradford



14-Inch Lathe, Five Step Cone, Single Back Gear.

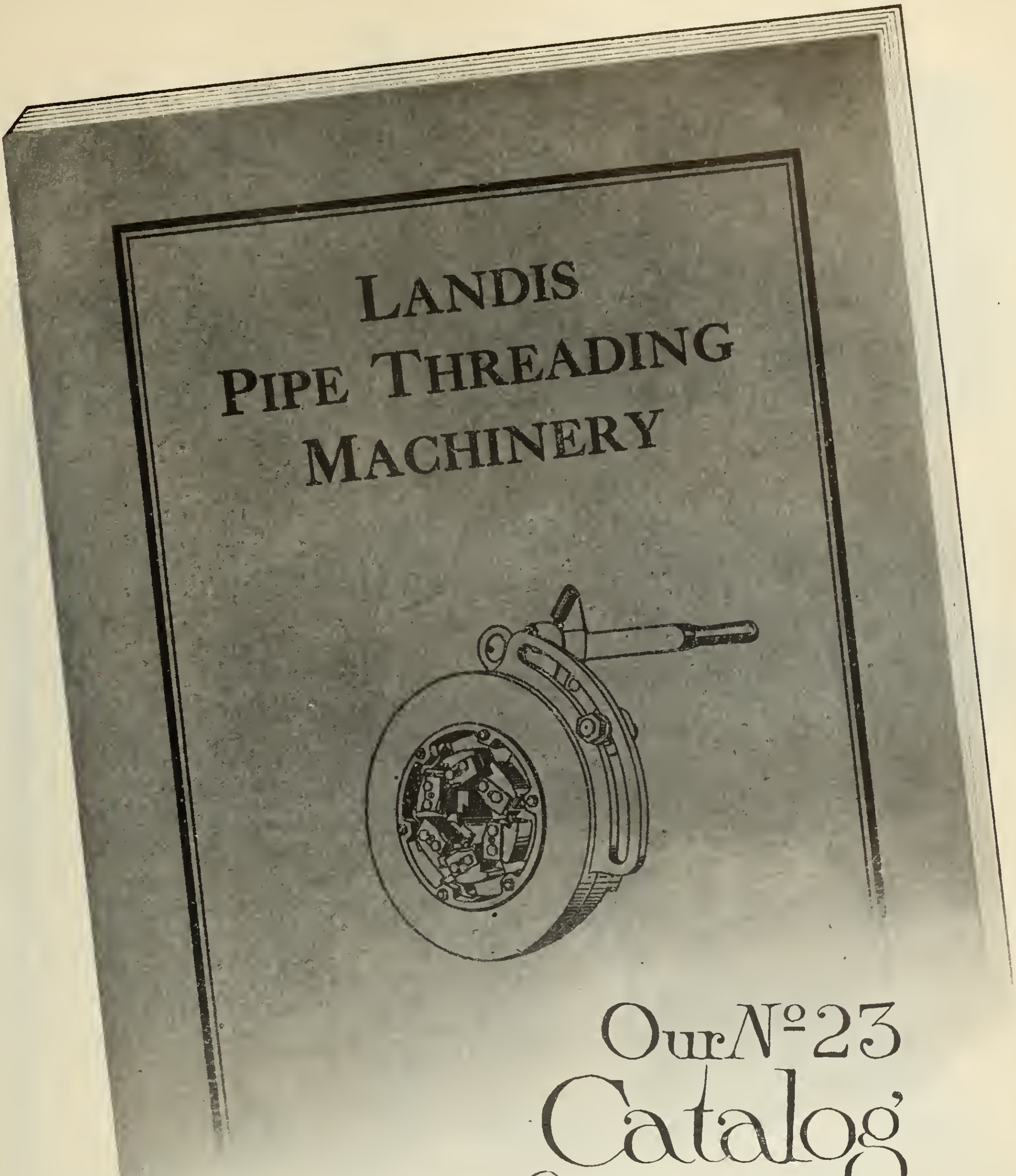
At the Hanscom Cutter Works, Hyde Park, Mass., they turn out counterbores and small cutters—good ones, too—by the bushel. In this hustling plant a 14-inch "Bradford" Lathe is among the busiest machines. With back gears out and belt running on the second (smallest) step, this machine peels the stock off small counterbores at a remarkable rate—and in spite of the high speed there's not the slightest "whip" or vibration. Stiff, compact, and well-balanced design permits the high speeds that mean fast production on such work. There are a wealtl of good features in Bradfor Lathes—fully outlined in ou catalogue.

Send for a copy.

Bradford Machine Tool Company

CINCINNATI, OHIO, U. S. A.

AGENTS: Swind Machinery Co., Philadelphia. Taylor Machinery Co., Boston, Mass. Stocker-Rumley-Wachs Co., Chicago, Ill. Somers, Fitler & Todd Co., Pittsburgh, Pa. The E. A. Kinsey Co., Cincinnati, O., and Indianapolis, Ind. The Mine & Smelter Supply Co., Denver, Colorado. Pacific Tool & Supply Co., San Francisco, Cal.

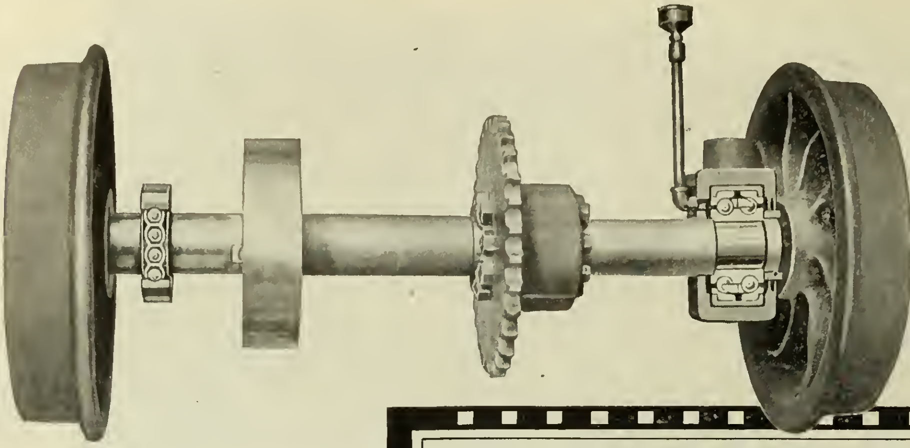


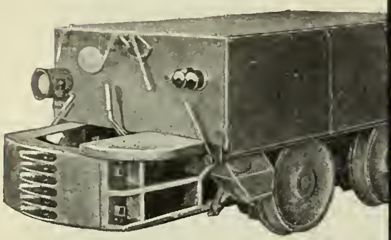
Our No 23 Catalog is Now Ready for Distribution

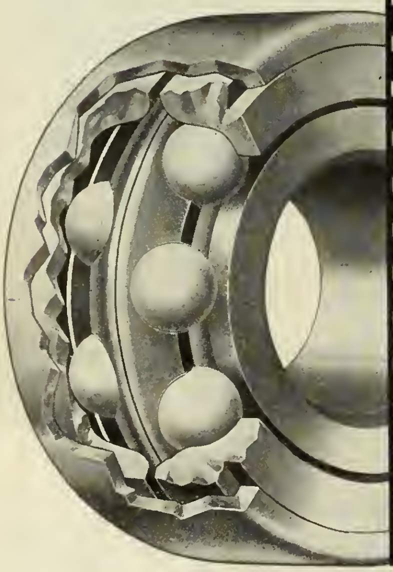
It lists the Landis "Pipe Threading Line"—Pipe and Nipple Threading Machin
Pipe Threading and Cutting Machines, also the Landis Chaser Grinder. V
illustrated with diagrams and detailed descriptions to show the advantages of La..
Chaser and Die Head design, construction, etc.

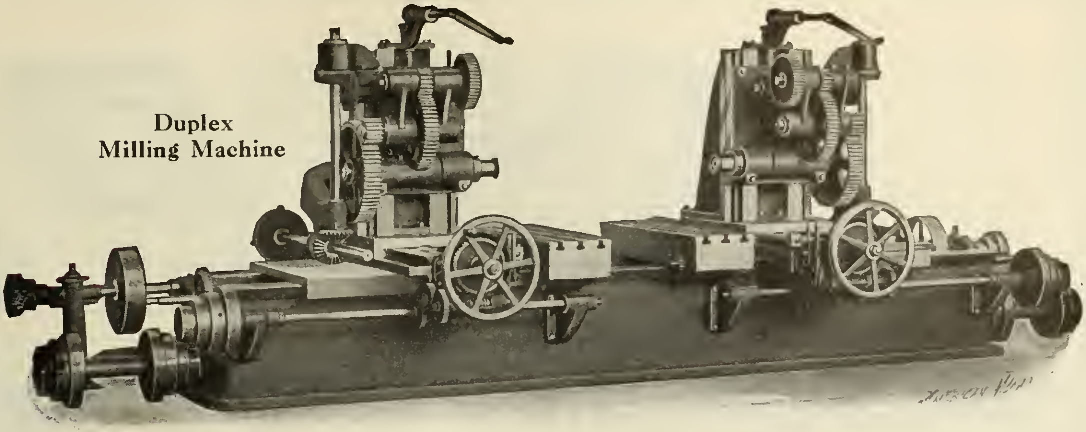
If you have not already received a copy your name is not on our lists. You should write us at once—a post card will do.

LANDIS MACHINE COMPANY, Inc.
WAYNESBORO PENNSYLVANIA, U. S. A.







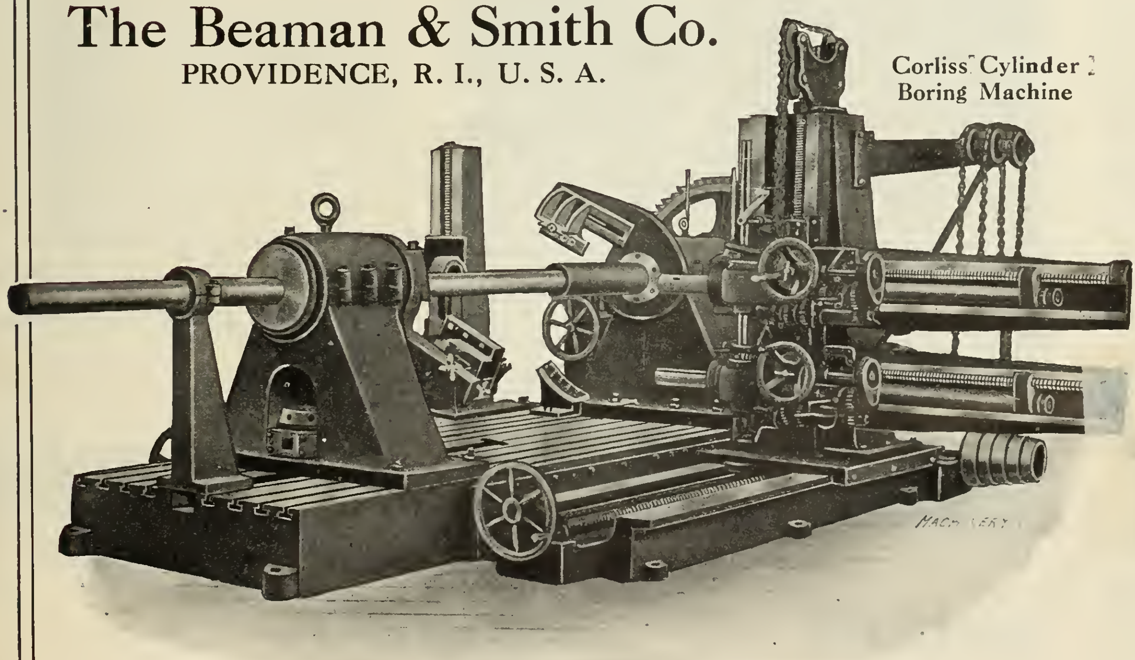


Duplex
Milling Machine

If You Want Higher Production
Consult Beaman & Smith

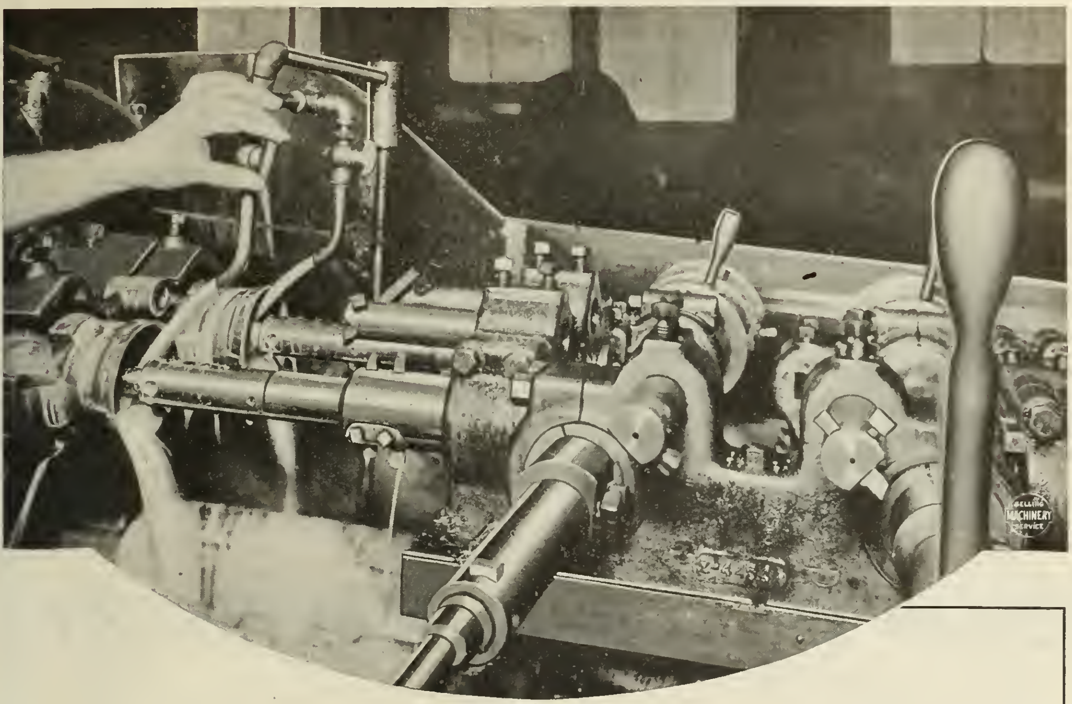
We design and build machines for accuracy, speed, ease of operation, and to give long, efficient service—machines capable of putting through several parts at one setting or performing several operations simultaneously. Consulting us involves no obligation. If you cannot use the machines we build to advantage we will say so frankly.

The Beaman & Smith Co.
PROVIDENCE, R. I., U. S. A.



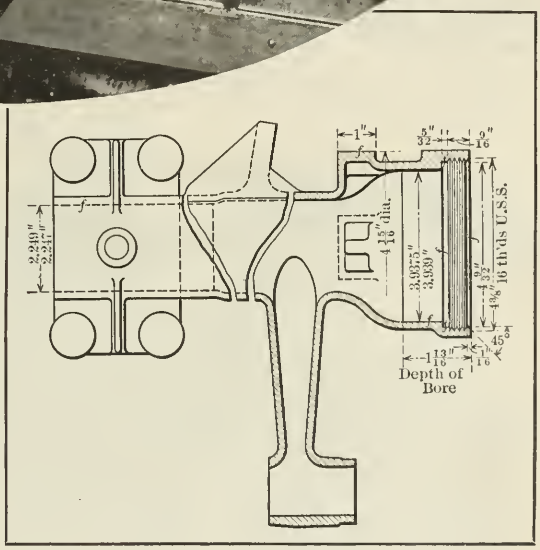
Corliss Cylinder
Boring Machine

Flat Turret Lathe



The time has been given and the conditions have been stated. Draw your own conclusion! If there is any other machine on which this can be done faster and better than the Jones & Lamson Double Spindle Flat Turret Lathe—we would like to hear about it.

This illustration was secured through the courtesy of the H. H. Franklin Manufacturing Co., Syracuse, N. Y., where there are fourteen double spindle flat turret lathes in use. With that number in service the Franklin people realize their full possibilities; but output in this plant is no greater than may be secured anywhere with these machines on similar work.



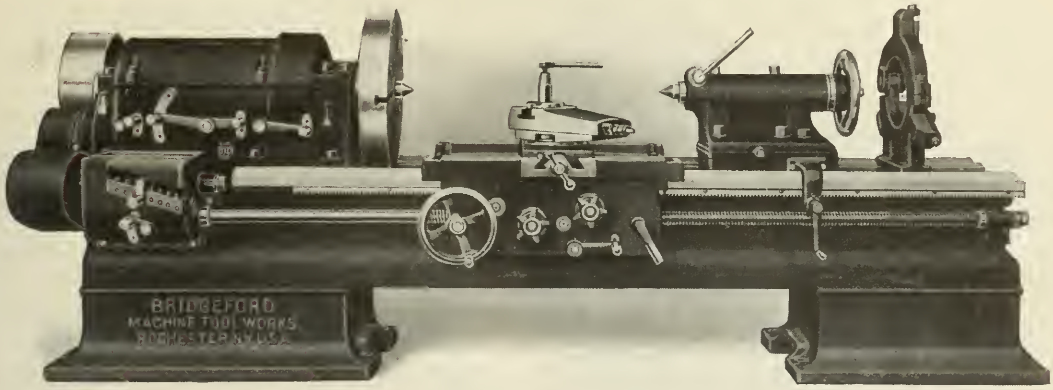
Why not get thoroughly posted on the possibilities of the Flat Turret Lathe? Single and Double Spindle—each for a particular purpose.

MACHINE COMPANY **109 QUEEN VICTORIA ST. LONDON, E. C.**

HOLLAND: Spliethoff, Beeuwkes & Co., Rotterdam.

Bridgeford Lathes

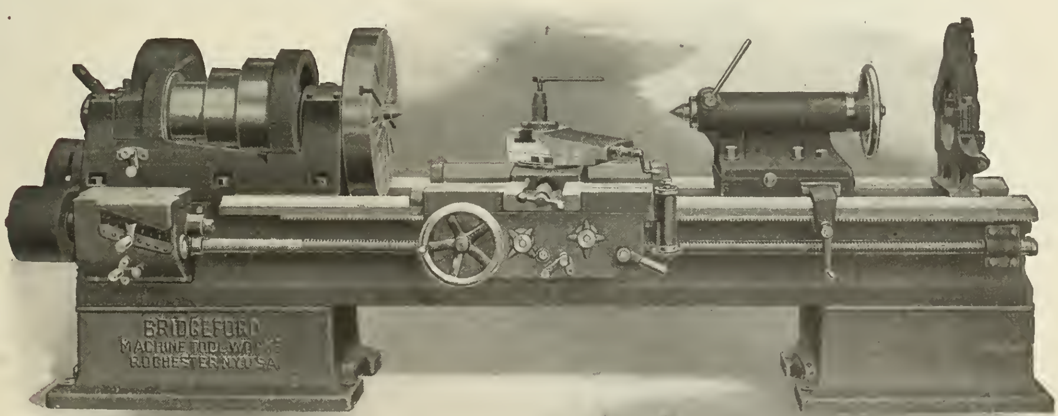
26" Cone and Geared Head Types



THERE is not a better lathe than the "Bridgeford" for handling heavy duty turning. Big shafts, heavy rolls, massive pinion blanks—work that tries the staying qualities of a lathe to the utmost—are the jobs that make up the daily work of these machines. Tremendous pulling power, backed by staunch construction and unusual convenience, make them speedy and efficient on really difficult work—the triumph of two decades of specialization in heavy lathe design.

Two models, 26″ size, are shown. The Cone Drive Bridgeford is an accurate, speedy machine—a splendid all-round lathe. The Geared Head model is a wonder for heavy manufacturing, with a pulling power of 9,000 pounds.

Let us tell you more about these lathes.



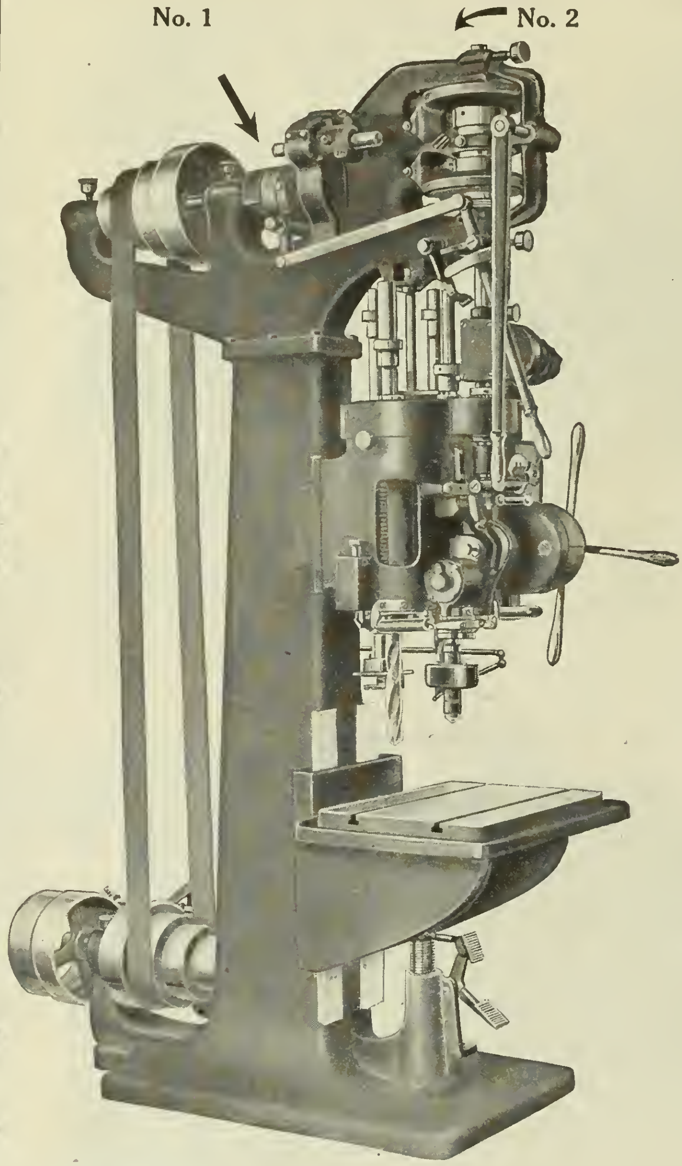
SPECIALISTS IN LATHE CONSTRUCTION FOR MORE THAN 20 YEARS

Bridgeford Machine Tool Works

151 Winton Road ROCHESTER, N. Y.

THE JOHNSON FRICTION CLUTCH

Used on the Semi-Automatic Turret Machines Recently Put on the Market by the Turner Machine Co., Danbury, Conn.



Courtesy of
The Turner Machine
Co., Danbury, Conn., U. S. A

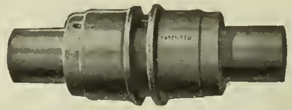
The back gears on the New Turner Turret Machine, which may be thrown out of engagement like the back gears of a lathe when not in use, are operated by a No. 5 Double Johnson Friction Clutch as shown by arrow No. 1.

Another Double Johnson Friction Clutch No. 5 operates the forward and reverse of the spindles as shown by arrow No. 2.

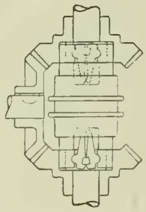
The latest and most up-to-date machines are equipped with Johnson Friction Clutches.

Why?

Because the "Johnson" is the smallest and most compact clutch and because it is more easily made to meet modern conditions and because it is the most powerful clutch of its size. It's the clutch with a reputation.



Double Clutch Exterior



Double Clutch in Nest of Gears

Write for Catalogue "A" and booklet "Clutches as Applied in Machine Building."

CANADA—Williams & Wilson, 320 St. James St., Montreal. The Canadian Fairbanks-Morse Co., Ltd., Toronto.
ENGLAND—The Efandem Co., Ltd., 159 Gt. Portland St.,London, W., Sole Agents for British Isles.
AUSTRALIA—George Wills & Co., Brisbane, Queensland.

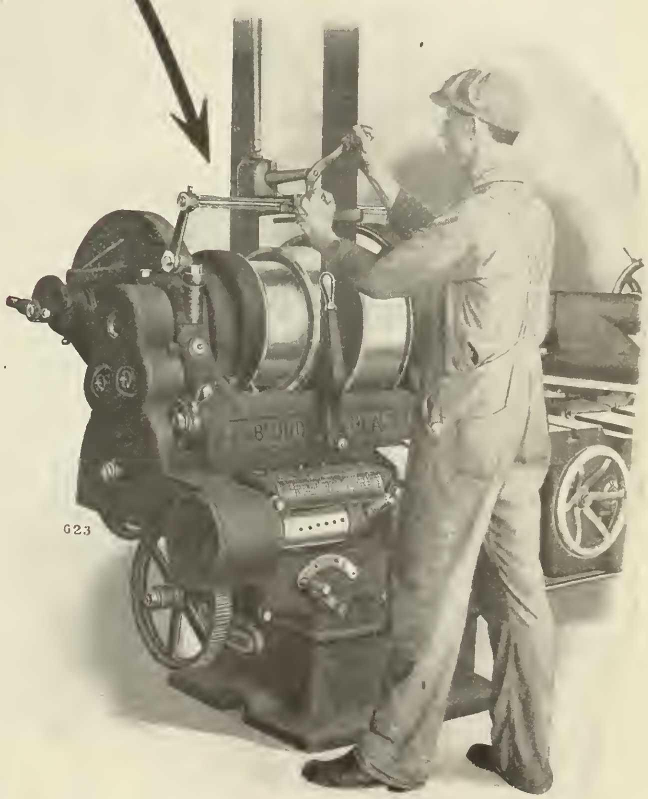
THE CARLYLE JOHNSON MACHINE CO. MANCHESTER CONN.

The Simplified Selective Speed Headstock

This is the simplest form of Selective Speed Headstock. The entire range of back geared speeds is obtainable while running and under cut.

The powerful double friction back gears are capable of transmitting loads greater than the full capacity of the wide high speed driving belt, and the change from high to low ratio can be made instantly by simply shifting the back gear lever.

The belt is shifted rapidly over the cone by a single turn of an ordinary crank shown in the grasp of the operator.

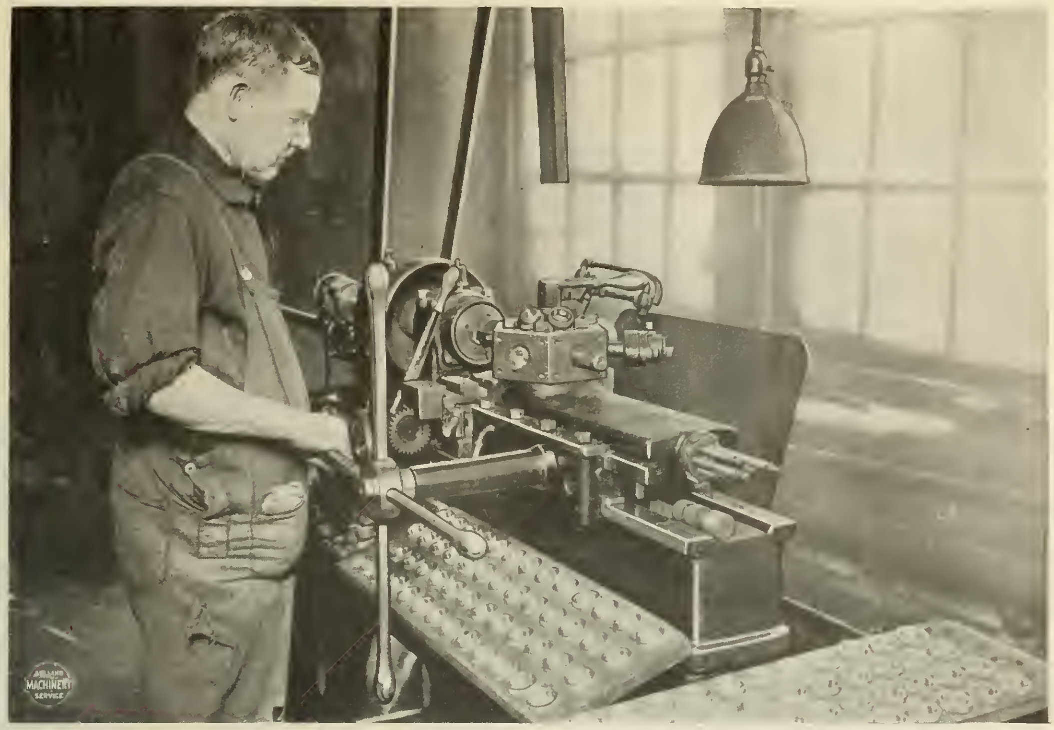


No other type of Headstock, regardless of its manufacture, provides this convenience at equal investment, and under no condition can equal its low upkeep cost and general reliability.

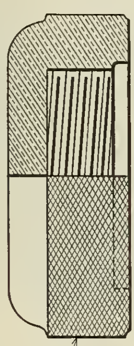
The R. K. LeBlond Machine Tool Co.

CINCINNATI OHIO, U.S.A.

Agents in Principal Cities



One Minute! Nothing, or a Lifetime!



Let us tell you more about the good features that make the Cincinnati-Acme Screw Machine a different lathe of this type.

In some forms of animal life a minute is an entire lifetime; in others it is nothing. It all depends upon what is done with, or in, the minute.

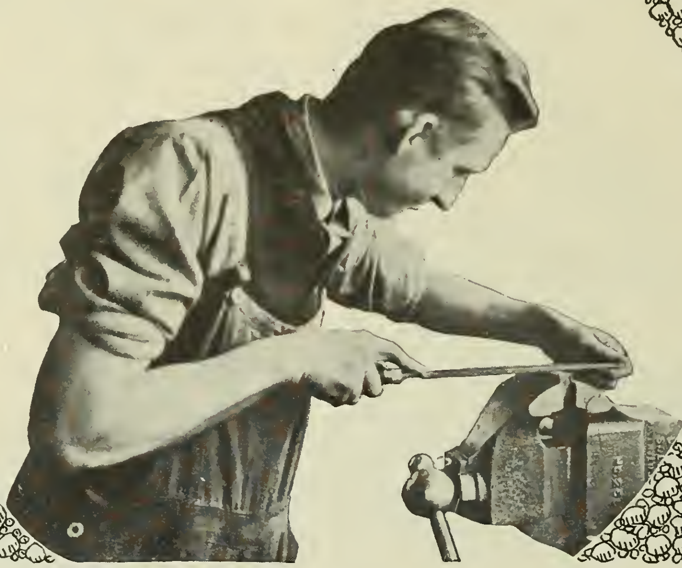
One minute is sufficient time in which to complete the second operation on this brass cap—turn, face and knurl—the work being held on a thread arbor.

The machine that makes such good use of a minute is a Cincinnati-Acme Screw Machine—and this is *average* time, output is 60 per hour, all day long.

This machine has been used by the Westinghouse Air Spring Co., New Haven, Conn., for a few months only; but this has been long enough to demonstrate its efficiency and economy over a wide range of work. And there are hundreds of concerns who have demonstrated the same things.

THE ACME MACHINE TOOL COMPANY

CINCINNATI, OHIO, U. S. A.



The "Feel" of a Good File

Did you ever watch a really capable mechanic test a file? He has a way of passing a sensitive thumb over its jagged surface. Instinctively, unfailingly, he thereby determines whether it is fit for use.

This man invariably chooses NICHOLSON FILES. He never buys blindly. He can "feel" that a NICHOLSON FILE is right. He can "feel" its sharp, keen-cutting teeth, arranged in rows of perfect uniformity. There is no doubt in his mind. He buys NICHOLSON. He makes sure of satisfaction.

NICHOLSON U.S.A. (TRADE MARK)

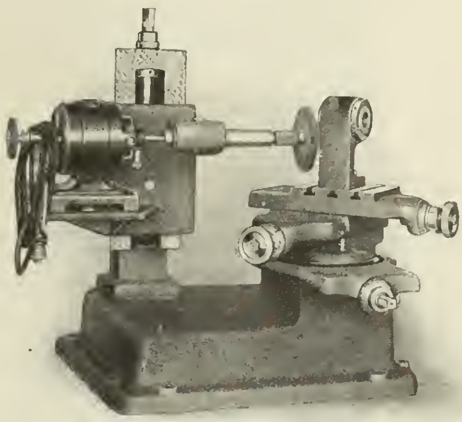
BY INVITATION MEMBER OF

Our catalog and copy of "File Filosophy" will interest you. Write for them today.

NICHOLSON FILE CO., Providence, R. I.

NICHOLSON

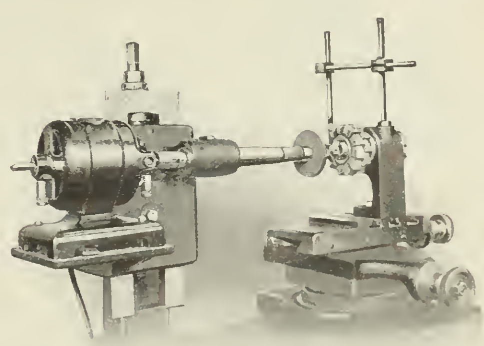
The Cleveland Milling Machine Co.
PROFILE GRINDER



Is used to grind concave and convex cutters, cutters for fluting drills, cutters that are irregular but having a number of true curves, accurately rounding the corners on side mills and face mills, formed tools for lathes, planers and shapers.

The maximum radius that can be ground is 3 inches either convex or concave up to 12″ diameter.

The center cut shows a variety of formed cutters accurately ground on this machine. This, however, is only a small percentage of the uses that this tool can be put to. Users are finding it indispensable in the tool room.



The wheel carrying spindle is direct connected onto the motor shaft and has adjustable bronze bearings and carries a wheel 4″ diameter, ¼″ wide, ⅜″ hole.

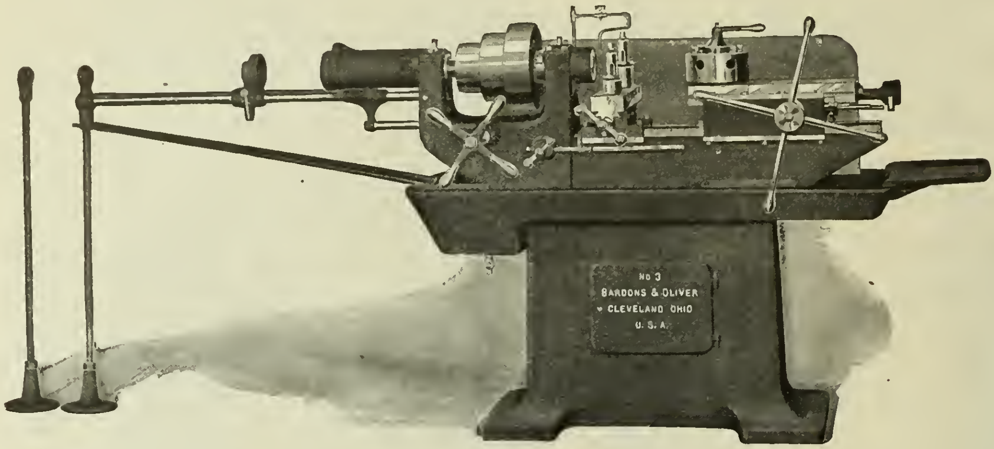
A type "D" Universal Dumore motor is furnished with ten feet of wire and lamp socket.

Complete equipment is furnished for all classes of work.

Immediate delivery if you get your order in now.

The Cleveland Milling Machine Co.
18511 EUCLID AVENUE CLEVELAND, OHIO

Bardons & Oliver
TURRET LATHE



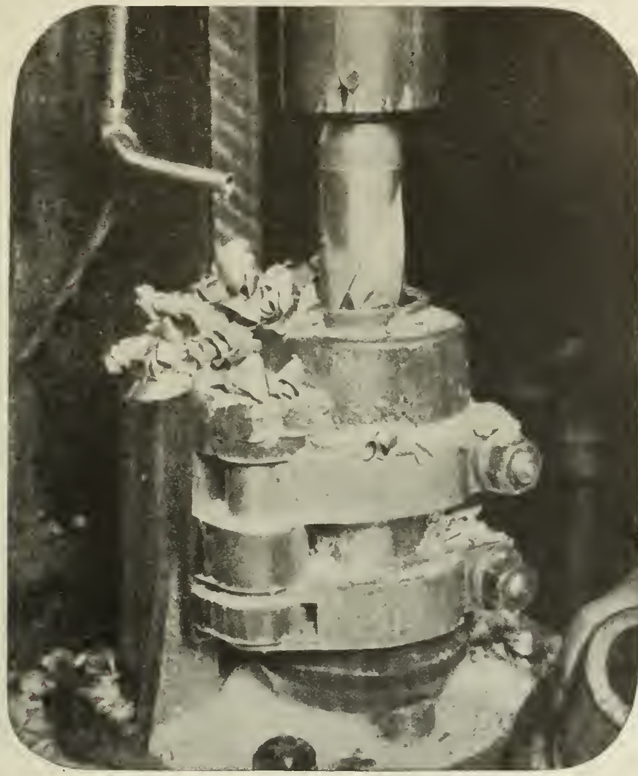
Conveniences That Speed Up Production

The Bardons & Oliver Turret Lathe is a machine of exceptional ease of manipulation—and any manufacturer knows that convenience is of really great importance. In these lathes the tooling system is so simple and complete that setting-up entails little loss of time, output naturally increasing in proportion as the maximum possibilities of the machine are utilized.

Operating facilities enable Bardons & Oliver Lathes to turn out an enormous amount of accurate work under ordinary conditions, and are a guarantee against any tendency to slow up under forced draft. Production never fails to jump wherever these lathes are installed. Unless you are familiar with their possibilities your output is probably far from what it should be. Let us send full description of the lathe and tell you where you can see them in action.

BARDONS & OLIVER

CLEVELAND, OHIO



Standing Up—

Under Fifteen Thousand Pounds

A 1¼″ drill should not break under *ordinary* conditions. But have you any idea of the tremendous stress it often undergoes in eating its way through the metal?

Add fifteen thousand pounds of vertical thrust to the grinding resistance and you have a fair idea of the kind of material and skill that make Union Twist Drills stand up.

Cutting coolly and rapidly, and with minimum wear, is a result that can come only from the broadest knowledge of tool requirements, together with the most scientific methods of material selection and manufacture.

The Union catalog also shows the full line of Union Tools—shall we send a copy?

UNION TWIST DRILL CO.
ATHOL MASSACHUSETTS


THE FINAL PROOF
F.G.S.Co.
THE FELLOWS GEAR SHAPER
FOREIGN AGENTS: Alfred Herbert, Ltd., Coventry, England;

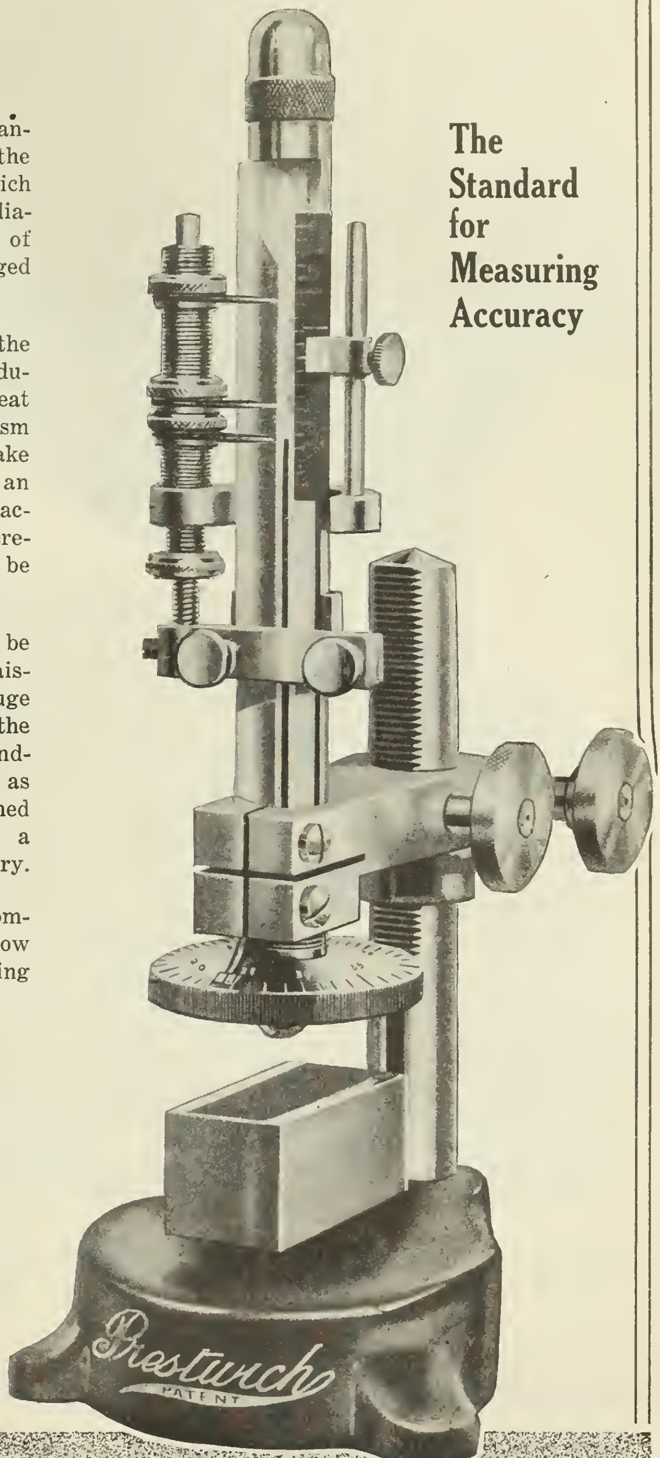
Prestwich Fluid Gauge
Only One Mechanical Movement

THERE'S just one mechanical movement in the action of the Prestwich Fluid Gauge—that of the diaphragm, the displacement of which by the object being gauged runs up the liquid in the tube

Th simplicity of this action, the readiness with which fine graduations can be read, the great durability of the mechanism and its wide adaptability make the Prestwich Fluid Gauge an ideal instrument for manufacturing purposes—for use where-ever quantities of work must be gauged to close limits.

The range of work that can be gauged is remarkable. By raising or lowering the gauge column on its standard the measuring anvils can be extended or brought close together as required. The object is pushed between the anvils — and a glance at the level tells the story.

We'll be glad to send the complete story and show you how to speed up your measuring methods. Write us.



The Standard for Measuring Accuracy

Manufactured under license for the United States and Canada by

Coats Machine Tool Co.

INCORPORATED

30 Church Street NEW YORK

Two High Grade Products

Each a "Top-Notcher" in Its Particular Field

Assembled, tested, supplied with "juice" and cranked for a run, the Peerless looks, and is, a quality car from stem to stern. Geometric Tools—Die Heads and Collapsing Taps—help make it so. They contribute threads of the highest grade, accurate, finely finished threads, cut with remarkable speed and economy. It happens to be an internal threading job we are showing this time—differential cages in which the hole is 2⅝" diameter, and the U. S. S. 16 pitch thread is ⅝" in length. Not spectacular threading this; but interesting to the production investigator because it shows how a wideawake concern secures results.

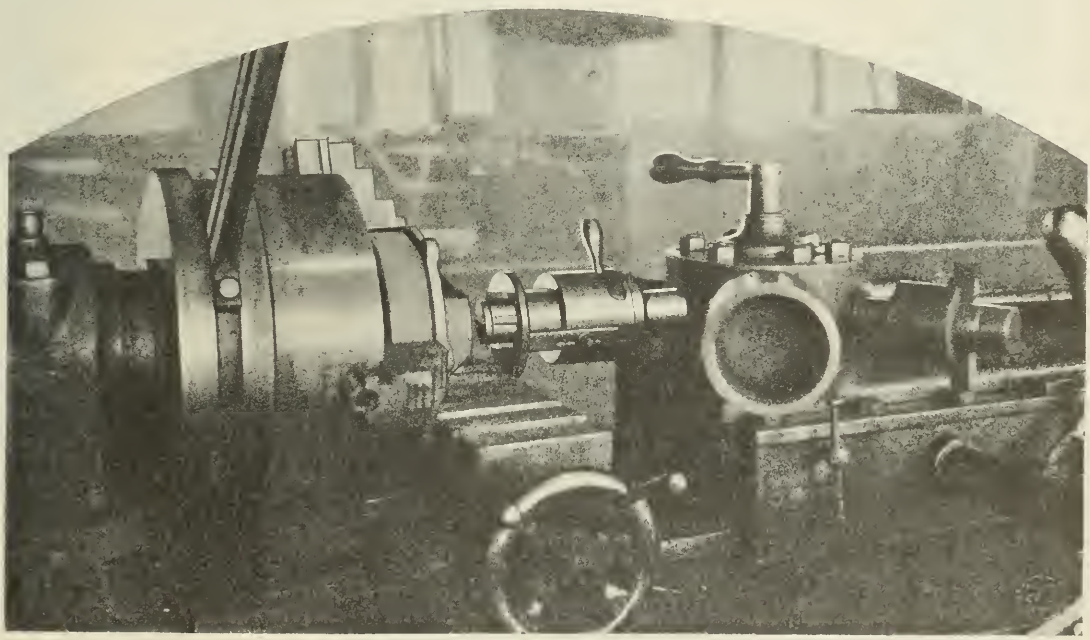
THE GEOMETRIC TOOL COMPANY

CHICAGO OFFICE:

REGULAR AGENTS: The Chas. A. Strelinger Co., Detroit, Mich.; Hill, Clarke & Co., Inc., Boston; Vandyck Churchill Co., New York and Philadelphia; Brown & Zortman Machinery Co., Pittsburgh, Pa.; The E. A. Kinsey Co., Cincinnati, O.; Strong, Carlisle & Hammond Co., Cleveland, O. **PACIFIC COAST:** General Machinery & Supply Co., San Francisco, Cal.; Perine Mchy. Co., Inc., Seattle, Wash. **CANADA:** The A. R. Williams Machinery Co., Ltd., Toronto, Winnipeg and St. John, N. B.; Williams & Wilson, Ltd., Montreal.

Geometric DIE HEADS

Geometric Tools are old timers with a record for universally efficient, economical service. They cut long, short, fine, coarse, tapered, inside or outside threads. Let us show how profitably they can cut threads for you. *Write for the Geometric Catalog.*



NEW HAVEN, CONNECTICUT, U. S. A.

545 W. Washington Blvd.

FOREIGN AGENTS: Chas. Churchill & Co., Ltd., London, Birmingham, Manchester, Newcastle-on-Tyne, Glasgow. Donauwerk Ernst Krause & Co., Vienna. V. Lowener's Maskinforretning, Sverre Mohn, Norway. Bevan & Edwards Pty., Ltd., Melbourne, and White & Rae, Sydney, Australia. Andrews & George, Tokyo, Japan. Also all manufacturers of Screw Machines and Turret Lathes.

Good Production Secured with

Heald Grinders

We are showing bearing races ranging from 1¾″ to 11″ diameter, close limit grinding of the kind that Heald Grinding Machines handle remarkably well.

There are 36 Heald Grinders used in the production of Bock Bearings, at the Bock Bearing Company's plant, Toledo, Ohio—36 thoroughly satisfactory machines.

Our Engineers will be glad to study your requirements.
For quick service write the nearest branch office.

ALD

The large bearing has an inside taper of 18° 30′ 6″, is 10.233″, plus or minus .001″, at the large end, and has .048″ stock removed. They come off the machine at the rate of four pieces per hour, as accurately ground as you could wish, "passed by the censor," who uses a test gauge on every bearing that comes through.

PACIFIC COAST AGENTS: Eccles & Smith Co., San Francisco and Portland. Smith-Booth-Usher Co., Los Angeles.

FOREIGN AGENTS: Alfred Herbert, Ltd., England, Italy, France, Switzerland, Spain and Portugal. F. W. Horne Co., Japan. Wilh. Sonesson & Co., Ltd., Sweden, Denmark and Norway. Post van der Burg & Co., Holland. Iznosskoff & Co., Russia.

SKF

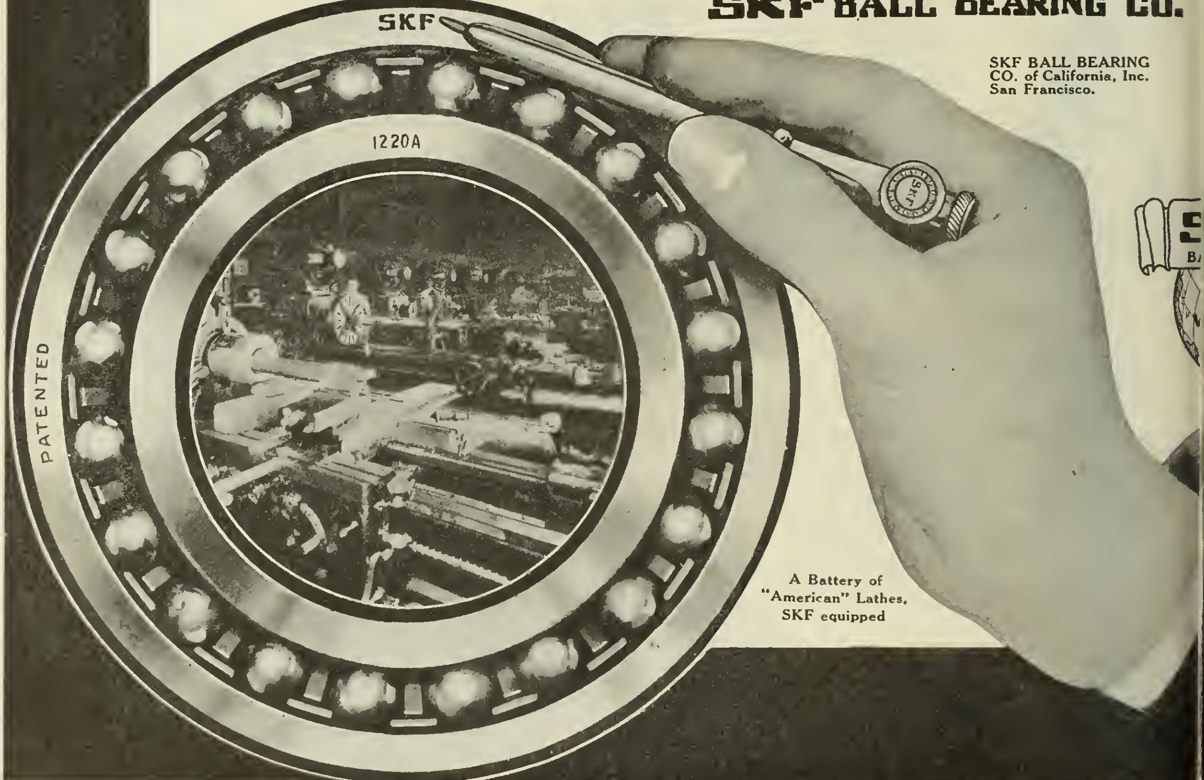
Look for the mark SKF on the Machine Tools you build and buy

In every industrial center throughout the world the mark SKF on a ball bearing is the symbol of excellence. Its meaning is not limited. It stands not only for bearing quality and service, but also for unique design and for the brain, the skill and the spirit of the SKF organization. It stands for excellence—in all ways, in all nations, at all times.

BALL BEARINGS

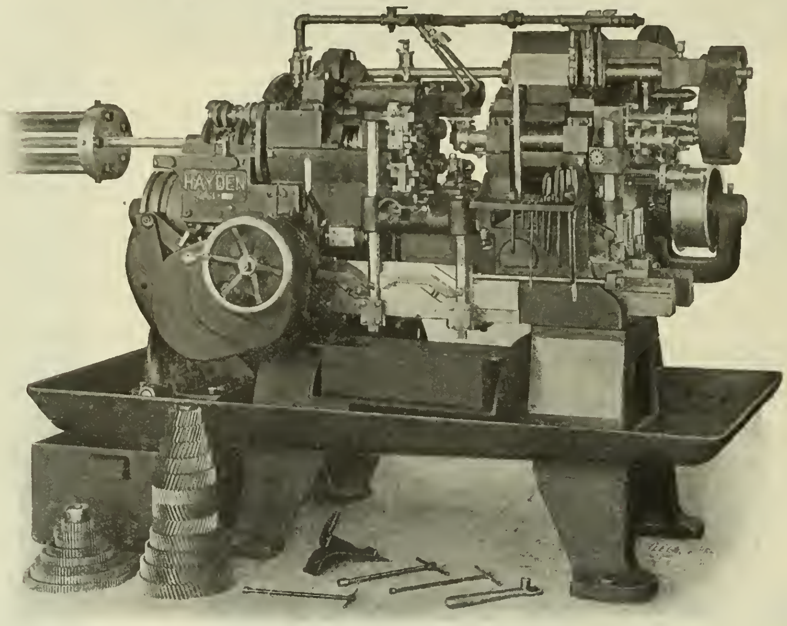
SKF BALL BEARING CO.

SKF BALL BEARING
CO. of California, Inc.
San Francisco.



A Battery of
"American" Lathes,
SKF equipped

The Hayden Automatic From Any Angle



STUDY this machine from any viewpoint — investment, maintenance, operating costs, quantity or quality of output—and you'll understand why the Hayden Automatic always comes up for discussion when machines of this class are under consideration.

We claim that the Hayden Automatic is the superior of all other machines of its class, *in every respect.* And the net result is the greatest possible production at the lowest costs. These are strong claims; but we have proved them to many men and are ready to prove them to you—in any manner you may desire.

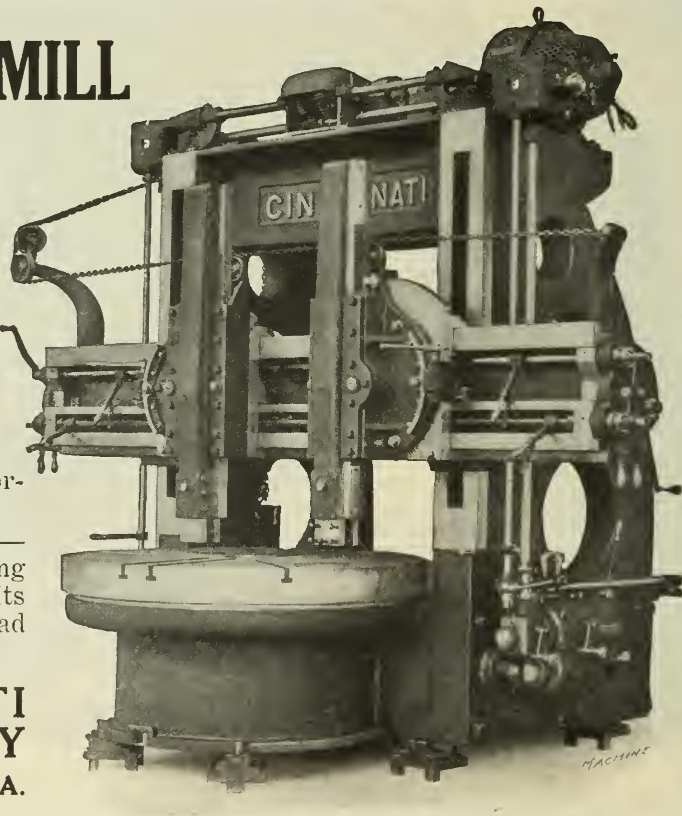
Send for the catalogue and the whole story.

CINCINNATI AUTOMATIC MACHINE CO., Oakley, Cincinnati, Ohio, U.S.A.

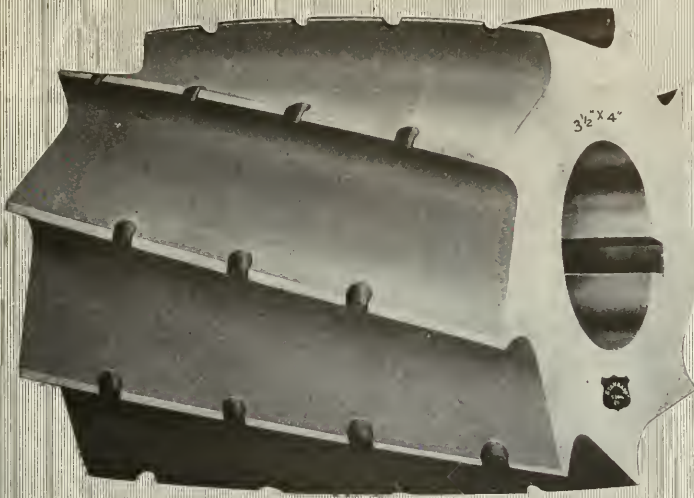
THE BORING MILL

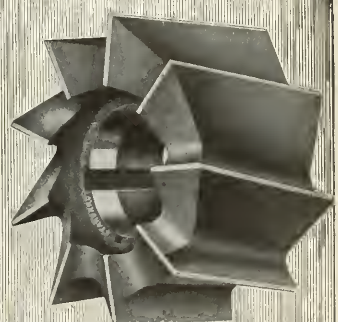
The modern boring mill is more than its title indicates. It is a manufacturing tool—big, powerful, yet easy to operate, its special field being the machining of work of large diameter. It is accurate as well as powerful—carries wide forming tools and finishes such work as automobile tire molds to extremely close limits. It is carefully designed and thoroughly well built.

Such is the modern boring mill—such is the Cincinnati Boring Mill. No better machine of its class can be built. We'll be glad to prove it.



THE CINCINNATI PLANER COMPANY
CINCINNATI OHIO, U. S. A.

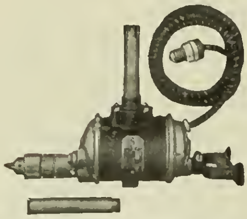




IT'S UP TO YOU

To increase your Production and Reduce your Costs by installing "CINCINNATI" Portable Electrics

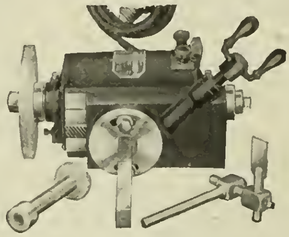
TRY THIS TRIO



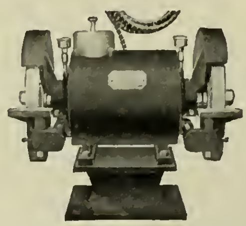
HAND OR BREAST DRILLS
¼", ⅜", ½", ¾" capacities. Weight from 7 pounds up. Gears run in grease. Single and two speeds.

SCREW-FEED DRILLS
¾" to 2" capacities.

SCOTCH RADIAL DRILLS
⅞" to 2½" capacities.



TOOL POST GRINDERS
¼ to 3 H. P. Weight from 16 pounds up. Free hand feed. Bearings adjustable to wear. Horizontal and vertical feeds. Different types for all purposes.



BENCH GRINDER OR BUFFER
Five sizes, ¼ to 3 H. P. Also Pedestal Floor Grinder 1 to 3 H. P. Fully enclosed. Dirt- and dust-proof. Ball bearings.

Special Features: *Air Cooled. Ball and Thrust Bearings. All working parts hardened. Overload Allowance. Guaranteed Mechanically and Electrically.*

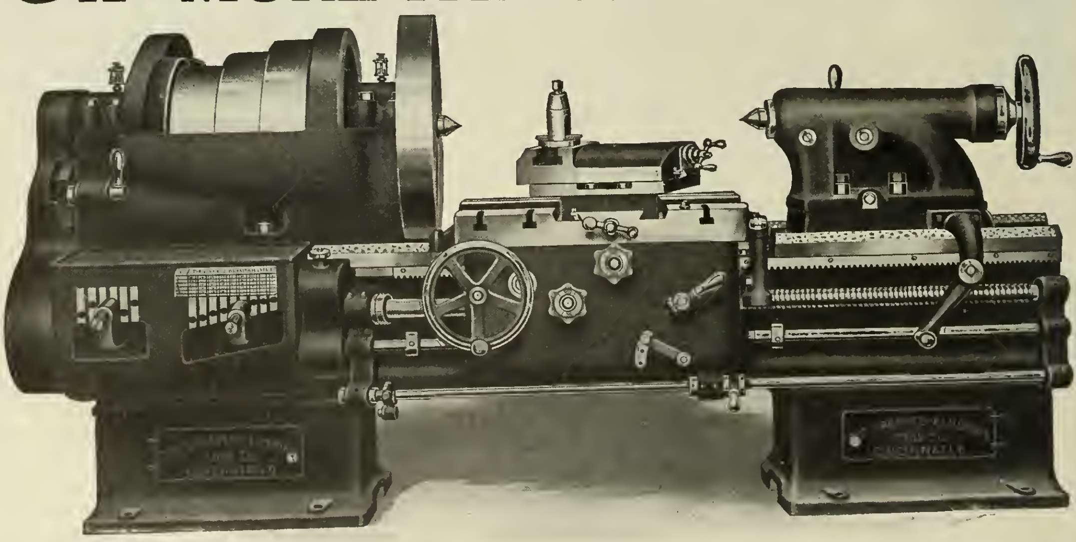
CINCINNATI ELECTRICAL TOOL CO.

650-652 Evans Street **CINCINNATI, OHIO**

FOREIGN AGENTS: England: S. Wolf & Co., London. Australia: Parke & Lacy Co., Ltd., Sydney. Norway: V. Lowener, Christiania. France: R. S. Stokvis & Fils, Paris. Holland: R S. Stokvis & Zonen, Ltd., Rotterdam. Japan: Yamatake & Co., Tokyo.

New York Office, 50 Church Street **Stock and Service Department**

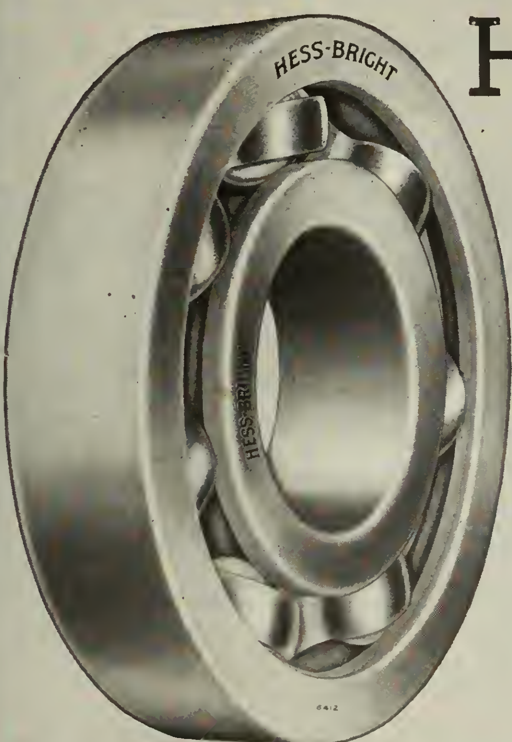
G-K—MORE THAN JUST A LATHE



Most lathes are just lathes—nothing out of the ordinary, good enough for some purposes, most of them honestly built, but as like as peas in a pod. A G-K Lathe is different, different in important respects, in many details, in its very appearance. It is a better lathe—worth more because it can earn more—with an established company and years of experience behind it. Let us send the Booklet "G-K Betterments"—you'll find it worth studying.

THE GREAVES-KLUSMAN TOOL CO., Cincinnati, Ohio

HESS-BRIGHT BALL BEARINGS



HAVE turned millions of revolutions on thousands of machines of hundreds of types for scores of purposes, standing millions of pounds of radial and thrust pressure.

They have done this in all climes, under varying conditions, with and without proper care, properly and improperly mounted or applied—*and they have stood up under it all.*

Thus they are carrying industry's burdens to the greater benefit of mankind.

Such is their reward. Their virtues have been proved. They have stood the test of time's worst task-master—Service.

Select the right Hess-Bright for *your* need and *your* bearing problems are solved. Let our engineers aid you in the solution of your problems.

HESS-BRIGHT'S CONRAD PATENTS
ARE THOROUGHLY ADJUDICATED

HESS-BRIGHT MANUFACTURING COMPANY

FRONT STREET AND ERIE AVENUE ∴ ∴ ∴ PHILADELPHIA, PA.

Two Cuts at One Time on the Universal Hollow-Hexagon Turret Lathe

Because the Anderson Electric Car Company of Detroit machines its differential cases on the Universal Hollow-Hexagon Turret Lathe it is able to reduce operations at the first setting, normally seven, to five. Consequently a ten hour day's production at the first setting is fifty cases. The Anderson people consider this most excellent performance.

The material is malleable iron. The operations at the first setting are as follows:

First, chamfer 45 degrees. Second, rough bore, face inside race with turret, and *at the same time* face the 8 1-2 inch diameter flange with the carriage. Third, rough turn radius. Fourth, finish bore, and *at the same time* finish face gear bearing, finish flange, and finish radius surface. Fifth, ream.

This ability to take two cuts at one time is furnished by means of independent feed shafts for carriage and turret saddle. Each has ten individual feeds in either direction. While boring or turning with the hexagon turret the carriage will face, undercut or form.

Among the other good features of the Universal Hollow-Hexagon Turret Lathes are the power rapid traverse, great reserve power, and the rigidity that assures accuracy.

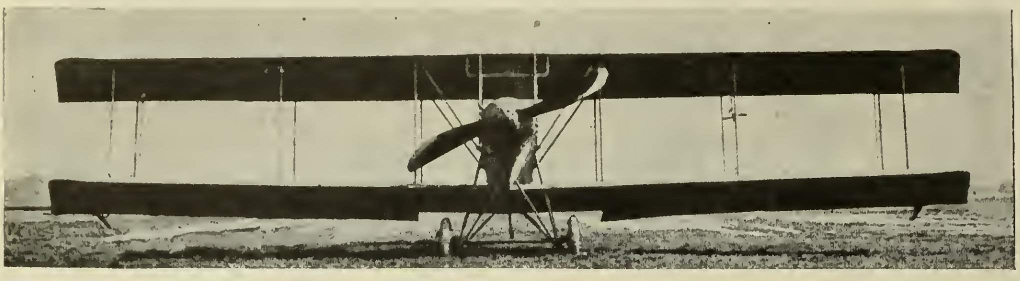
Send blueprints of one of your exacting jobs for a reliable estimate of the time saving effected by these machines

COMPANY, Cleveland, Ohio

FOREIGN AGENTS: Chas. Churchill & Co., Ltd., London, Birmingham, Manchester, Newcastle-on-Tyne and Glasgow. Allied Machinery Company, Paris and Turin. Van Rietschoten & Houwens, Rotterdam. Yamatake & Co., Tokio. Benson Brothers, Sydney and Melbourne. A. Asher Smith, Sydney. A. R. Williams Machinery Co., Ltd., Toronto, St. John, Winnipeg and Vancouver. Williams & Wilson, Ltd., Montreal.

THE TILTED TURRET

A CLEAR TRACK FOR THE STOCK



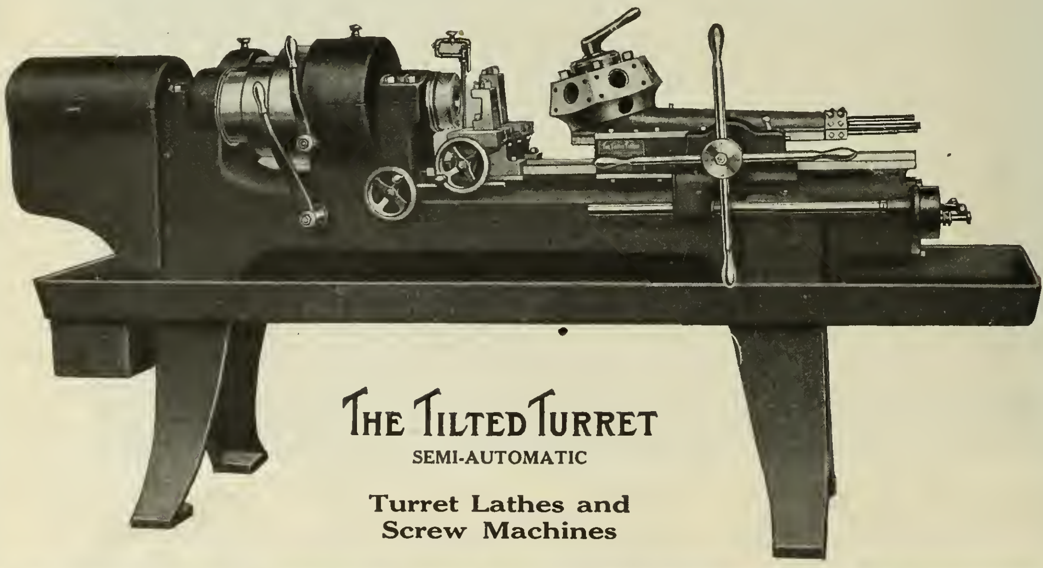
WHERE ACCURACY and DEPENDABILITY
Are Vital Factors of Construction

ACCURACY is one of the most important and prime features of construction in airplane work. Mechanical parts are subject to the most rigid and minute inspection.

It is in this class of work THE TILTED TURRET excels. No matter whether your operations be on bar stock or chuck work, where duplicate parts are essential, you will find THE TILTED TURRET a superior machine tool. At the present time, a large portion of the entire production of THE TILTED TURRET is being purchased by airplane manufacturers, which proves its DEPENDABILITY. THE TILTED TURRET is fifteen years old and the duplicate orders prove its efficiency. Ask the user.

Do These Facts Interest You As a User or Prospective Purchaser of Turret Machinery?

Our Catalog M-19 describes methods of construction of THE TILTED TURRET as well as showing the various sizes and models we manufacture. Your copy awaits you.



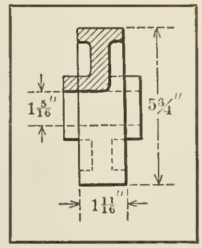
THE TILTED TURRET
SEMI-AUTOMATIC

Turret Lathes and Screw Machines

WOOD TURRET MACHINE CO.

BRAZIL INDIANA U.S.A.

Absolutely O.K.



"Leave it to Libby"

The work is gear blanks 5 3/4" diameter, 1 11/16" face, 1 5/16" bore; 3/16" stock is removed, two cuts are taken, two settings finish the job. Close accuracy and fine finish are observed, yet the Libby Lathe turns out a gear blank complete in *12 minutes.* "Absolutely O. K.," says the Troy Laundry Machinery Co., Ltd., Chicago, Ill.—and they demand big things of their machines.

"Libby" users consider "Libby" speed, power, accuracy and range about the finest production combination on the market. These machines are designed and built to turn out the maximum of work at minimum cost. They are simple machines to operate, have power for heavy cuts, can be driven hard and are economical on all work they handle.

If you've an unsolved production problem "Leave it to Libby." We shall be glad to show how a Libby Lathe will take care of it.

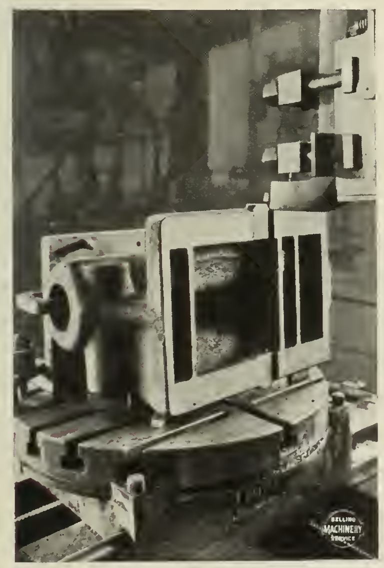
INTERNATIONAL MACHINE TOOL CO.

INDIANAPOLIS, INDIANA, U. S. A.

DOMESTIC AGENTS: Bowman-Blackman Machine Tool Co., St. Louis, Mo. Brown & Zortman Machinery Co., Pittsburgh, Pa. Eccles & Smith Co., San Francisco, Cal.; Los Angeles, Cal.; Portland, Ore. E. L. Essley Machinery Co., Chicago, Ill., and Milwaukee, Wis. Strong, Carlisle & Hammond Co., Detroit, Mich., and Cleveland, Ohio. Vandyck-Churchill Co., New York, N. Y.; New Haven, Conn., and Philadelphia, Pa. Syracuse Supply Co., Syracuse, N. Y., and Buffalo, N. Y. FOREIGN AGENTS: Coats Machine Tool Co., Ltd., London, Eng. Ugo Violini & Co., Milan, Italy. Iznosskoff & Co., Petrograd, Moscow and Ekaterinburg, Russia.

The DILL SLOTTER is a Manufacturing Machine

It was purchased for the purpose of helping the Shepherd Engineering Co., Williamsport, Pa., to build engines. When this concern, under stress of necessity, began turning out lathes, the machine that helped tide them over the hard spots was this same Dill Slotter. It planed, shaped, milled—did everything put up to it with true Dill efficiency. The bottoms of 20″ lathe tailstocks—a machining job that looked like a sticker because no machine could be spared for the work—is just one of the jobs on which the Dill made a record.



Photographs secured through the courtesy of the Shepherd Engineering Company, Williamsport, Pa.

A single iron fixture holds the work. When a tailstock comes off, even a surface plate fails to show up a low spot; the slot has been run across the surface and in the tongue recess at the rate of 25 pieces per 25 hours, floor to floor.

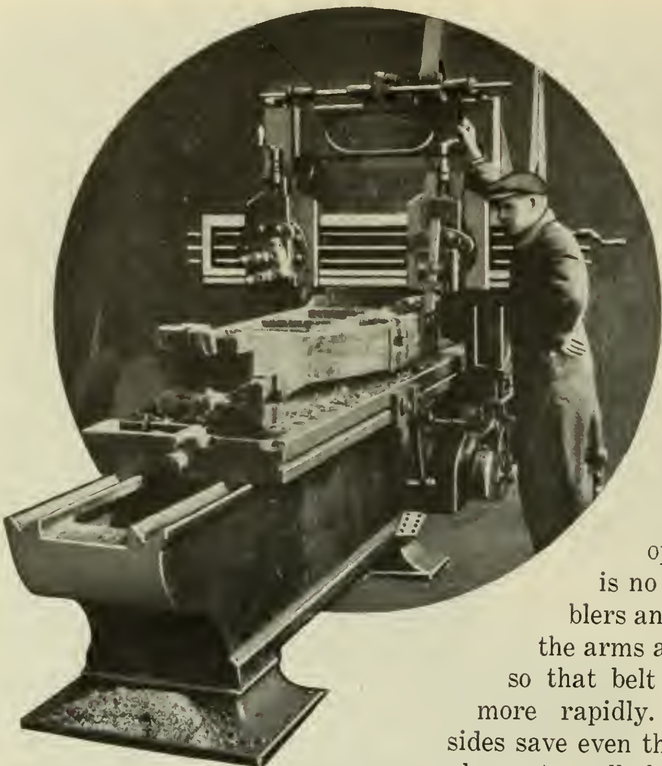
With a Dill Slotter handy you can do practically anything on any shape or size work. There are reasons—Dill rotating lathe, traveling head and a few others.

Write for the whole story.

T. C. Dill Machine Company

The Dill Slotter People, Philadelphia, Pa.

FOREIGN AGENTS: Coventry, London, Birmingham, Leeds, Manchester, Newcastle-on-Tyne and Glasgow, Alfred Herbert, Ltd. France: Alfred Herbert, Ltd. Italy: Alfred Herbert, Ltd. Japan: Alfred Herbert, Ltd., Yokohama. Germany and Austria: Heinrich Dreyer, Berlin, Germany. Holland: R. S. Stokvis & Zonen, Ltd., Rotterdam. Belgium: R. S. Stokvis & Fils, S.A., Brussels.

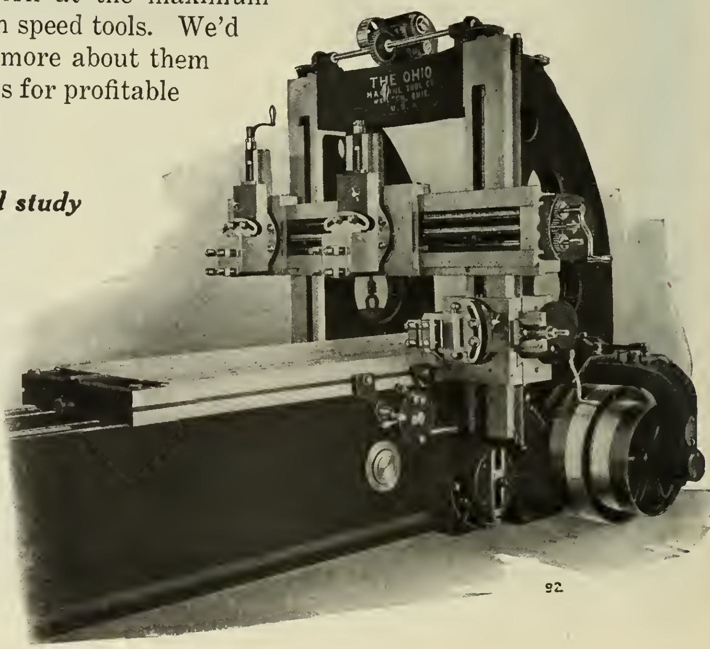


The "OHIO" Planer Has Table Dogs and Shifter Levers on Both Sides

This feature is right in line with the high production principle so thoroughly developed in "Ohio" Planers. There is no lost motion between the tumblers and the belt shifter arms, and the arms are located close to pulley so that belt can be shifted much more rapidly. Levers on both sides save even the time it takes a workman to walk from one side to the other.

The "Ohio" represents the latest design in metal planing machines, and is built throughout for accurately machining the heaviest classes of work at the maximum capacity of high speed tools. We'd like you to know more about them and their possibilities for profitable service in your plant.

Send for the catalogue and study their many fine points.

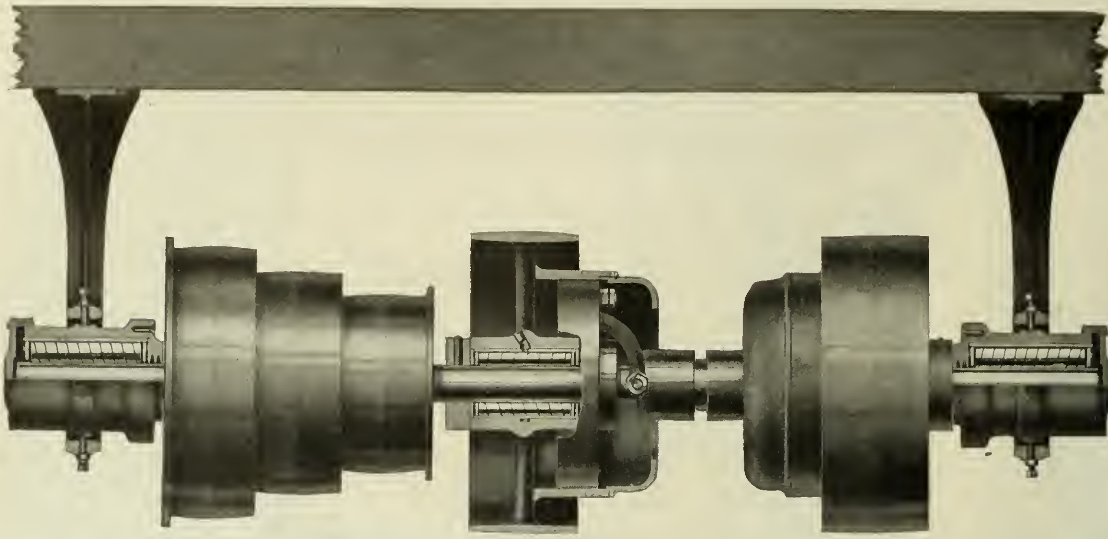


OHIO MACHINE TOOL COMPANY

KENTON OHIO

Planers and Shapers Since 1887


When East and West Agree
This punch—
Made by Mehl Machine Tool & Die Co., Roselle, N. J.—
For Western Electric Co., Hawthorne, Ill
Allowed limit of error ± .0001″.
Time and material have been wasted if this punch is rejected. Will the inspector in Illinois agree with the toolmaker in New Jersey on **what is .0001″?** Sure!
They both use Johansson Standard Gages.
Johansson Standard Gages have unlimited use in the toolroom and inspection department. Every day, toolmakers are finding new uses for them in laying out and checking jigs, dies, fixtures, gages, etc. No two manufacturers use the Johansson Standard Gages alike. ***All agree they cannot get along without them.***
THE SWEDISH GAGE CO., Incorporated
16 WEST 61st STREET, NEW YORK CITY



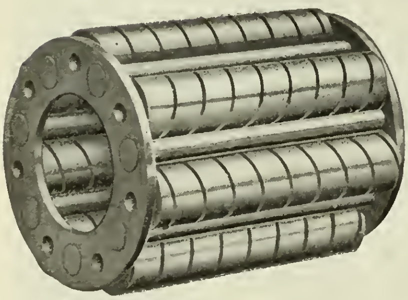
In the Cause of Better Bearings;

The shortcomings of old-fashioned plain bearings have been known to machine tool manufacturers for many years. Long ago it was decided by many of the manufacturers that plain bearings were a failure, especially on countershafts.

In theory plain bearings may be all right. But in practice they fall down hard.

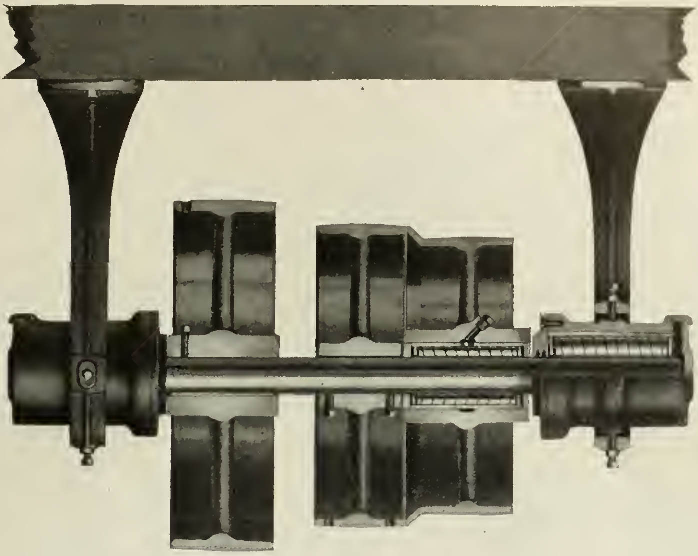
Bad lubrication is chiefly responsible for their miserable failure. They won't hold the lubricant at all. The oil leaks out; the bearing runs dry. The machine must stop.

A machine tool operator must not be hampered by unreliable bearings. He must feel free to speed up his machine whenever conditions demand it. He must not live in fear of his bearings breaking down. For the sake of his efficiency, you should save him the worry of bearing trouble. Let him have confidence in his machine—put Hyatt Bearings on the countershaft.



Hyatt Roller Bearings are anti-friction. They save power.

HYATT BEARINGS



Greater Speeds, Constant Service

And Hyatt Roller Bearings solve lubricating troubles. Hyatt Rollers are hollow and have spiral slots. Each roller acts as a reservoir for oil. Through the spiral slots the oil is sent oozing out over the whole bearing surface and back into the roller again. The oil is always on the move and always doing good. Every drop of oil is used to such advantage that Hyatt Bearings don't need oiling more than once a month.

Greater speeds! Constant service! Long life! Ideal lubrication! That's what Hyatt Bearings should mean to you. Think the matter over.

PARTIAL LIST OF USERS

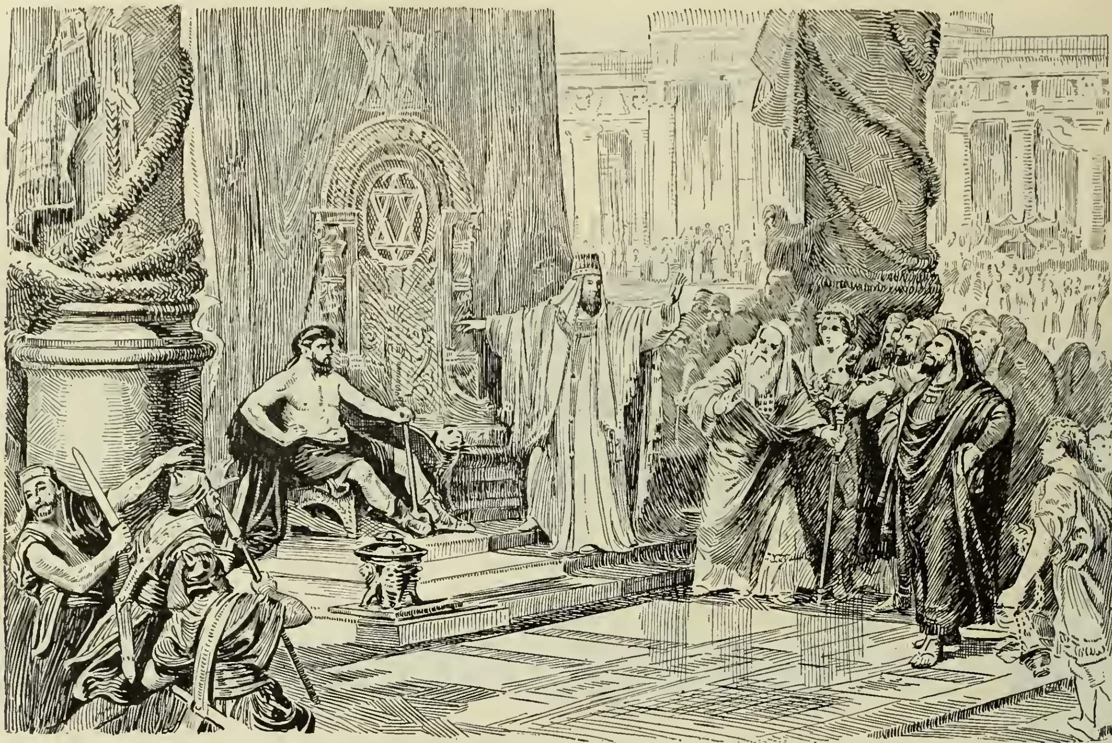
Cleveland Automatic Machine Tool Co., Cleveland, Ohio
Hardinge Brothers, Chicago, Ill.
Bullard Machine Tool Co., Bridgeport, Conn.
Chard Lathe Co., New Castle, Ind.
Foote-Burt Co., Cleveland, Ohio
National Automatic Tool Co., Richmond, Ind.
Baush Machine Tool Co., Springfield, Mass.
Rockford Drilling Machine Co., Rockford, Ill.
Fox Machine Company, Grand Rapids, Mich.
Ingersoll Milling Machine Co., Rockford, Ill.
Rockford Milling Machine Co., Rockford, Ill.
Landis Tool Co., Waynesboro, Pa.
Fitchburg Grinder Co., Fitchburg, Mass.
Barber-Colman Co., Rockford, Ill.
Heald Machine Co., Worcester, Mass.
American Tool Wks., Cincinnati, Ohio

When you want data on HYATT BEARINGS for countershafts, drop us a line.

HYATT ROLLER BEARING CO.
NEWARK NEW JERSEY

401

FOR COUNTERSHAFTS



And Solomon

Forgot to invite the Forgeman to the banquet celebrating the completion of the temple.

When the throne was unveiled however there sat the forgeman in the seat of honor the uninvited.

The guards rushed to cut him down; but Solomon said "How could this temple have been built but for this man?"

Now then, when building your engines, ships and machinery invite prices on

CAMDEN FORGINGS

We feel honored in receiving your invitation and shall strive to secure the place of honor by taking your order.

We are thoroughly equipped to make many forgings, light or heavy, for various industries and simply add what is below as a

"BUYERS GUIDE"

High and Low Carbon Bars
Press Columns and Rams
Water Cylinders
Pull Back Cylinders
Valve Bodies
Plungers
Weldless Steel Rings
Lathe Spindles, solid and hollow bored
Long Feed Screws
Power Press Crank Shafts
Cam Shafts

Eccentric Shafts
Crusher Shafts
Gear and Pinion Blanks
Locomotive: Side and Main Rods; Crank Pins; Axles; Rod Straps; Guides; Parts of frame both in iron and steel
Hammered Iron Bars for locomotive Repairs

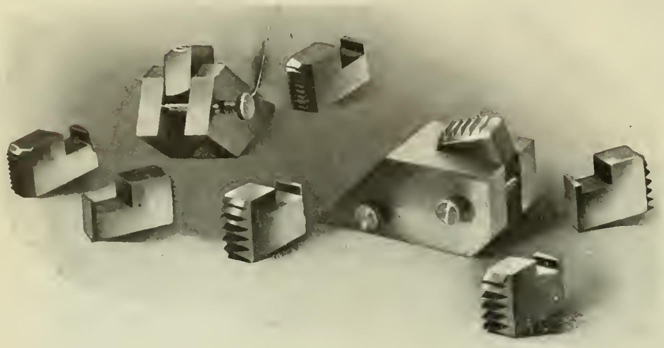
Marine Shaft
Marine Connecting and Eccentric Rods
Rolls: Bending; Feed; Straightening; Embossing
Large Wrenches
Saw Arbors
Steam Engine Forgings
Pump Crank Shafts
Pump Connecting Rods

Large Nuts
Turbine Shafts
Mill Shafting
Trolley Car Axles
Electric Motor Axles

Any forging to your print and specifications, smooth forged, rough machined or finished complete in either iron or steel.

CAMDEN FORGE CO.
Mt. Ephraim Ave., CAMDEN, N.J.

Chasers for Hartness Dies Are Easily Ground



These jigs are supplied gratis with new dies, and are sold separately at modest prices.

Full instructions for grinding chasers are sent with chasers.

A special grinder for this purpose *is not required.*

These Jigs and Any Small Grinder will Grind Hartness Chasers Quickly and Correctly

JONES & LAMSON MACHINE CO.

AUTOMATIC DIE DEPARTMENT

109 QUEEN VICTORIA ST. LONDON, ENG.
SPRINGFIELD VERMONT, U. S. A.

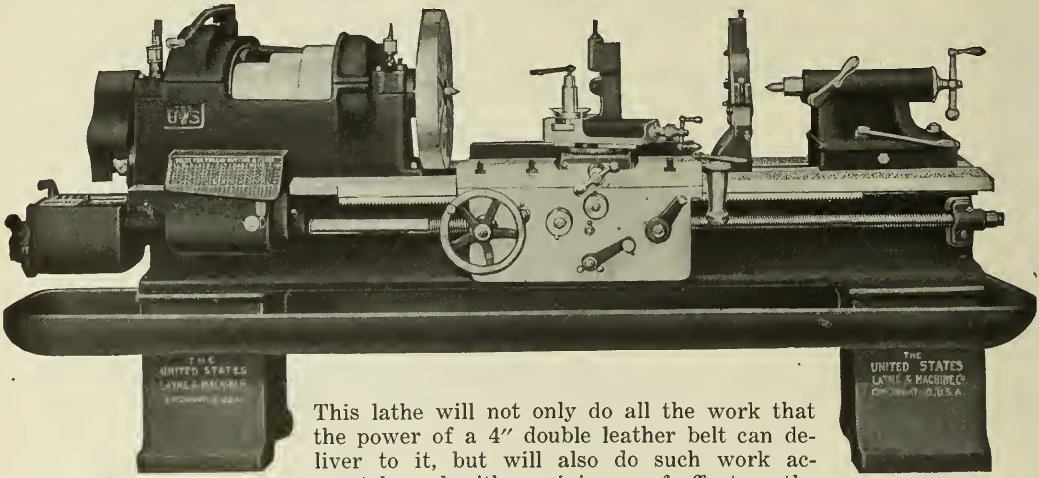
AMERICAN AGENTS FOR DIES AND CHASERS

Barwood-Richards Mchy. Co., Bourse Building, Philadelphia.
Boyer-Campbell Co., Detroit.
Carey Mchy. & Supply Co., Baltimore.
E. L. Essley Mchy. Co., Chicago.
The E. A. Kinsey Co., Cincinnati and Indianapolis.
Machinists Supply Co., Pittsburgh.
Pacific Tool and Supply Co., San Francisco and Los Angeles.
The W. M. Pattison Supply Co., Cleveland.
Robinson, Cary & Sands Co., St. Paul.

FOREIGN AGENTS

For France, Spain and Belgium; F. Auberty & Co., 91 Rue de Mauheuge, Paris.
For Holland: Spliethoff, Beeuwkes & Co., Rotterdam.
For Australia: McPherson's Pty., Melbourne.

"United States"—Lathes for Service



This lathe will not only do all the work that the power of a 4″ double leather belt can deliver to it, but will also do such work accurately and with a minimum of effort on the operator. Investigate it.

The United States Lathe & Machine Co.

CINCINNATI, OHIO, U. S. A.

MODERN

Fine Die Heads for Fine Threads

Modern Self-Opening Adjustable Die Heads, recognized as standard for thread cutting, are regularly made in sizes with capacities from 1-16" to 5 1-2" diameter. Larger sizes to order.

Modern Die Heads are found in every conceivable line of manufacture; the photograph illustrating an instance of their adaptability. This picture was secured in the plant of one of the country's foremost safe and vault builders, where all the screws used are threaded by the Modern Die Head.

This particular job is threading ¾" x 1"—14 pitch steel screws. Production is 1600 in 10 hours—every thread perfect in dimension and clean cut.

Use Modern Die Heads for maximum efficiency and accuracy on *your* thread cutting. Send for the facts.

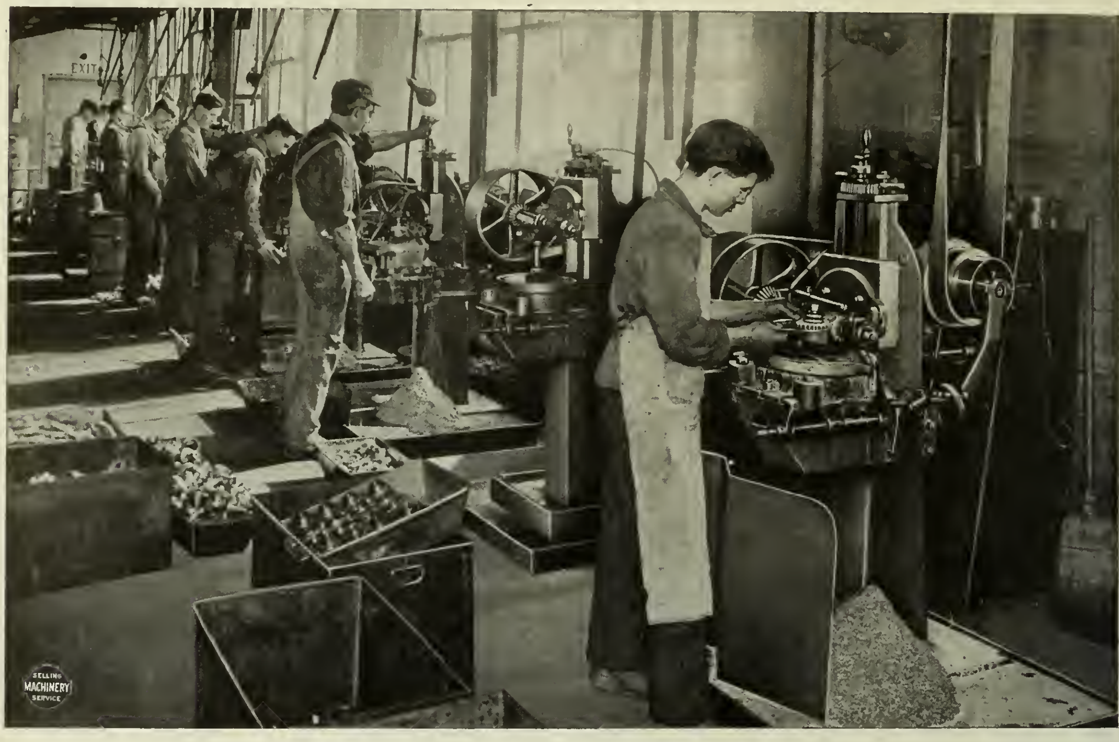
MODERN TOOL COMPANY

Main Office and Works:

SECOND AND STATE STS. ERIE, PA., U. S. A.

Chicago Office: 32 N. Clinton St. Detroit Office: 1223 Dime Bank Bldg. New York Office: 2 Rector St.
F. Wesley Parker, Residence Engineer and Export Agent, 2 Rector St., New York.

Here's A Profitable Battery of Farwell Gear Hobbers



Profitable not only in the sense that they do their work well, *but that they do it with remarkable economy.* The machines are nine Farwell Gear Hobbers owned by the Stewart-Warner Speedometer Corporation, Chicago, Ill. The work is forged steel gears, average diameter 4″, ½″ face, ranging in pitch from 6 to 8, with special emphasis on accuracy and all the speed possible. Production per day of 8¾ hours averages 65 gears, each machine. The work is economically done, because a Farwell Gear Hobber never requires all of an operator's time. Once the work is set up and the cut started, the machine requires no further attention till the gear is completed. In many instances one operator looks after four busy machines.

Farwell Gear Hobbers are simple, efficient, powerful, rugged—record producers, profitable machines in every sense of the word.

If you buy or make gears, let us tell you more about Farwell Hobbers.

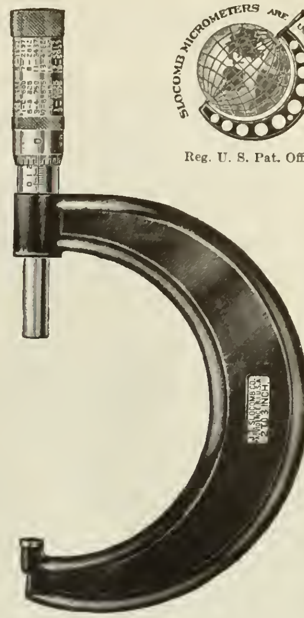
THE ADAMS COMPANY, 1903 MARKET STREET DUBUQUE, IOWA, U.S.A.

What the Slocomb Says is Right—The Inspector Marks O. K.

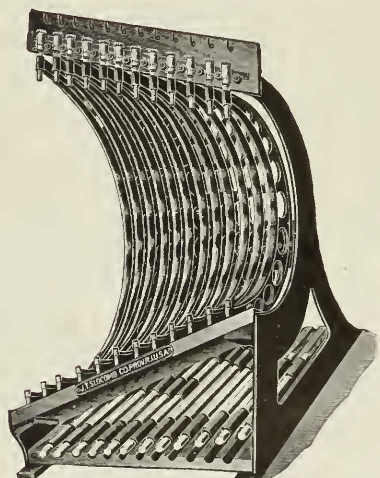
Requirements were never more severe as to accuracy, and by the same token, never were more Slocomb Micrometers in use. Manufacturers whose business is accurate production are not taking chances—they're making sure. And in an increasing number of cases they are making sure with Slocomb Micrometers, because they meet the current demand.

Slocomb Micrometers are true—absolutely true—with the strength to stand up to the usage popular tools get in busy shops. The drop forged I-section frame combines strength with lightness; the Slocomb screw is hard tool steel working in a nut giving four times the bearing surface found in other micrometers.

The Slocomb is "the longest lived micrometer that can be bought."



Reg. U. S. Pat. Office



No. 28—12 to 24 Inches
Set of Micrometer Calipers

Write for Catalogue No. 15.

J. T. Slocomb Company

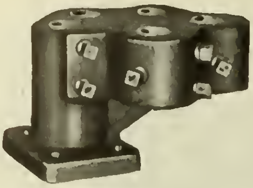
Providence, R. I., U.S.A.

Representatives in England: Chas. Churchill & Co., Ltd., London, Birmingham, Manchester, Newcastle-on-Tyne and Glasgow.

Representatives in Japan: Alfred Herbert, Ltd., Yokohama.

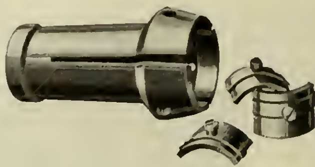
Representatives in Italy: Chas. Civita, Milan.

Representatives in Australia: Edwin Wood, Pty., Ltd., Melbourne and Sydney.

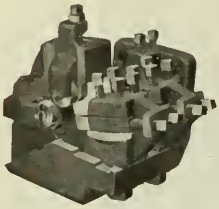


No. 107
Multiple Turning Head

No. 108
Facing Head

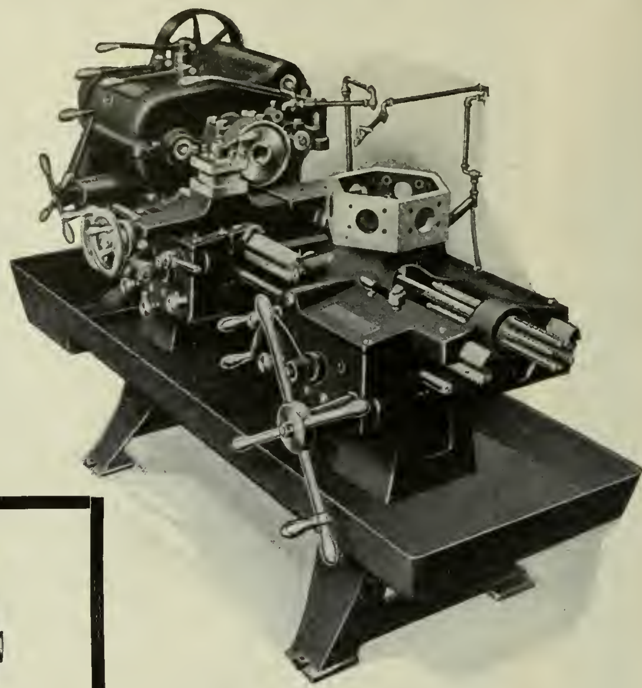


Push-Out Collet with Bushings

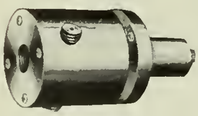


No. 139
Multiple Cutter Turner

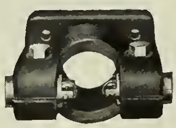
The FOSTER 1-B Universal Turret Lathe with its tools and attachments is establishing a new and higher standard of production per dollar invested. Let us tell you more about it.



No. 142
Center Drilling Tool

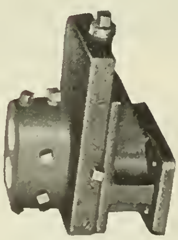


No. 120
Adjustable Drop-off Tap Holder



No. 143
Knurling Tool

No. 149
Rear Forming Tool Holder

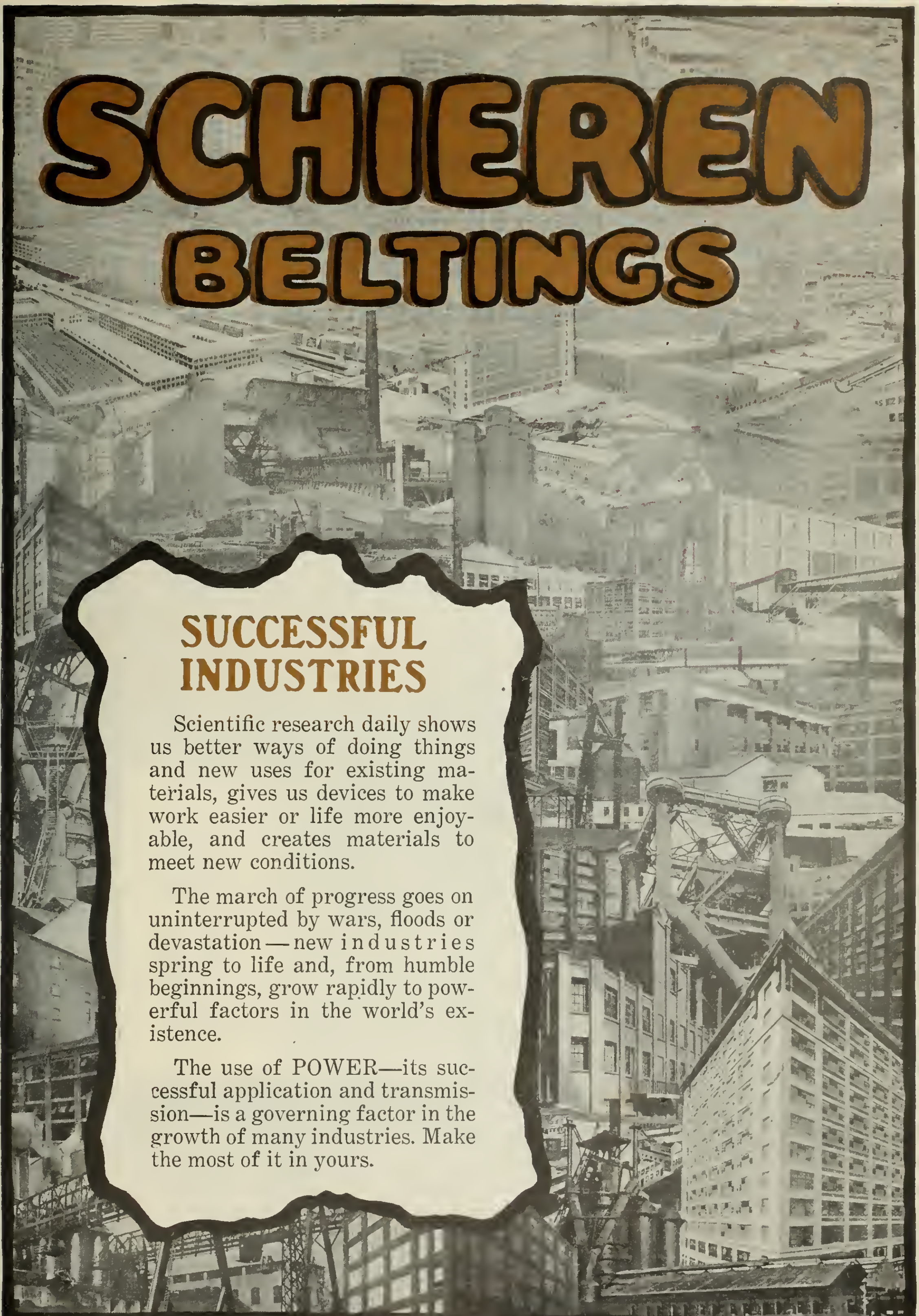


No. 116
Slide Tool

The Foster 1-B Universal Turret Lathe

A machine that is adapted for manufacturing in large quantities as well as producing a wide variety of parts in small lots—a machine that brings to its work tremendous power, rigidity and strength. The Foster 1-B is provided wtih a complete and extensive equipment of standard tools and attachments, and with means for handling work of more or less special nature. Range includes bar and chucking work, from wide forming in steel to turning hard cast iron of large diameter. As many as twelve cutters can be mounted on the two tool carrying units; turret and cross slide can be operated simultaneously and independently with widely different feeds. A carefully devised arrangement of operating helps aids in maintaining a high rate of production.

FOSTER MACHINE COMPANY
ELKHART, INDIANA, U. S. A.


SCHIEREN
BELTINGS
SUCCESSFUL INDUSTRIES
Scientific research daily shows us better ways of doing things and new uses for existing materials, gives us devices to make work easier or life more enjoyable, and creates materials to meet new conditions.
The march of progress goes on uninterrupted by wars, floods or devastation—new industries spring to life and, from humble beginnings, grow rapidly to powerful factors in the world's existence.
The use of POWER—its successful application and transmission—is a governing factor in the growth of many industries. Make the most of it in yours.

Practical Economy in Belting Application

As the user and buyer, you know first of all that **a belt** is needed to transmit so much power from motor, engine or lineshaft to a certain machine.

You have first-hand knowledge of the place it is to go into, and the conditions under which it must operate. Your specifications are final—accepted without question—because you are on the ground **and know.**

That is the initial step in the application of a belt for transmitting power.

The second step is the selection of the **proper belt** to successfully transmit the desired amount of power under your conditions.

That is where **Schieren Engineering Service** comes in.

We have not been manufacturing and installing leather belts for more than fifty years without gaining a broad experience and an immense reserve knowledge of what a leather belt will do under any and all conditions.

We **know** the kind as well as size of belt you should use as soon as we learn your requirements and the conditions of service.

Schieren brands of belting, in all grades, have always stood for honesty in manufacture, and **Schieren Engineering Service,** based upon honesty in application, will not let you buy other than **the belt which will most economically meet your requirements.**

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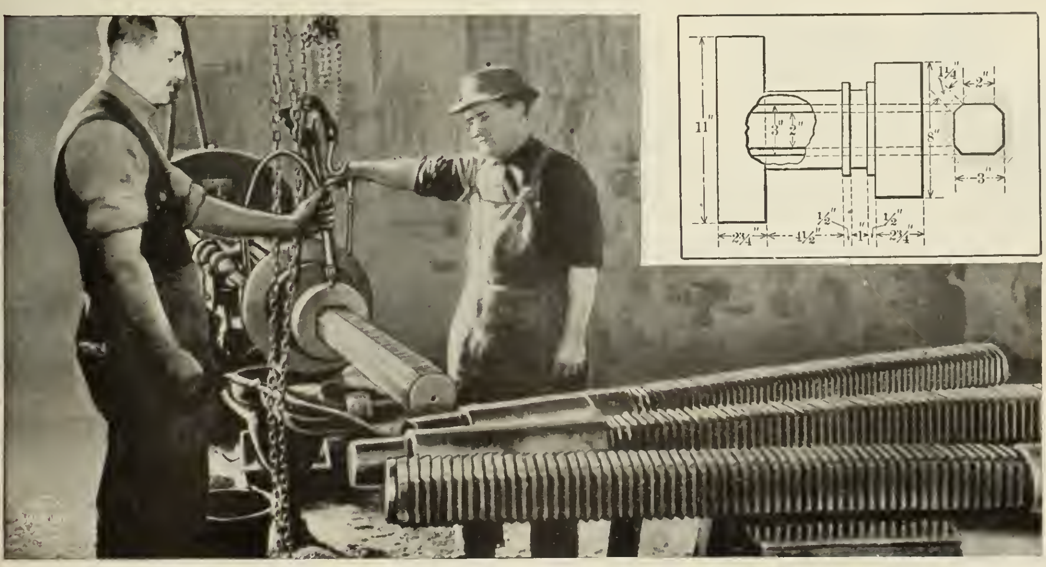

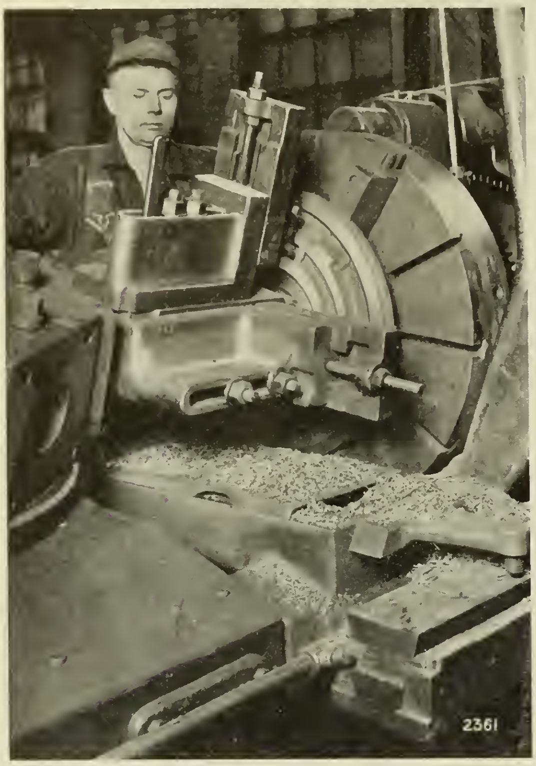

Lowering Costs with a Gisholt Turret Lathe

The use of tool post and turret simultaneously is one of the means offered for lowering costs with the Gisholt Turret Lathe. The photographs herewith and the accompanying sketch illustrate this Gisholt practice. The machine is a standard 34″ Gisholt Turret Lathe equipped with standard tools for finishing the piece shown in the line drawing as indicated by finish marks. The piece is the back plate for a 24″ scroll chuck. It is of cast iron and must be finished within very close limits.

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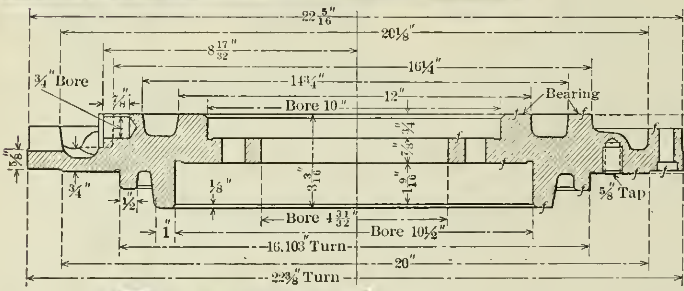

And these parts, when completed, are virtually self-assembling, and this, we claim, is the test of true efficiency in a machine tool. The Gisholt Turret Lathe has been simplified and perfected to such a degree that it produces finished parts so close to the required standard that hand-work is practically eliminated.

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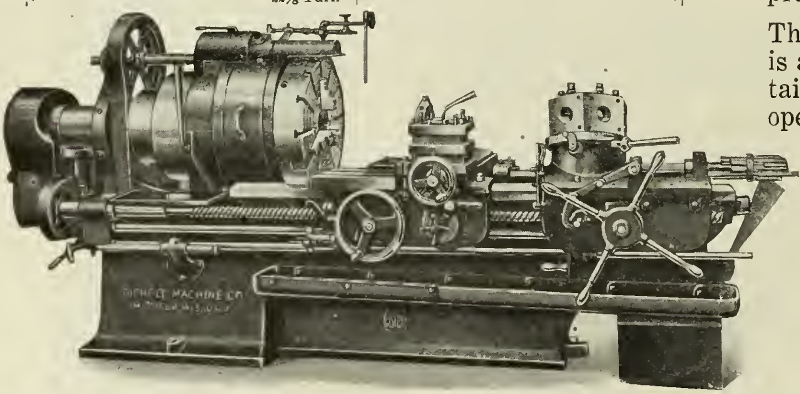

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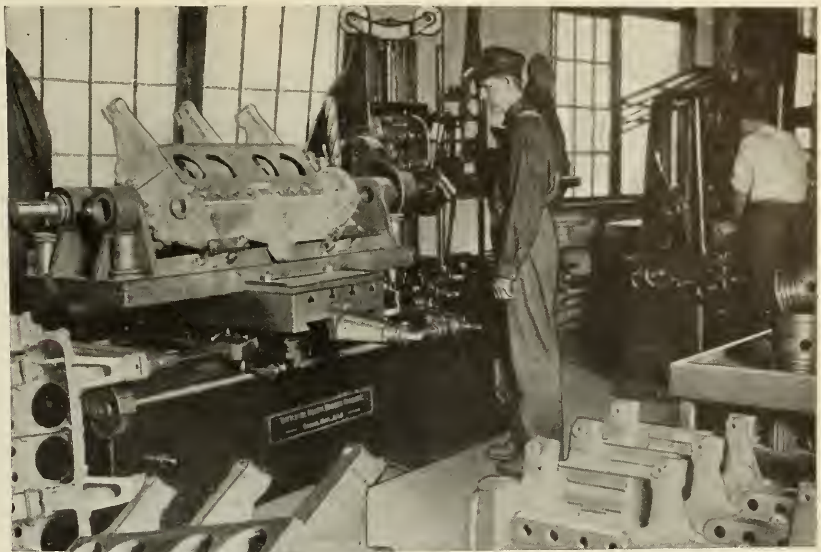

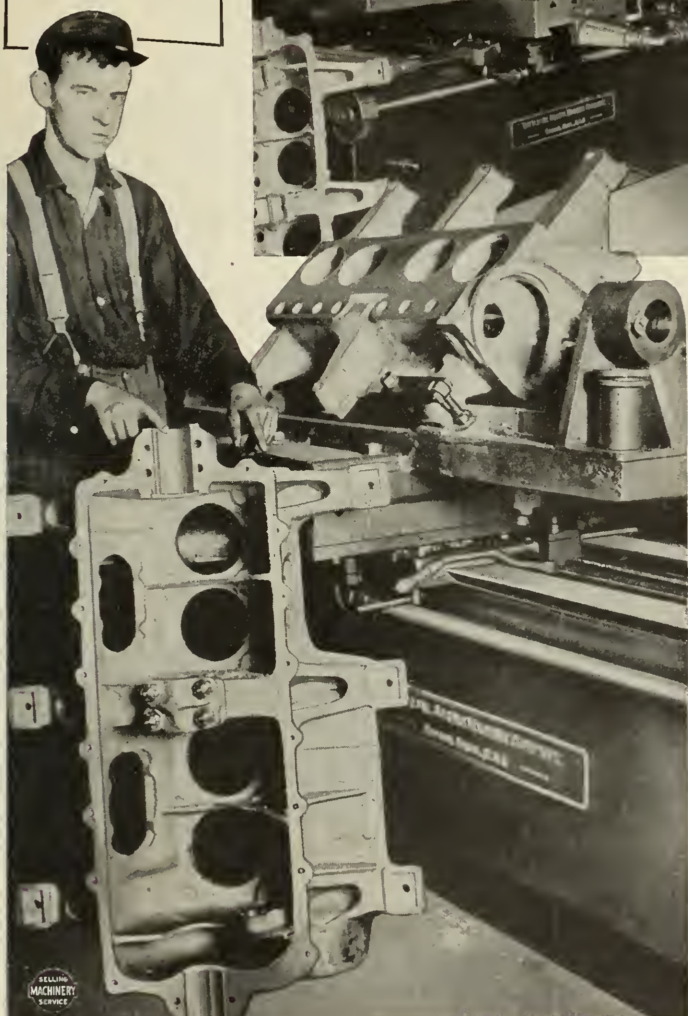

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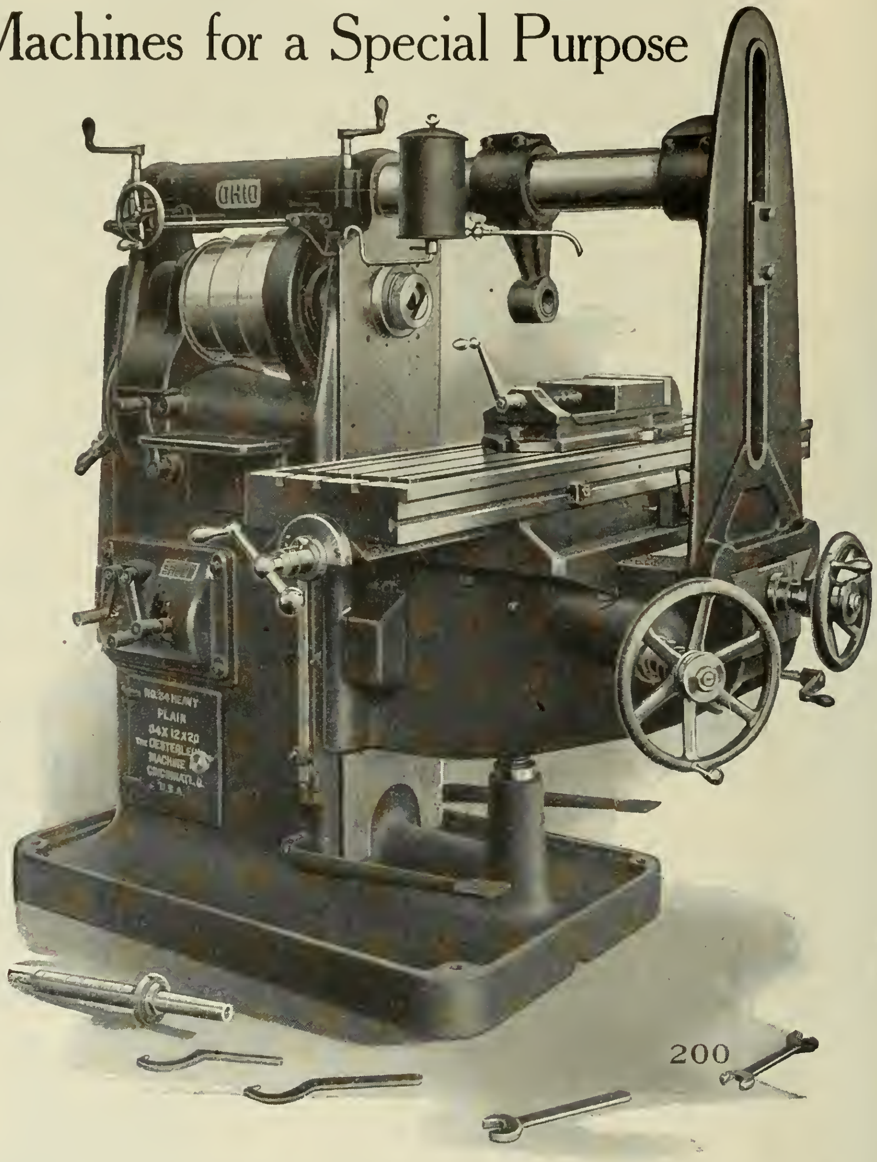

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Van Norman Machine Tools

were exhibited at Springfield. There is no reason why these tools shouldn't prove as popular on foreign soil as they have here. They are adaptable machines, highly accurate, with many exclusive features—popular because they are efficient.

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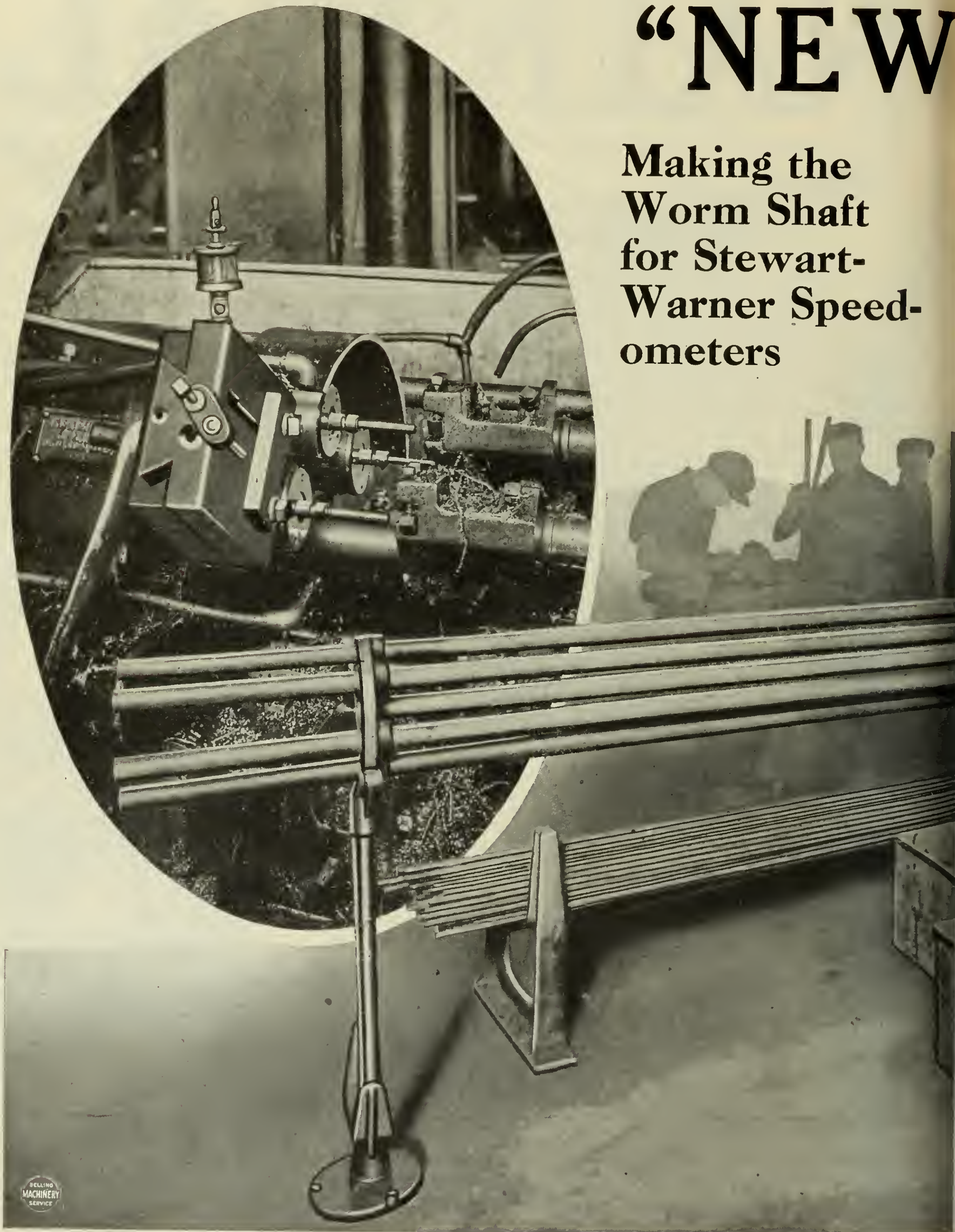

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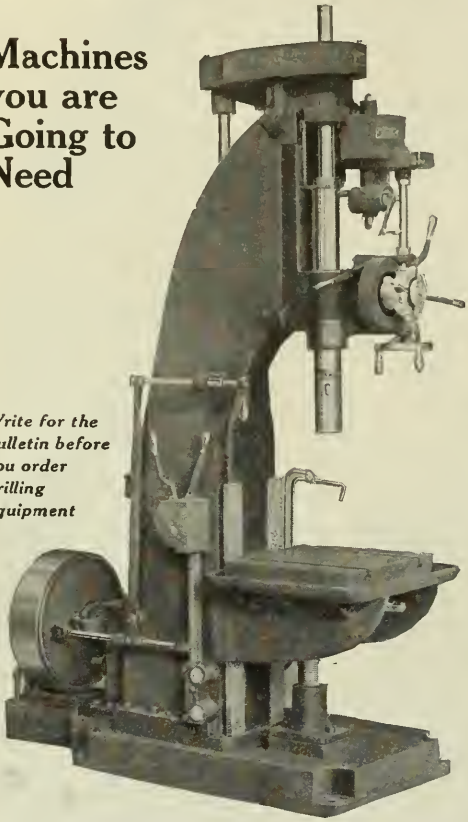

Write for the Bulletin before you order drilling equipment

With all the forces of the United States organized for offense and defense, American manufacturers are facing the busiest and most important period of industrial history. Their prime need is machines—good machines, machines built like the Foote-Burt No. 25 High Duty 24″ Drilling Machine.

The No. 25 is as rigid as a machine can be made, modern to the smallest detail, and drives high speed drills, up to 3″ size, to full cutting edge capacity. All speed and feed changes are made through quick change gear device of special design; spindle is of forged high carbon steel, fitted with ball bearing thrust of our own design, *guaranteed not to crush under the severest duty.* All levers are within easy reach. Briefly, the function of this machine is to work hard and keep at it.

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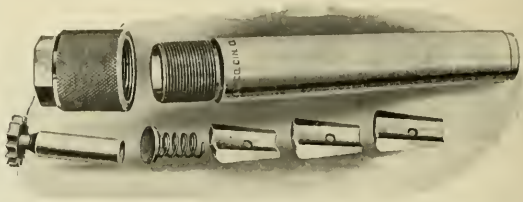

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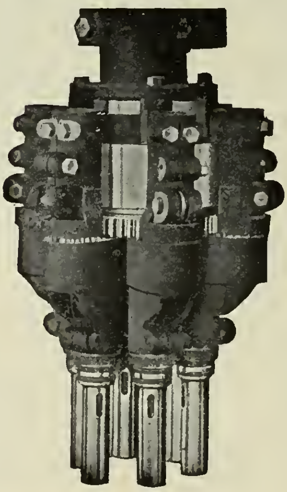

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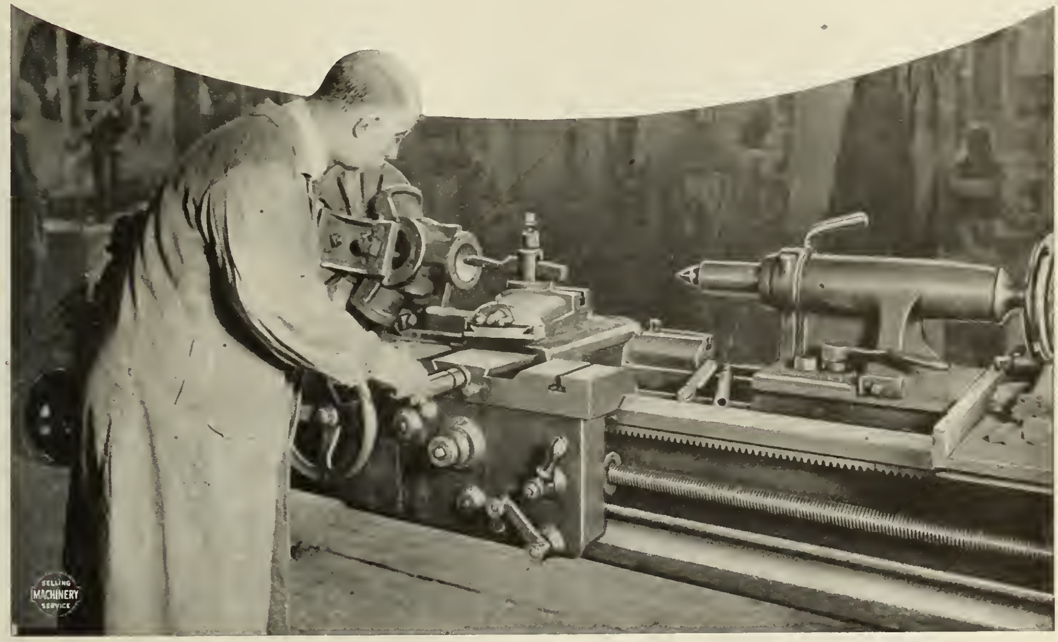
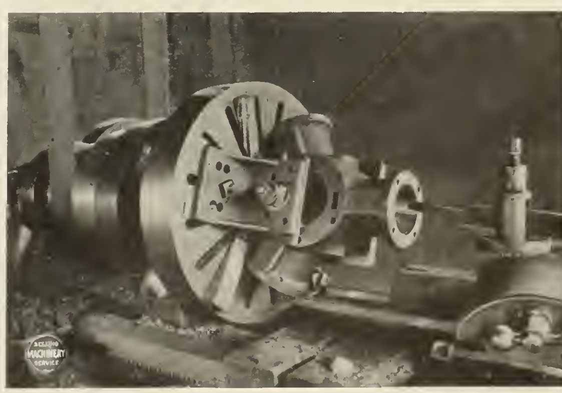
THE ROULSTED TWENTY

On Jobbing Work—an Adaptable Lathe



The Barbour-Stockwell Company, Cambridge, Mass., makes good use of the Roulsted Lathe. When the investigator paid the company a visit recently, here's what he saw. A cylinder casting for an oil engine strapped on an angle iron on the faceplate of the Roulsted ready to be bored out. Three cylinders were bored, the casting being re-set for each operation. Aside from the quick work of the lathe, the overhang from the faceplate is the interesting feature of this job. Roulsted spindle construction, however, is a marvel of strength. It will support work adequately at even a greater distance from the faceplate.

The Roulsted Twenty is a heavy all-around engine lathe, built by specialists. Carriage has full length bearing on the vees; apron is of double-plate type. Actual swing over bed 21", over carriage 14".



If the Roulsted Lathe is new to you ask for details

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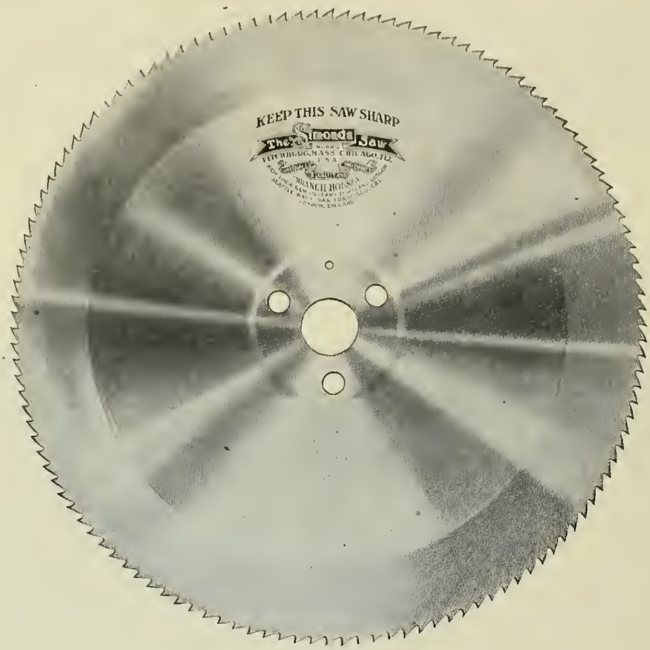

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Every firm using Metal Cutting Saws, Metal Slitters, Screw Slotting Saws, or Inserted Tooth Metal Saws, should find an opportunity to prove to itself that the Simonds Special Blades, which we now manufacture in large quantities, of our own steel and in our own factories are unquestionably superior and economical saw blades.

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The Caterpillar Tractor

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The importance of road transportation in times of war and peace warrants the presentation of this article on the design and construction of the Holt Mfg. Co.'s caterpillar tractor, which is the foundation of the British and French "tanks," and in many respects the most remarkable machine ever developed for any purpose.

WAR stimulates the invention of destructive devices and promotes the adaptation of machines to offensive purposes for which they were not originally planned. One of the strange developments of the European struggle is the so-called "tanks," those lumbering land battleships, invulnerable to machine-gun fire, that travel over ground plowed by shells, and cross ditches, crawl up precipitous banks, push down walls, and accomplish that which would be impossible for any of the four-wheel type motor trucks. The tanks are adaptations of an American invention, being reconstructed caterpillar[1] tractors built in the United States and invented by Benjamin Holt, president of the Holt Mfg. Co., of Stockton, Cal., and Peoria, Ill.

Benjamin Holt was born in New Hampshire and had New England thrift and native Yankee inventive ability. He went to California in the early eighties, and with his brothers established a factory at Stockton for building wagons and farm implements. The vast agricultural areas, the forests and the great mines of the Pacific coast all demanded new methods of farming, lumbering and mining. Twenty-five years ago Mr. Holt invented the Holt combined harvester and thresher, which cuts and threshes the grain at one operation. This machine quickly came into extensive use in the Pacific coast states. Mr. Holt then began the manufacture of steam traction engines for pulling gangs of plows and other tillage implements, but these engines were only partially successful, as the soft lands of the San Joaquin valley could not support the weight, although driving wheels were built as large as eight feet wide and twelve feet diameter. These were too heavy and cumbersome and did much damage to the surface traversed. Then realizing that the reason for using such enormous driving wheels was simply to obtain the projected area on the ground required to support the weight, Mr. Holt, in 1904, discarded the large-diameter, wide-tire wheels and designed a virtually flat wheel in the form of an endless sectional track which the tractor first lays down, rolls over and then finally picks up one section at a time, thus giving a solid steel road-bed to travel on. The belts were provided with guide wheels similar to an animal tread power, and, in fact, the driving elements or track assemblies are identical in principle with tread powers; they are laid on the ground

[1] The term "Caterpillar" used throughout this article is copyrighted, and has reference only to the tractor made by the Holt Mfg. Co.

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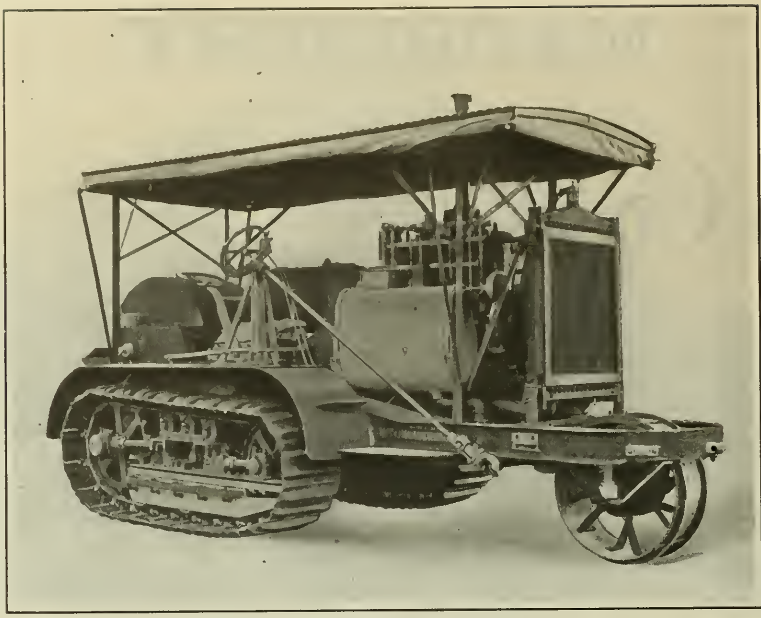


Fig. 1. Seventy-five-horsepower Internal-combustion Motor Caterpillar Tractor

and pushed by engine power instead of being pushed by animal power. The engine drives through sprocket wheels, which engage the links of the belt or chain. This form of driving element can be proportioned to give almost any required area to support the load, and it was found to have certain other valuable characteristics not possessed by the traction engine. It not only had great tractive power, but could be maneuvered much more easily. It is possible to turn a caterpillar within its own length and to traverse broken ground that would stop any wheel vehicle. The reason for the latter is that the belts bridge narrow ditches and support the engine without dropping in and having to climb out. If the ditch is broad, the great tractive power enables the machine to cross even if the sides are inclined at as steep an angle as 45 degrees.

The Holt Mfg. Co.'s caterpillar tractors are built in four sizes, *viz.*, 18, 45, 75 and 120 horsepower. The 18- and 45-horsepower sizes have no pilot or leading wheel. The larger sizes with greater power and a longer wheel-base are employed for heavy hauling, as well as for agricultural work, having power sufficient for pulling large gangs of plows or several loaded trailers, doing construction work and other labor requiring great tractive power. The 75-horsepower tractor weighs 24,000 pounds and develops a draw-bar pull of 9000 pounds; the 125-horsepower tractor develops 12,000 pounds draw-bar pull.

The tractors are equipped with internal combustion four-stroke cycle engines with four and six cylinders. The six-cylinder engines are used on the 75- and 120-horsepower tractors, while the 18- and 45-horsepower sizes have four-cylinder engines. The 45- and 75-horsepower motors are built in the Stockton plant, and the Peoria plant is devoted principally to the construction of the frames, track assemblies, clutches, transmission gears, and all the other principal parts. A few six-cylinder engines with certain special features for military tractors are built in the Peoria plant. The general design of the engine does not differ radically, however, from that of the engines for motor trucks except in general ruggedness and strength, being comparatively slow speed and heavy per unit horsepower. The 75-horsepower tractor is driven at two speeds, either 2⅛ and 3, or 1½ and 2⅛ miles per hour. The slow speeds, of course, give the greatest tractive power and are used in heavy pulling. When climbing a bank or getting out of a mud-hole, the operator uses the multiple-disk master clutch to increase the tractive power momentarily. He lets the engine speed up and then jams in the clutch, thus utilizing the inertia of the flywheel and obtaining a tremendously increased tractive power momentarily. It is because of the peculiar features of the driving gear and the low unit pressure of the tractor on the earth that the Holt caterpillar can cross gullies, plow through mud, and pull a load where other tractors would be practically helpless.

The control of the Holt tractor is different from that of the ordinary motor truck. On the 45-horsepower tractor the operator's seat is at the rear, where he has at his hand and feet three clutches to operate, two for steering and one—the master clutch—for controlling the transmission of power from the engine to the driving gear. The master clutch must be pressed into engagement by the operator when he wishes to drive, instead of employing the pressure of a coiled spring, as in the transmission of the ordinary motor car. The two steering cone clutches are located in the jack-shaft. To turn the tractor to the right, the operator releases the right-hand clutch partially or entirely, depending on the shortness of the turn required, and drives with the left-hand clutch, causing the machine to curve to the right. If a very short turn is to be made, the right-hand clutch is fully disengaged and the brake applied to the clutch drum, thereby locking the driving gear on the right-hand side and causing the machine to pivot on the center of the right-hand track assembly. Thus it is possible to turn the tractor easily within its own length.

Caterpillar tractors are manufactured, but all the parts are not made strictly interchangeable, although they are practically so. For instance, the bearings for the transmission shafts are babbitted with babbitting jigs and are afterward reamed, scraped and fitted to their respective shafts, thus securing close fits,

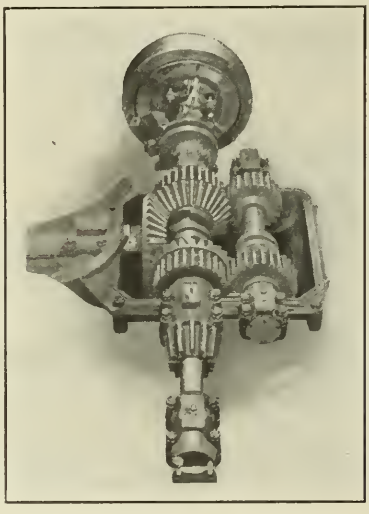


Fig. 2. Master Clutch and Transmission Assembly of 75-horsepower Tractor

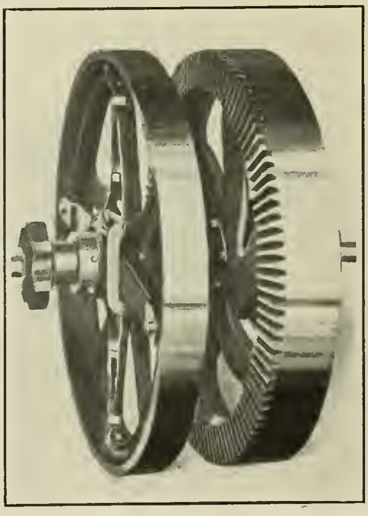


Fig. 3. Main Drive Gear and Friction Wheel of 75-horsepower Tractor

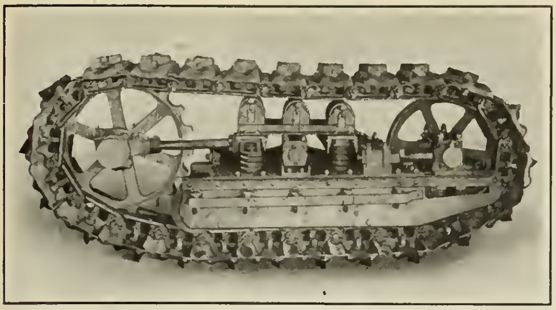


Fig. 4. Track Assembly of 75-horsepower Holt Caterpillar Tractor

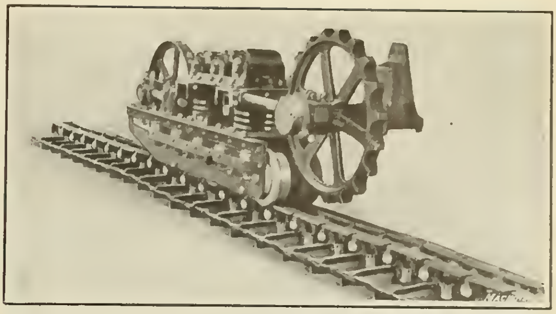


Fig. 5. Track Assembly with Track opened out, 75-horsepower Tractor

smooth action and durability. When replacements are necessary, some refitting may have to be done. The frame is bent to shape over forms and the bearing castings are set, the holes are drilled and then reamed in position. The general practice is the same as that followed by locomotive builders. The effort is to secure a strong, well-knit construction that will withstand indefinitely the shock and wear of use.

Cut gears are used throughout the transmission. The bevel gears are planed on Gleason bevel gear templet planers. Great

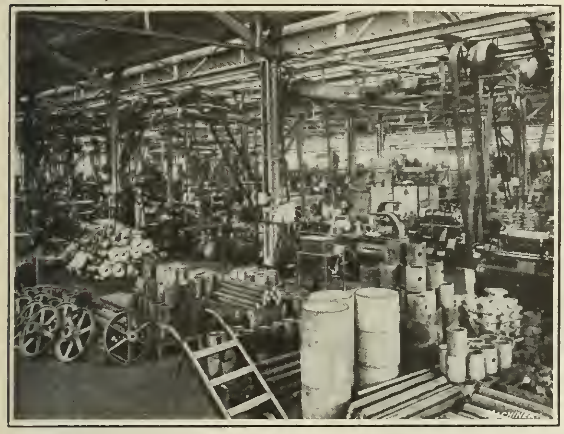


Fig. 6. Machine Shop of Holt Mfg. Co., Peoria, Ill.

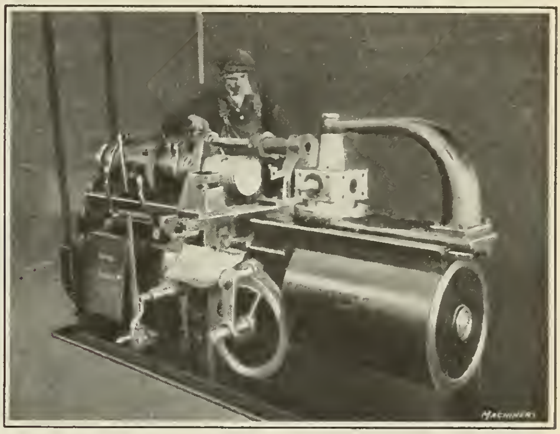


Fig. 7. Potter & Johnston Automatic Lathe turning Pistons

care is exercised to obtain perfect alignment of engine crankshaft bearings, the boring being done on Lucas horizontal machines.

The working parts of the caterpillar that excite the liveliest interest in the mechanic are the track assemblies. In these we have a mechanism exposed to dust, sand, mud and water, while working under heavy stress. To have designed and constructed a flexible steel track that sustains a load of several thousand pounds and that propels the machine under the most severe deteriorating influences is an accomplishment worthy of the highest commendation. The structure is made to exclude dirt to a considerable extent, but it works without trouble or rapid wear when submerged in mud or sand.

The steel track of the caterpillar is composed of links, connected by casehardened pins and bushings, and plow steel plates pressed into shape while hot. Each link is a double rail over which the track rollers revolve. A plow steel plate of high tensile strength is attached to each link. The plates have curved ends and overlap, so there is no opening between them in any position. They are made sufficiently heavy to withstand severe use and, owing to the design and materials used in construction, are extremely durable. There is little or no friction between the plates and the ground, the track being merely laid down and picked up again, one section at a time.

Fig. 8. Turning Six-throw Crankshafts for 120-horsepower Engine

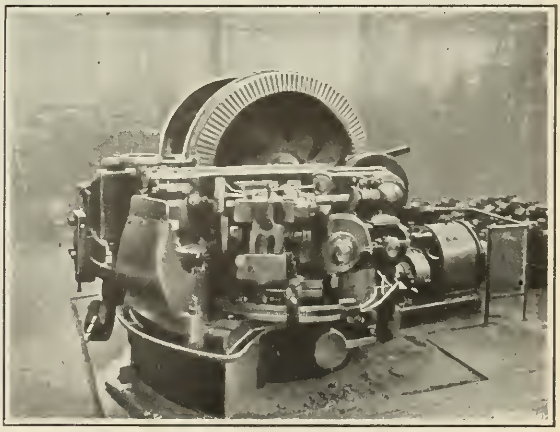


Fig. 9. Gleason Templet Gear Planer planing Bevel Main Drive Gears

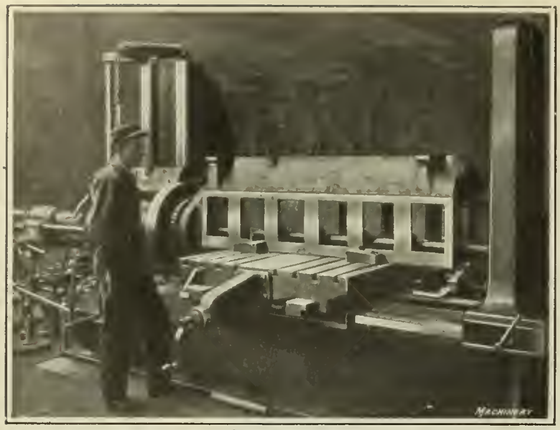


Fig. 10. Lucas Horizontal Milling and Boring Machine boring Bearing for Six-cylinder, 120-horsepower Crank-cases

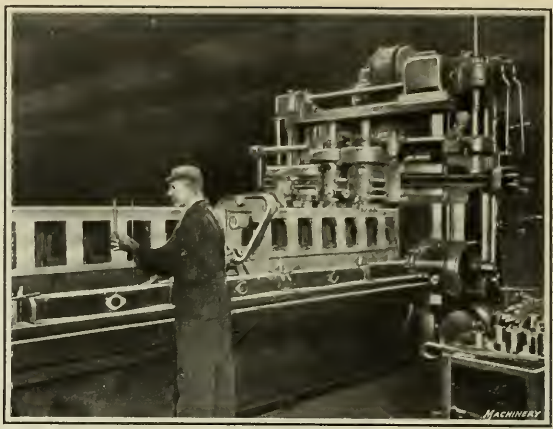


Fig. 11. Ingersoll Milling Machine working on Crank-case of Six-cylinder, 120-horsepower Engine and Radiator Headers simultaneously

The extraordinary capacity of the caterpillar to travel over soft ground is due in large part to the low unit pressure imposed on the supporting track. There are usually eight track links or shoes on each track of a 45-horsepower tractor in contact with the ground, so that with the standard 13-inch width tracks the total bearing surface is 2080 square inches and the ground pressure is only $6\frac{1}{4}$ pounds per square inch. For very soft ground, special 30-inch width tracks are provided, giving a total bearing surface of 4800 square inches and reducing the ground pressure to 3 pounds per square inch, or 432 pounds per square foot. This pressure is much less than the foot pressure of either man or horse; hence it is obvious that the heavy tractor can work over soft soils, and will pack the ground less than horses.

The load is transferred on each side of the 45-horsepower caterpillar to five truck wheels or rollers, spring-supported beneath the main frame. The driving sprocket is at the rear and small rollers are provided at the top for supporting the chain as it travels to the blank sprocket or idler at the forward end. The truck rollers have chilled faces and revolve on heat-treated shafts fitted with long phosphor-bronze bearings provided with grease cups. The hubs are counterbored to receive washers that are ground to size. The washers act as a thrust bearing and exclude dust, sand and dirt.

Fig. 12. Main Erecting Shop of the Holt Mfg. Co., Peoria, Ill.

Fig. 13. Babbitting Jig used for Bearings of 75-horsepower Tractors

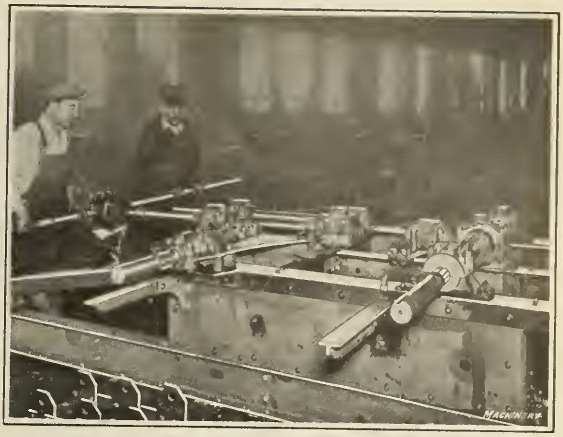


Fig. 14. Power Reamer for reaming Bearings on 75-horsepower Tractor

The gasoline tanks are made of galvanized sheet steel, rolled and spot-welded closely at the seams. The heads are formed with shallow flanges and set in place with the flanges outward in the spot-welded shell. The heads are closely spot-welded to the shell and then all seams are soldered. The spot-welding process of uniting the seams is rapid and effective; the spot-welds give the seam the necessary strength to hold and the solder seals the joints.

Fig. 15. Scraping Bearings for 75- and 120-horsepower Tractors

All tractors are subjected to a shop test of several hours' duration, running under brake load, to tune them up and get the bearings broken in. After the brake test, each tractor is taken out and driven about under heavy load until the operator is satisfied that it is fit for average road conditions.

Motor trucks and tractors are being widely used in the European war for hauling in place of horses. The movement of great guns and supply trains with the speed and rapidity accomplished would have been out of the question if the armies had to depend on horses. The extent to which mechanical traction is used is indicated in a manner by the fact that the Holt Mfg. Co. has sold over three thousand caterpillar tractors to the European countries, chiefly Great Britain and France. The advantages of motor-driven tractors are greater concentrated power than is possible with horses, freedom from disease, smaller number of men required to drive and care for them, capacity to travel continuously over rough roads, and possibility of being restored to use when damaged by shells.

Fig. 16. Assembling Tracks for 75-horsepower Tractors

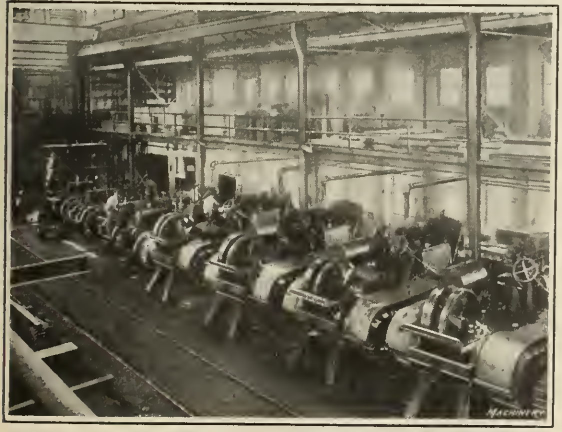


Fig. 17. Holt Caterpillar Tractors undergoing Shop Test on Blocks

Fig. 18. Seventy-five-horsepower Tractor, hauling Supply Train in Texas

Fig. 19. Seventy-five-horsepower Tractor crossing Deep Gully on Expedition

Fig. 20. Tractor at Bottom of Gully Ready to ascend Opposite Bank

Fig. 21. Holt Caterpillar having crossed Gully and ascended Opposite Bank

In view of the advantages of mechanical traction, particularly as shown in the European war, the United States Army has made an exhaustive study of the general problem of haulage and military supply trains. These tests began in 1915 and have steadily continued; they have included all the various field operations of the Quartermaster Corps, Engineers' Corps, light and heavy Field Artillery, Signal Corps, etc. Caterpillar tractors were found indispensable in building and maintaining roads for the motor truck trains during the expedition into Mexico in 1916; they are being used for hauling supply trains through the Big Bend District, Texas, where the troops guarding the Rio Grande boundary are from sixty to one hundred miles from the base of supply at Marfa. The Big Bend District consists principally of steep, rough mountain grades and desert roads. For the first time in the history of the United States Army, tractors were used in March, 1917, for hauling supplies in connection with marching troops. The initial trip was made from Fort Sam Houston to Laredo, a distance of 170 miles, where caterpillar 75-horsepower tractors accompanied the 37th Infantry, and after reaching Laredo, made the return to Fort Sam Houston with the 9th Infantry. It was necessary for the tractors at all times to maintain the speed of the marching regiment, so as to make camp each day on time with the regimental supplies. Although many severe road conditions were encountered, the tractors successfully met all requirements without mishap or breakage. Fig. 18 shows the supply train accompanying the 37th Infantry, consisting of fifteen Troy trailers, fourteen of which were of 1½ ton capacity and one of 3 tons capacity. The total weight of the trailers is 15 tons and of the cargo 30 tons, making a net hauling weight of 45 tons. One of the regular army escort wagons was later added, making the total hauling weight 53 tons. It would have required thirty army escort wagons with four mules each to handle this same tonnage.

Tractors are formidable in war, but they will achieve greater victories in times of peace. There is no doubt that agricultural work on large farms of the West and on many of the smaller farms of the East will eventually be done almost exclusively by means of tractors, and this, of course, applies also to agricultural work in all the countries of the world. The machine that has great pulling power, which can be used on soft soils and turn within its own length is at an advantage as compared with those requiring a large turning radius and firm soils to work efficiently, for purely agricultural purposes. For long overland hauling, especially where bad roads exist, the caterpillar tractor has proved capable of hauling at a lower cost per ton mile than by other methods. For road hauling where greater speed is required and comparatively small tractive power is needed by reason of uniformly good roads, the four-wheel motor truck has some advantage, but no wheel vehicle can follow the caterpillar type tractor through muddy, sandy and rough roads or over steep grades or where no roads of any kind exist. F. E. R.

* * *

The by-products of the 48,000 sawmills in the United States, in the form of sawdust, shavings, slabs, etc., is estimated at 36,000,000 cords a year. About one-half of this is used as fuel, but the remaining 18,000,000 cords is a source of danger to the mill and requires the expenditure of time and money for its disposal. As the production of this waste is unavoidable, the forest service is seeking some way of turning it to account.

INDUSTRIAL EXPOSITION AND EXPORT CONFERENCE

The first annual Industrial Exposition and Export Conference of the allied industries of the United States was held at the Eastern States Exposition Grounds, Springfield, Mass., June 23 to 30. The purpose of this exposition and conference is to develop export opportunities for American manufacturers and to discuss problems incident to the supplying of foreign markets with American goods.

Thursday, June 28, was "Metals Day," and at the morning session, presided over by Charles E. Hildreth, general manager of the National Machine Tool Builders' Association, the following papers were presented:

"After the War—What of Machinery Export?" by C. O. Smith, Export Manager, Norton Grinding Co., Worcester, Mass.

"American Tools in Foreign Markets," by Oren O. Gallup, New York City Export Manager, Simonds Mfg. Co., Fitchburg, Mass.

"Metal Fittings in Overseas Markets," by Adolph W. Gilbert, Chapman Valve Mfg. Co., Indian Orchard, Mass.

At this session MACHINERY'S motion picture, depicting the manufacture of 9.2-inch high-explosive howitzer shells, was shown, accompanied by an explanatory lecture by Chester L. Lucas of MACHINERY'S staff.

In connection with the exposition there were interesting exhibits by 160 concerns, among whom were the following:

Bilton Machine Tool Co., Bridgeport, Conn. Gear-cutting machinery, sensitive drill presses, milling machines, and riveting machines.

Cowan Truck Co., Holyoke, Mass. Elevating electric and hand trucks, transportation systems.

Fitchburg Grinding Machine Co., Fitchburg, Mass. Grinding machines.

Peter A. Frasse & Co., Inc., Hartford, Conn. Tubing, steel, tools and supplies.

C. G. Garrigus Machine Co., Bristol, Conn. Machine tools.

General Electric Co., Schenectady, N. Y. Electrical apparatus.

Graton & Knight Mfg. Co., Worcester, Mass. Leather belting, leather specialties.

Greenfield Tap & Die Corporation, Greenfield, Mass. Screw cutting tools and machinery; gages, reamers, etc.

Hampden Corundum Wheel Co., Springfield, Mass. Grinding wheels and polishing abrasives.

Holyoke Truck Co., Holyoke, Mass. Transfer and elevating trucks.

Napier Saw Works, Inc., Springfield, Mass. Metal cutting saws and sawing machines.

National Scale Co., Chicopee Falls, Mass. Counting machines, calling system, elevating trucks, sectional steel shelving.

Noble & Westbrook Mfg. Co., Hartford, Conn. Marking and filing machinery, grinders and buffing lathes, steel dies.

Norton Co., Worcester, Mass. Grinding wheels, grinding machinery.

Norton Grinding Co., Worcester, Mass. Grinding wheels, grinding machinery.

Reed-Prentice Co., Worcester, Mass. Lathes, drilling machines, vertical surface grinding machines.

Springfield Grinding Co., Chester, Mass. Grinding wheels.

L. S. Starrett Co., Athol, Mass. Fine mechanical tools.

Union Twist Drill Co., Athol, Mass. Twist drills, gear and milling cutters.

Van Norman Machine Tool Co., Springfield, Mass. Machine tools, milling machines and grinders.

Walworth Mfg. Co., Boston, Mass. Valves, fittings and tools for steam, water and gas.

Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass. Engine lathes and metal planers.

PYROMETERS OF THE PAST, PRESENT AND FUTURE[1]

A REVIEW OF DEVICES FOR MEASURING THE TEMPERATURE OF FURNACES, THEIR LIMITATIONS AND POSSIBLE FUTURE DEVELOPMENTS

As far as we know, the ancients, who baked excellent bricks and forged iron, measured temperature by a means still used today, but with ever-diminishing success—the eye. But at a very early date attempts were made to measure temperature by the expansion, contraction, or fusing points of clay. Even today the heat of brick and pottery kilns is determined by placing side by side, where they can be seen through a peep-hole, three cones with fusing points, for instance, of 2100, 2120 and 2140 degrees F. When the first cone softens and falls over, it indicates that a temperature of 2100 degrees F. has been attained, and the firing is stopped. If the other cones are still standing, the temperature has not exceeded 2120 degrees F. Unfortunately, though, the cones are affected by both time and temperature, and will soften or fall over at a higher temperature when heated up slowly for 100 hours than when heated to the softening point in an hour or two. They are not suitable for use in heat-treating furnaces for this reason, although attempts have been made to use them. However, some fusible salts have recently been brought out that seem to give reasonably satisfactory results. The capsules containing them are placed on a piece of steel in the furnace and the salts indicate, by melting, when a certain temperature has been attained.

Another of the early devices is the mercurial thermometer, with which everyone is familiar. For temperatures up to 600 degrees F., these have a vacuum above the mercury column. Thermometers graduated above 674 degrees must have the mercury column under pressure to prevent boiling; but 1000 degrees is about the limit for thermometers of this kind.

The first mechanical pyrometers depended on the difference in the expansion of iron and brass for their operation. This form of pyrometer has a tendency to change in its reading with time and temperature, due to the coefficient of expansion of the metals changing through continuous heating and cooling. This occasions frequent readjustments of the pointer to compensate for this error. Another early device was formed by placing a pipe in the furnace, through which water flowed under constant pressure. Thermometers at the inlet and outlet measured the temperature of the water, and the rise in temperature of the water was equivalent to a certain actual temperature in the furnace. The trouble with this device was that leaks occurred which it seemed impossible to prevent. The Siemens water pyrometer is used quite largely by armorplate manufacturers for heat-treatment. It consists of a copper ball, which is placed on the steel in the furnace and left until it has fully attained the temperature, when it is quickly removed and dropped into a vessel containing a thermometer and a measured quantity of pure water. The rise in temperature of the thermometer in the water is read off in actual temperature degrees on a corresponding scale. An accuracy within about 25 degrees F. is usually attained with this instrument.

There have also been developed a number of pyrometers that compare either a light or different colors with the piece of steel in the furnace. The trouble with all of these is that no two operators get the same results. Resistance thermometers operate on the principle that the electrical resistance of metals changes with the temperature. This instrument is an exceedingly accurate one for measuring low temperatures, but is hardly to be recommended for high temperature service.

Thermo-electric Pyrometers

For measuring temperatures above 1000 degrees F., the thermo-electric method has come to be by far the most largely used. A thermo-electric pyrometer consists of a thermo-couple, a measuring device, and the wires connecting the thermocouple and the measuring device. If two pieces of wire of different metals are joined at one end and the junction is heated, a small current of electricity will be generated. At 2000 degrees F., a couple formed of iron and copper-nickel wires will generate 50 millivolts. For measuring temperatures up to 200 degrees F., a thermo-couple of bismuth and antimony is best; for temperatures up to 1000 degrees F., a satisfactory thermo-couple consists of one iron wire and one 60 per cent nickel and 40 per cent copper; for temperatures as high as 1800 degrees F., a very satisfactory base-metal thermo-couple is one wire of 90 per cent nickel and 10 per cent chromium and the other wire of 98 per cent nickel and 2 per cent aluminum. For constant service above this, a thermocouple, one wire of which is chemically pure platinum and the other 90 per cent platinum and 10 per cent rhodium, is recommended.

Thermo-couples of base metal are manufactured with wires from 0.01 inch up to 0.25 inch diameter. Some particular tests require thermo-couple wires of exceedingly small diameter to secure sensitiveness and quick readings. There is no doubt but that heavier wires forming the thermo-couple will increase the life where a base-metal thermo-couple is in constant service at temperatures up to 1600 or 1800 degrees F. While a heavier thermo-couple slightly increases the lag, this is not noticeable in heat-treating furnaces.

If after a base-metal thermo-couple has been used for some time another couple is made from the same wires, the voltage produced might vary as much as 50 degrees at a temperature of 1400 degrees F. Thermo-couples of nickel-chromium wire will vary as much as 30 degrees F., that is, 15 degrees plus or minus, depending on the particular coils from which the wire was cut.

The wires forming a thermo-couple must be insulated from each other throughout their length. A common method is to wrap base-metal thermo-couples with asbestos and paint the asbestos winding with a solution of sodium silicate; another method is to fit lava or porcelain beads over the thermo-couple wire. For the platinum thermo-couple, the insulation must be of porcelain or high-grade fireclay, free from impurities.

The life of a thermo-couple installed in a furnace largely depends on its protecting tube. For temperatures up to 1200 degrees F., a high-grade wrought-iron tube gives satisfactory results. Calorizing, a process recently developed by the General Electric Co., which impregnates the pipe with an aluminum oxide, will increase the life of the pipe about three times when used at temperatures around 1400 degrees F. Tubes of nickel-chromium give excellent results for temperatures as high as 1800 degrees, and they are to be recommended for the protection of base-metal thermo-couples where the temperature exceeds 1200 degrees. Their cost is many times higher than the ordinary wrought-iron pipe and about four times as much as calorized pipe, but their increased life would justify the increased first cost. Platinum thermo-couples must always be protected with a tube that is impervious to gases, such as porcelain, quartz, or alundum.

It is one of the properties of a thermo-couple that the voltage which it generates is dependent on the difference in the temperature of the hot junction and the cold junction, which is the point at which the alloy wires of the thermocouple join the copper leads of the instrument. It is therefore particularly important that the cold junction be maintained at a constant temperature. In recent years, it has been customary to run compensating leads of the same material as the thermo-couple to a distant point, where the temperature is uniform, instead of having the cold junction just outside the furnace wall, where it might vary several hundred degrees. These compensating leads, in duplex form with asbestos insulation, can be run into a pipe driven into the ground, ten or fifteen feet, where the temperature will remain constant within five degrees, winter or summer. Where it is impossible to place the cold junction in the ground, on account of the furnaces being on an upper floor of a building, a compensation

[1]Abstract of a paper by Richard P. Brown, read before the Steel Treating Research Club of Detroit, Mich.

box can be used, consisting of a lamp and thermostat, which will maintain the temperature constant within two degrees.

Measuring Voltage Produced by Thermo-couple

There are two methods of measuring the voltage produced by a thermo-couple, the millivoltmeter method and the potentiometer method. In the former, the instrument consists of a permanent magnet with its pole pieces, in the field of which a copper-wound coil swings in jeweled bearings. The millivoltmeter reads the temperature across the scale and is calibrated in actual temperature degrees. It indicates the temperature from zero to the maximum scale range and relies entirely on the voltage of the thermo-couple for its operation. No outside sources of current are necessary.

In the potentiometer method, the electromotive force produced by the thermo-couple is measured by opposing to it a known variable electromotive force, usually that of a dry cell contained in the instrument, so that when a balance is reached no current flows. A galvanometer is used to indicate the point at which no current is flowing, and the pointer on the galvanometer then indicates zero as the voltage of the thermo-couple is opposed to the dry cell. The advantages of the potentiometer method of measuring temperature are its extreme precision and its independence of resistance changes throughout the thermo-couple circuit. Its disadvantages are that it is not direct reading and some outside source of current is necessary.

Radiation Pyrometers

The radiation pyrometer is a development of the thermo-electric pyrometer. Instead of placing the thermo-couple inside the furnace, where the temperature is so high as to destroy it, it is placed in the back of a tube in front of a mirror. The rays of heat from the furnace enter the tube and, striking the mirror, are brought to a focus on the thermo-couple junction, which attains a heat of only 200 or 300 degrees. It is possible to secure an accuracy within one to two per cent with this instrument, if the instructions for its use are properly carried out. It is not recommended for service where a thermo-electric pyrometer with a base-metal or platinum thermo-couple can be used.

Methods of Standardizing Pyrometers

It is essential, if accurate results are to be secured from pyrometers, that they be restandardized at frequent intervals. The frequency depends on the precision necessary in the work and the equipment available. Some plants check their thermo-couples once a week; it should be done at least once a month. This checking can be satisfactorily accomplished by maintaining a standard platinum thermo-couple and using an electric furnace that is not less than 10 inches deep, so that a base-metal thermo-couple can project at least 6 or 8 inches inside. The base-metal and standard thermo-couples should be tied together with asbestos string with the junctions almost touching each other. Thermo-couples should never be tested in their protecting pipe. A base-metal thermo-couple should not be tested in a furnace with an insertion of less than 6 inches, for the cross-section of the thermo-couple wires is large and they conduct the heat from the furnace. The temperature of an electric furnace should be maintained constant for at least fifteen minutes before a reading is taken, and the tests should preferably be made at the working temperature of the thermo-couple. If the thermo-couple under test reads low and has no adjustable resistance, it must be junked. If it is furnished with a resistance for adjustment purposes, this adjustment can be easily made with a soldering iron.

The freezing point of pure salt is reliable for testing thermo-couples or the complete pyrometer. The thermo-couple should be inserted in a small crucible containing pure salt (ordinary table salt is satisfactory), heated to about 1600 degrees F. and then allowed to cool. At the freezing point of the salt, which will be indicated by the temperature remaining reasonably constant for four or five minutes, the pyrometer should read 1474 degrees. The melting point of a number of metals may also be used. The melting points of the metals most generally used for this purpose are: tin, 450 degrees F.; zinc, 787 degrees; silver, 1761 degrees; and gold, 1945 degrees.

The Future for Pyrometry

It would seem that the greatest development work in temperature-measuring instruments will be in the perfection of optical pyrometers, resistance thermometers, and thermo-electric pyrometers. There is a field for a high-grade optical pyrometer that can be used by any number of operators, all of whom can secure the same results from the instrument. Resistance thermometry will continue to be limited to low temperatures unless some more suitable metal than nickel can be used to form the bulbs. In thermo-electric pyrometry, it is possible to develop better materials for base-metal thermo-couples; the insulation or protecting tube will be difficult to improve upon. The direct-reading millivoltmeter and the potentiometer methods of temperature measurement will doubtless be improved.

However, the greatest future in pyrometry will be along the line of automatic temperature control. There is already an instrument that automatically controls the temperature of an electric furnace, maintaining it constant within 10 degrees F. In connection with this instrument, there are two lights which indicate whether the temperature is high or low. We can place a neutral point, 10 or 20 degrees in width, between the two contact points operating these lights, so that both lights will be out when the temperature is correct and the red or blue light will flash to indicate that the temperature is too high or too low. If a third contact is put in the instrument for this neutral point, it will cause a white light to glow when the temperature is correct. It is much easier to instruct a fireman to keep the white light burning and the other lights out than to get him to maintain 1380 degrees on the pyrometer. He can see the lights from some distance, and these are easily understood by him. It is only a question of time when a switching device will permit one instrument to operate the signal lights at a number of furnaces.

One of the greatest difficulties experienced by pyrometer manufacturers is to induce the user of these instruments to install them properly. Frequently this is left to someone who has absolutely no knowledge of pyrometers, and the instructions of the manufacturer are not carried out in a satisfactory manner. Recently, the service man of one pyrometer company found pyrometer equipment giving incorrect readings because it had been wired up throughout with small diameter uninsulated iron wire.

* * *

MILLING AND GRINDING

The use of milling machines and grinding machines has increased greatly during the past ten years, and these machines are now regarded generally as standard machine tool equipment. There is little question of the superiority of the milling machine over the planer or shaper for manufacturing parts in large quantities. Nor can the place of the grinding machine as a follower of the lathe for finishing cylindrical surfaces be longer denied. But notwithstanding the great increase in the use of these machine tools, the lathe is still the recognized leader of all. More lathes are built and sold than any other machine tool except drilling machines. Planers have their place in the machine shop and will always be used for jobbing and repair work and probably for planing the working surfaces of machines that must be highly accurate. The shaper and slotter have their recognized places also. The point to be made is that the development of any type of machine tool does not necessarily, if ever, result in displacing another; it may, in fact, make a broader and better market for all.

* * *

FOUNDRY AND MACHINE SHOP EQUIPMENT AND SUPPLIES EXHIBIT

The twelfth annual exhibit of foundry and machine shop equipment and supplies will be held in the Mechanics Bldg., Boston, Mass., under the auspices of the American Foundrymen's Association, September 25 to 28, inclusive. Copies of the rules and regulations may be obtained from C. E. Hoyt, manager of exhibits, 123 W. Madison St., Chicago, Ill.

MACHINE-CUT ELLIPTICAL GEARS[1]

LAYING OUT AND MACHINING ELLIPTIC AND OVAL GEARS

BY REGINALD TRAUTSCHOLD[2]

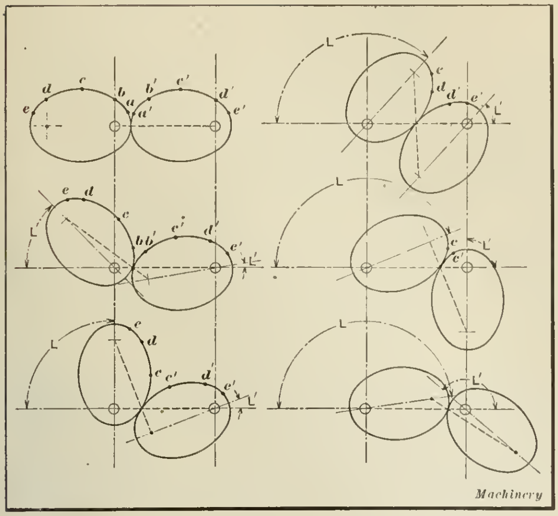


Fig. 1. Rolling Contact of Ellipses with Bore at Focus

THE correct proportioning of elliptic or elliptical gearing presents one of the most intricate problems confronting the gear designer, but, fortunately, it need not present the same difficulties to the machinist if the work is correctly laid out for him in the drafting-room. To cut elliptic gears successfully requires a high degree of skill and careful workmanship on the part of the machine operator, but the real problem is one of design. This is fortunate, for it permits the derivation of reliable formulas which, though they necessitate considerable accurate figuring on the part of the designer, greatly simplify the calculations and enable the problem to be put to the operator as a definite and concrete task: one that requires, in its execution, simply careful workmanship and proper attention to the adjustments of a comparatively simple fixture.

Elliptic gearing furnishes a comparatively cheap, efficient and positive mechanism for imparting a quick-return motion to the ram of shapers, planers and a large variety of machine tools. The variation in speed of these gears is from a maximum to a minimum, the bore being located at one of the foci of the ellipse. So-called "elliptical" gears with the bore at the center of the gear are also employed. These have not a true elliptic outline, but their circumference is appreciably greater than is that of a true ellipse of similar major and minor axes. To differentiate it from the one of true elliptic outline, this second variety of gear may be arbitrarily designated as an "oval gear"; while the term elliptic gear may be taken to designate a gear of true elliptic form.

[1] For previous articles on the design of gearing, see "Epicyclic Gear Trains" in the July, 1917, number of MACHINERY, and articles there referred to.
[2] Address: 39 Charles St., New York City.

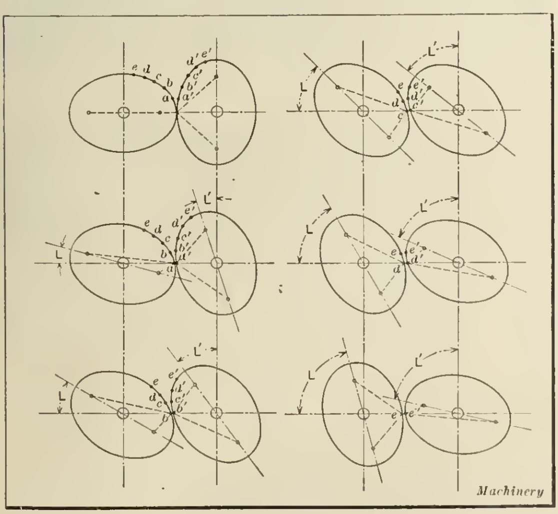


Fig. 2. Non-contact of Ellipses with Bore at Center

The rolling actions of the two forms of mountings, those with the bore at the foci and those with the bore at the center, are depicted in Figs. 1 and 2. In the case of ellipses with the bore at one of the foci, any point on the circumference of one of the ellipses, *a*, *b*, *c*, *d*, *e*, will be in contact with any similarly located point on the circumference of the other ellipse, *a'*, *b'*, *c'*, *d'*, *e'*, in the plane of the bores and a line connecting the stationary foci of the two ellipses will lie in this plane and intersect a plane tangent to both ellipses at the point of contact. In the case of the ellipses with the bore at the center, points on the circumference of one of the ellipses, *a*, *b*, *c*, *d*, *e*, will not be in contact with similarly located points on the circumference of the other ellipse, *a'*, *b'*, *c'*, *d'*, *e'*, on the bore plane, the centers of the bores being fixed as in the other instance, but will be separated by an amount depending on the proportions of the ellipses. Only when the major and minor axes of the ellipses are at right angles can the ellipses be in intimate contact. To secure contact at all points, the elliptic outlines must be increased by an increment that will fill in the gap between the ellipses; and in order that the two figures may be similar in outline, the increment should be the same for each ellipse.

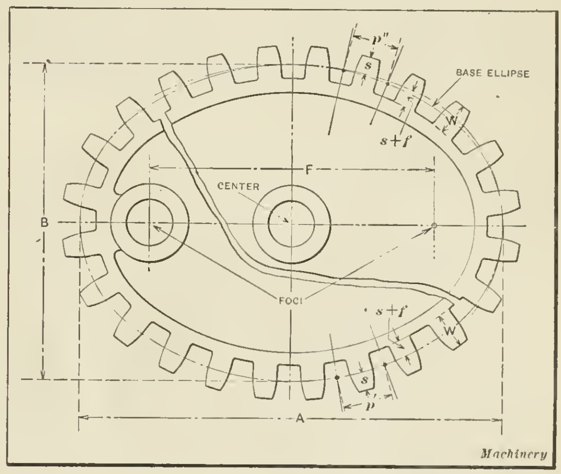


Fig. 3. Elliptic and Oval Gear Diagrams

The similarity between elliptic and oval gears lies only in the fact that they are both developed from ellipses. In one case the ellipse is the final outline; and in the other, the ellipse has to be modified by an increase in the length of curve included between the two axes' planes in each of the four quadrants. The lengths of the axes are not changed, nor should the degree of curvature at points of contact be altered; the variation in curvature is simply limited to sections between the required points of contact. Elliptic and oval gear sections are illustrated in Fig. 3 in a manner that brings out their similarity in general appearance as well as their difference in pitch outlines.

The Ellipse

The basic form of either the elliptic or the oval gear is the ellipse, so the characteristics of this figure should be clearly

understood before taking up the derivation of working formulas. An ellipse is shown in Fig. 4. Its governing peculiarity is that the sum of the distances of any point P on the circumference from the two foci is constant, and the normal passing through such point bisects the angle included between lines drawn from the point to the foci. The angle between the tangent to the point and one of the axes of the ellipse is equal to the angle between the normal to the point and the other axis of the ellipse. The distance between the two foci, the "focus distance," is equal to the square root of the difference of the squares of the major and minor axes. These definite relations establish the equation of the ellipse, which, though simple, necessitates an application of analytical geometry and calculus to establish the location of any particular point on the circumference, the angularity of tangents, etc. This involves much calculation that, from a practical point of view, is quite unnecessary.

The curvature of an ellipse really decreases in each quadrant, from the major to the minor axis, but for all practical purposes, there are but two degrees of curvature in each quadrant of any elliptic gear encountered in practice, or that is capable of practical use, so that a close approximation of a true ellipse may be drawn with circular arcs of but two radii. These radii, which, for convenience, will be designated as major and minor, are equal to the major axis minus one-half the minor axis and to three-quarters the minor axis minus one-quarter the major axis. The first is the radius of the curve straddling the minor axis, and the second is the radius of the curve straddling the major axis. In workable ellipses, such curves become tangent to each other at definite points, so that the length of the major-radius curve is an arc included by an angle of 73 degrees, 44 minutes, as shown in Fig. 4, and the minor-radius curve is an arc included by an angle of 106 degrees, 16 minutes. These angles may be arbitrarily taken as the same for all ellipses, irrespective of the axes' lengths.

Dimensions Required by the Machinist

Fig. 5 depicts the method of cutting both elliptic and oval gears, the rotary cutter being tangent to the pitch line at mid-tooth space. The angle of tangency, the angle included between the center line of the rotary cutter and the major axis, is the same for either type of gear, but the location of the bore in respect to the center line of the cutter differs. If the outlines of the two varieties of gears were similar, the difference in both vertical and horizontal coordinates would be controlled by the distance from the focus to the center of the gear. In fact, much of the trouble encountered in cutting oval gears with the bore at the center comes from just this particular point. Oval gears with the bore at the center are not elliptic in outline and cannot be successfully cut with settings that would be satisfactory were it not necessary to modify the elliptic form in order that the gears may roll together in intimate contact.

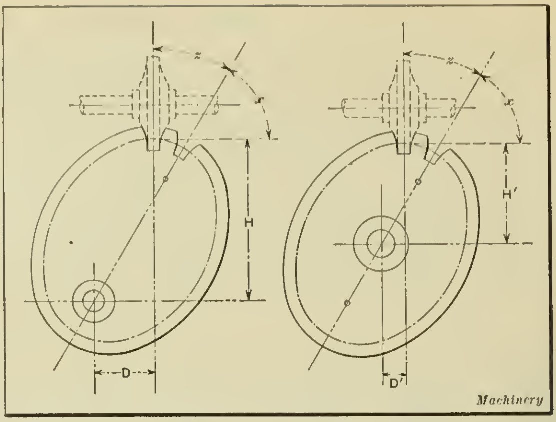


Fig. 5. Machining Elliptic and Oval Gears

Laying Out Elliptic Gears

The elliptic gear is the simpler variety to design, as an oval gear must first be proportioned as if it were truly elliptic in outline and then modified by the necessary increments. Both varieties are frequently laid out to a suitable scale and the required dimensions scaled; the "lay-out method" and a certain dependence on graphic depiction is a material aid even when employing the more accurate method of calculation of the necessary angles and dimensions.

The pitch outline of an elliptic gear is shown in Fig. 6. This may be drawn by the common "gardener's ellipse" method or by the use of the circular arcs, as has been described. The pitch circumference is then divided into as many equal sections as there are teeth in the gear, the points of division locating the centers of the tooth spaces. Preferably, the number of teeth in an elliptic gear should be odd, so that a tooth space at one end of the gear is opposite a tooth at the other end, thereby permitting both gears of a pair to be identical. If the number of teeth is even, a double set of calculations becomes necessary, as the tooth spaces of one of a pair must coincide with the teeth of the mating gear.

The coordinates of the center of the tooth spaces, with reference to the stationary focus, are readily calculated for an ellipse laid out with circular arcs, and are, for all practical purposes, the same as those of similar points about a true ellipse. The distance of each tooth-space center from the stationary focus is then readily obtained, as it is the length of the hypotenuse of a right-angle triangle having for its other sides the coordinates of the tooth-space center with respect to the stationary focus. These coordinate dimensions are the horizontal and vertical settings required by the machinist, and the angular setting of the blank is the angle included between the tangent at mid-tooth space and the major axis of the ellipse.

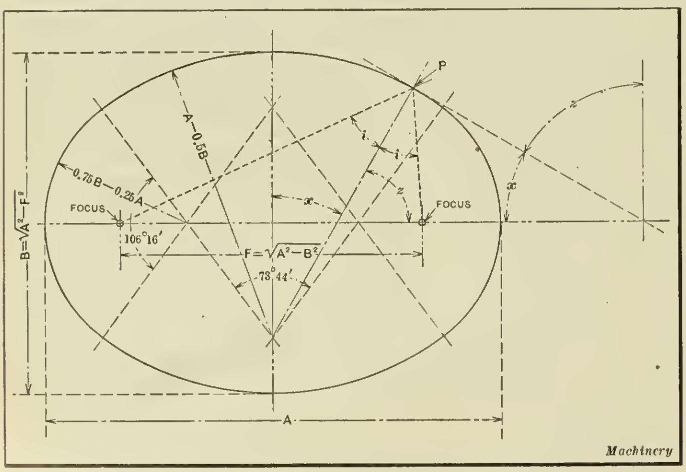


Fig. 4. The Ellipse

Laying Out Oval Gears

Oval gears should have an even number of teeth, so that but one set of calculations is necessary, and the teeth should be arranged so that they do not come on the axis of the ellipse, but so that the transverse pitch line on the profile of a tooth falls on the axes of the gear, as shown in Fig. 7. This illustration depicts the basic oval outline of the gear, not its final pitch outline.

The coordinates of the tooth-space centers, with reference to the center of the gear, are found in a manner similar to that employed for elliptic gears. The distance of each tooth-space center from the center of the gear on the base ellipse is then found and normals through each of the tooth-space centers are drawn. The horizontal setting D' is found directly from the triangle formed by the line connecting the center tooth space on the ellipse and the rectangular

coordinates of such point about the center of the gear. The ordinate of the point is also calculated, though it is not equal to the vertical setting, which is controlled by the amount of increment added to the ellipse at each tooth space.

The distance between shafts of mating oval gears is constant and equal to one-half the sum of the major and minor axes of the gear, so that if the sum of the distances from the tooth-space center of conjugate tooth spaces is made equal to the distance between shafts, constant contact is secured. The proper total increment required in order to secure such intimate contact between mating gears is the difference between the sum of the distances of center tooth points on the ellipse of conjugate tooth spaces and the distance between the shafts of the respective gears. Half of this total increment added to each gear will keep the gears similar in outline. The increment is not added to the oval outline normally, but so that the distance from the pitch center of the tooth space on the mid-tooth space normal to the center of the gear is equal to the distance from the center of the gear to the center of the tooth space on the ellipse, plus half the total increment required for intimate contact, see Fig. 8. A smooth curve passing through the points thus located on the tooth space normals gives the required pitch outline of the gear. To this must be added, in the gear blank, sufficient metal to accommodate the addendum of the teeth, etc. The correct vertical setting is then obtained by direct proportion, the same relationship existing between the distance of the mid-tooth space point on the ellipse and this same dimension plus the necessary increment as exists between the ordinate of the center tooth space on the ellipse and the correct vertical setting.

Notation for Elliptical Gearing

Major axis (pitch)	A
Minor axis (pitch)	B
Focus distance, distance between foci	F
Pitch circumference of ellipse	C
Quick-return ratio of elliptic gears	R
Number of teeth	N
Circular pitch of elliptic gears	p'
Major radius for ellipse	r'
Minor radius for ellipse	r''
Angular pitch of major radius segment	a
Angular pitch of minor radius segment	a'
Angle included between tooth-space tangents and major axis	x
Angularity of ratchet index	z
Ordinate of tooth-space center on ellipse	h'
Abscissa of tooth-space center on ellipse	v'
Distance between tooth-space center on ellipse and focus axis	Y
Angle included between Y and major axis	y
Angle included between Y and tooth-space tangent	w
Vertical setting for machining fixture	H
Horizontal setting for machining fixture	D
Effective circular pitch of oval gears	p''
Distance between tooth-space center on ellipse and gear center	Y''
Sum of conjugate Y''	X
Correction increment	j
Distance between tooth-space pitch center and gear center	Y'
Angle included between Y'' and major axis	y'
Angle included between Y'' and tooth-space tangent	w'
Vertical setting on ellipse	H''
Vertical setting for machining fixture	H'
Horizontal setting for machining fixture	D'

Formulas for Elliptic and Oval Gears

$$B = \sqrt{A^2 - F^2} \quad (1) \qquad F = \frac{A(R-1)}{R+1} \quad (2)$$

$$R = \frac{A+F}{A-F} \quad (3) \qquad r' = A - 0.5B \quad (4)$$

$$r'' = 0.75B - 0.25A \quad (5) \qquad C = 1.6464A + 1.4952B \quad (6)$$

$$p' = \frac{C}{N} \quad (7) \qquad a = \frac{57.295p'}{r'} \quad (8) \qquad a' = \frac{57.295p'}{r''} \quad (9)$$

$$h' = r'' \sin z \quad \text{(in minor-radius segments)} \quad (10)$$

$$h' = r' \cos x - r' + 0.5B \quad \text{(in major-radius segments)} \quad (10a)$$

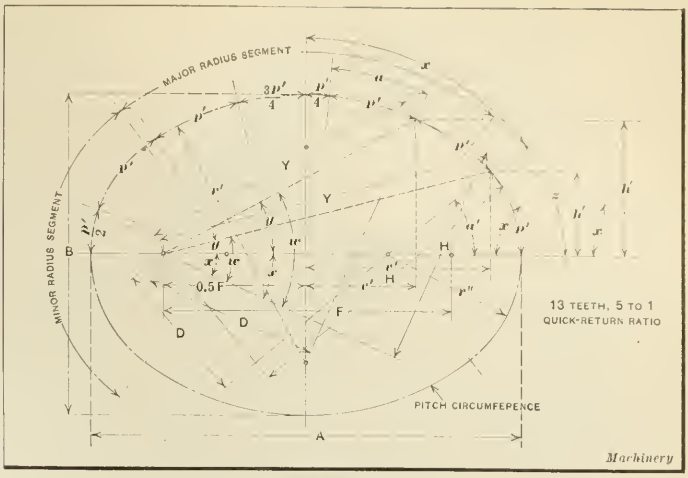


Fig. 6. Elliptic Gear Diagram

$$v' = r'' \cos z + 0.5A - r'' \quad \text{(in minor-radius segments)} \quad (11)$$

$$v' = r' \sin x \quad \text{(in major-radius segments)} \quad (11a)$$

$$Y = \sqrt{h'^2 + (\pm 0.5F \pm v')^2} \quad (12) \qquad \tan y = \frac{h'}{\pm 0.5F \pm v'} \quad (13)$$

$$w = y \pm x \quad (14) \qquad H = Y \sin w \quad (15)$$

$$D = Y \cos w \quad (16) \qquad p'' = \frac{C}{N} \quad (17)$$

$$Y'' = \sqrt{h'^2 + v'^2} \quad (18) \qquad j = 0.5(0.5A + 0.5B - X) \quad (19)$$

$$Y' = Y'' + j \quad (20) \qquad \tan y' = \frac{h'}{v'} \quad (21) \qquad w' = y' + x \quad (22)$$

$$H'' = r'' + (0.5A - r'') \cos (90 - x) \quad \text{(in minor-radius segments)} \quad (23)$$

$$H'' = Y'' \sin w' \quad \text{(in major-radius segments)} \quad (23a)$$

$$H' = \frac{H''Y'}{Y''} \quad (24)$$

$$D' = (0.5A - r'') \sin (90 - x) \quad \text{(in minor-radius segments)} \quad (25)$$

$$D' = Y'' \cos w' \quad \text{(in major-radius segments)} \quad (25a)$$

Discussion of Formulas

The relationships existing between the major axis, the minor axis, and the focus distance are the ordinary characteristics common to the ellipse. The quick-return ratio of elliptic gears is the ratio between the maximum and minimum distances of the pitch circumference from the stationary, or bore, focus. No such ratio exists for oval gears, as the distance between the shafts of the gears with the central bore is equal to half the sum of the major and the minor axes. Two speed changes occur during a complete revolution of the gears in such an arrangement; one is measured by the ratio of the major axis to the minor axis, and the other by the ratio of the minor axis to the major axis.

The major and minor radii of the ellipse are the radii of circular arcs straddling the minor and the major axes, respectively; the former contains 73 degrees, 44 minutes, and the latter 106 degrees, 16 minutes. The sum of the lengths of the two major-radius segments and the two minor-radius segments equals the circumference of the ellipse. This divided by the number of teeth gives the circular pitch for elliptic gears.

The circular pitch multiplied by 360 degrees and the product divided by the circumference of a circle having a radius equal to the major radius of the ellipse gives the angular pitch in the major-radius segments. The same product divided by the circumference of a circle having a radius equal to the minor radius of the ellipse gives the angular pitch in the minor-radius segments.

To obtain the ordinate of the tooth-space center on the pitch ellipse necessitates two formulas: one for cases where the tooth-space center falls within the minor-radius segments, and

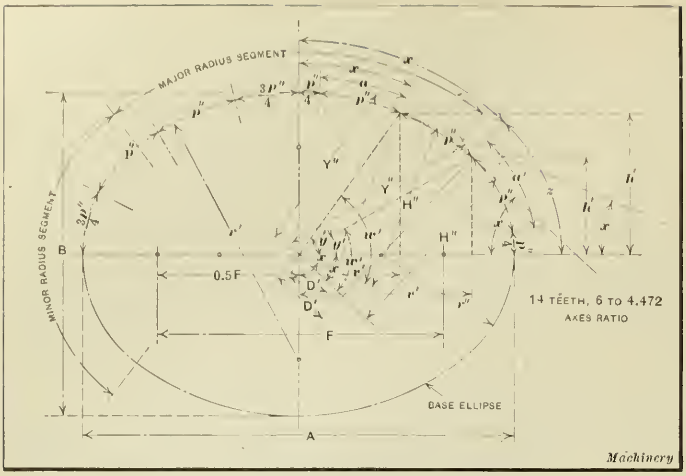


Fig. 7. Base Ellipse for Oval Gear

the other for points that fall within the major-radius segments. In the former, the ordinates are equal to the minor radius times the sine of the angle included between the normal passing through the tooth-space center and the major axis. Within the major-radius segments, the ordinates are measured by the product of the major radius and the cosine of the angle included between the normal passing through the tooth-space center and the minor axis, minus the difference between the major radius and one-half the minor axis. This value, by which the product of the major radius and the cosine of the angle is reduced, is the distance from the major axis to the center of the major radius.

The abscissa of the tooth-space center on the pitch ellipse is found in a similar manner, two formulas being required. For centers within the minor-radius segments, the abscissas are equal to the product of the minor radius and the cosine of the angle included between the normal passing through the tooth-space center and the major axes, plus the difference between half the major axis and the minor radius. Within the major-radius segments, the abscissas are equal to the major radius multiplied by the sine of the angle included between the normal passing through the tooth-space center and the minor axis.

The distance between the tooth-space center on the ellipse and the stationary focus in elliptic gears is equal to the square root of the sum of the square of the ordinate plus the square of the distance of the projected center on the major axis from the stationary focus. When the projection of the center on the major axis falls on the farther side of the minor axis from that on which the stationary focus is located, this distance is equal to one-half the focus distance plus the abscissa; when between the near center of the minor radius and the minor axis, it is equal to the focus distance minus the abscissa; and when between the near minor radius center and the near end of the major axis, it is equal to the abscissa minus half the focus distance.

The tangent of the angle included between Y and the major axis is equal to the ordinate of the tooth-space center divided by the distance of the projected center on the major axis from the stationary focus. This angle plus or minus the angle included between the tangent to the tooth-space center and the major axis equals the angle included between Y and the tooth-space tangent. When the tooth-space center lies on the far side of the minor axis, the angle included between Y and the tooth-space tangent is the sum of the two smaller angles; when on the near side, it is equal to the difference of the two angles.

The vertical setting for the machining fixture, the distance between the plane of the rotary cutter and a parallel plane passing through the stationary focus of the gear, is equal to the distance between the tooth-space center and the stationary focus multiplied by the sine of the angle included between Y and the tooth-space tangent; while the horizontal setting for the machining fixture is equal to the product of this same dimension by the cosine of the angle.

The effective circular pitch of oval gears corresponds to the circular pitch of elliptic gears and is found in the same manner; namely, by dividing the pitch circumference of the base ellipse by the number of teeth in the gear.

The distance between the center of the tooth space on the ellipse and the central bore of the gear is equal to the square root of the sum of the squares of the ordinate and abscissa dimensions of the tooth-space center on the base ellipse.

The correction increment is equal to half the sum of the major and minor axes of the gear, minus the sum of the distances of conjugate tooth-space centers on the base ellipse from the center of the gear divided by 2. Conjugate tooth spaces are a tooth space on one gear and the space opposite the tooth on the mating gear that will engage the tooth space on the first gear. For instance, in a pair of mating oval gears with fourteen teeth, the conjugate tooth space of the first tooth space on the driving gear is the fourth tooth space on the driven gear, counting tooth spaces from similar points on the two gears. Similarly, the conjugate tooth space for the second tooth space on the driver is the third on the driven gear, and for the remainder of the tooth spaces the conjugates are the third and second, fourth and first, fifth and fourteenth, sixth and thirteenth, seventh and twelfth, eighth and eleventh, ninth and tenth, tenth and ninth, and so forth.

The correction increment added to the distance between the tooth-space center on the base ellipse and the central bore gives the distance of the actual pitch center of the tooth space from the center of the gear.

The tangent of the angle included between the line connecting the tooth-space center on the base ellipse with the center of the gear and the major axis is equal to the ordinate dimension of the point on the base ellipse divided by its abscissa dimension. This angle plus the angle included between the tooth-space normal and the minor axis (the complement of the angle included between the tooth-space normal and the major axis) equals the angle included between Y'' and the tooth-space tangent on the base ellipse.

The vertical setting on the base ellipse, when the normal of the tooth space crosses the minor-radius segment of the base ellipse, is equal to the minor radius plus the product of the cosine of the complement of the angle included between the

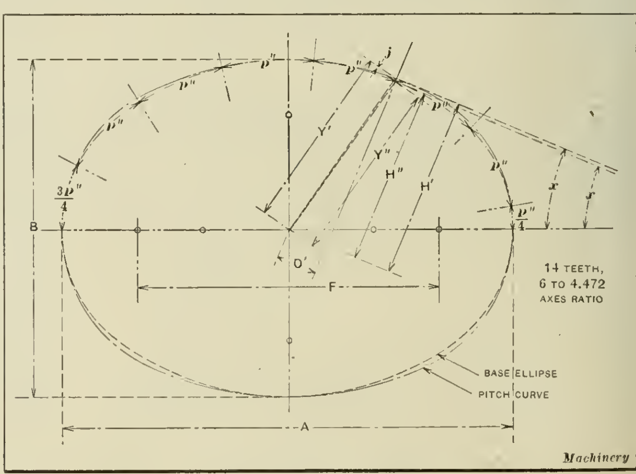


Fig. 8. Oval Gear Diagram

tooth-space tangent and the major axis by the difference between half the major axis and the minor radius of the base ellipse. When the tooth-space normal crosses the major-radius segment, the vertical setting on the base ellipse is equal to the product of Y'' by the sine of the angle included between Y'' and the tooth-space tangent.

The vertical setting on the base ellipse multiplied by the quotient of Y' divided by Y'' equals the vertical setting for the machining fixture. This dimension is the distance between a tangent to the pitch curve at the tooth-space normal and a parallel line passing through the central bore of the gear.

The horizontal setting for the machining fixture, in minor-radius segments, is equal to the product of the sine of the complement of the angle included between the tooth-space tangent and the major axis by the difference between half the major axis and the minor radius of the base ellipse. The horizontal setting for tooth spaces crossing the major-radius segment is equal to the product of Y'' by the cosine of the angle included between Y'' and the tooth-space tangent. For tooth spaces lying to the right of the gear center, the horizontal settings are also measured to the right; and for tooth spaces lying to the left of the gear center, the horizontal settings are in the same direction.

Example 1—Required, a pair of elliptic gears; 6-inch centers, 5 to 1 quick-return motion, 13 teeth; bore at focus.

$$F = \frac{6(5-1)}{5+1} = 4 \text{ inches} \quad (2)$$

$$B = \sqrt{36-16} = 4.472 \text{ inches} \quad (1)$$

$$C = 1.6464 \times 6 + 1.4952 \times 4.472 = 16.5649 \text{ inches} \quad (6)$$

$$p' = \frac{16.5649}{13} = 1.2742 \text{ inch} \quad (7)$$

$$r' = 6 - 0.5 \times 4.472 = 3.764 \text{ inches} \quad (4)$$

$$r'' = 0.75 \times 4.472 - 0.25 \times 6 = 1.854 \text{ inch} \quad (5)$$

$$a = \frac{57.295 \times 1.2742}{3.764} = 19.396 \text{ degrees} \quad (8)$$

$$a' = \frac{57.295 \times 1.2742}{1.854} = 39.377 \text{ degrees} \quad (9)$$

Tooth-space Number	x, Degrees	z, Degrees	Tooth-space Number	x, Degrees	z, Degrees
1	90.000	0.000	8	70.312	199.688
2	50.623	39.377	9	33.943	236.057
3	24.245	65.755	10	14.547	255.453
4	4.849	85.151	11	4.849	274.849
5	14.547	104.547	12	24.245	294.245
6	33.943	123.943	13	50.623	320.623
7	70.312	160.312			

Tooth-space Number		
1	$h' = 0.000$ inch	
2	$h' = 1.854 \times 0.63451 = 1.175$ inch	(10)
3	$h' = 3.764 \times 0.91176 - 1.528 = 1.902$ inch	(10a)
4	$h' = 3.764 \times 0.99642 - 1.528 = 2.227$ inches	(10a)
5	$h' = 3.764 \times 0.96793 - 1.528 = 2.114$ inches	(10a)
6	$h' = 3.764 \times 0.82960 - 1.528 = 1.592$ inch	(10a)
7	$h' = 1.854 \times 0.33682 = 0.625$ inch	(10)
8	$h' = 0.625$ inch	
9	$h' = 1.592$ inch	
10	$h' = 2.114$ inches	
11	$h' = 2.227$ inches	
12	$h' = 1.902$ inch	
13	$h' = 1.175$ inch	

Tooth-space Number		
1	$v' = 3.000$ inches	
2	$v' = 1.854 \times 0.77292 + 1.146 = 2.578$ inches	(11)
3	$v' = 3.764 \times 0.41072 = 1.549$ inch	(11a)
4	$v' = 3.764 \times 0.08455 = 0.318$ inch	(11a)
5	$v' = 3.764 \times 0.25122 = 0.947$ inch	(11a)
6	$v' = 3.764 \times 0.55830 = 2.106$ inches	(11a)
7	$v' = 1.854 \times 0.94157 + 1.146 = 2.890$ inches	(11)
8	$v' = 2.890$ inches	
9	$v' = 2.106$ inches	
10	$v' = 0.947$ inch	
11	$v' = 0.318$ inch	
12	$v' = 1.549$ inch	
13	$v' = 2.578$ inches	

Tooth-space Number		
1	$Y = 0.5 \times 4 + 0.5 \times 6 = 5.00$ inches	
2	$Y = \sqrt{(1.175)^2 + (2 + 2.578)^2} = 4.72$ inches	(12)
3	$Y = \sqrt{(1.902)^2 + (2 + 1.549)^2} = 4.03$ inches	(12)
4	$Y = \sqrt{(2.227)^2 + (2 + 0.318)^2} = 3.22$ inches	(12)
5	$Y = \sqrt{(2.114)^2 + (2 - 0.947)^2} = 2.32$ inches	(12)
6	$Y = \sqrt{(1.592)^2 + (2.106 - 2)^2} = 1.60$ inch	(12)
7	$Y = \sqrt{(0.625)^2 + (2.890 - 2)^2} = 1.09$ inch	(12)
8	$Y = 1.09$ inch	
9	$Y = 1.60$ inch	
10	$Y = 2.32$ inches	
11	$Y = 3.22$ inches	
12	$Y = 4.03$ inches	
13	$Y = 4.72$ inches	

Tooth-space Number			
1	$\tan y = 0.000;$	$y = 0.000$ degrees	(13)
2	$\tan y = \frac{1.175}{2 + 2.578} = 0.257;$	$y = 14.416$ degrees	(13)
3	$\tan y = \frac{1.902}{2 + 1.549} = 0.536;$	$y = 28.199$ degrees	(13)
4	$\tan y = \frac{2.227}{2 + 0.318} = 0.962;$	$y = 43.883$ degrees	(13)
5	$\tan y = \frac{2.114}{2 - 0.947} = 2.007;$	$y = 63.516$ degrees	(13)
6	$\tan y = \frac{1.592}{2.106 - 2} = 15.03;$	$y = 86.200$ degrees	(13)
7	$\tan y = \frac{0.625}{2.890 - 2} = 0.703;$	$y = 35.1 + 90$ degrees $= 125.100$ degrees	(13)
8	$y = 125.100$ degrees		
9	$y = 86.200$ degrees		
10	$y = 63.516$ degrees		
11	$y = 43.883$ degrees		
12	$y = 28.199$ degrees		
13	$y = 14.416$ degrees		

Tooth-space Number		
1	$w = 0 + 90 = 90.000$ degrees	
2	$w = 14.416 + 50.623 = 65.039$ degrees	(14)
3	$w = 28.199 + 24.245 = 52.444$ degrees	(14)
4	$w = 43.883 + 4.849 = 48.732$ degrees	(14)
5	$w = 63.516 - 14.547 = 48.969$ degrees	(14)
6	$w = 86.200 - 33.943 = 52.257$ degrees	(14)
7	$w = 35.100 + 70.312 = 105.412$ degrees	(14)
8	$w = 105.412$ degrees	
9	$w = 52.257$ degrees	
10	$w = 48.969$ degrees	
11	$w = 48.732$ degrees	
12	$w = 52.444$ degrees	
13	$w = 65.039$ degrees	

Tooth-space Number		
1	$H = 5 \times 1 = 5.000$ inches	(15)
2	$H = 4.72 \times 0.90659 = 4.275$ inches	(15)
3	$H = 4.03 \times 0.79276 = 3.190$ inches	(15)
4	$H = 3.22 \times 0.75165 = 2.420$ inches	(15)
5	$H = 2.32 \times 0.75433 = 1.750$ inch	(15)
6	$H = 1.60 \times 0.79076 = 1.265$ inch	(15)
7	$H = 1.09 \times 0.96402 = 1.050$ inch	(15)
8	$H = 1.050$ inch	
9	$H = 1.265$ inch	
10	$H = 1.750$ inch	
11	$H = 2.420$ inches	
12	$H = 3.190$ inches	
13	$H = 4.275$ inches	

Tooth-space Number		
1	$D = 5 \times 0 = 0$	(16)
2	$D = 4.72 \times 0.42192 = 1.99$ inch	(16)
3	$D = 4.03 \times 0.60960 = 2.456$ inches	(16)
4	$D = 3.22 \times 0.65956 = 2.123$ inches	(16)
5	$D = 2.32 \times 0.65650 = 1.523$ inch	(16)
6	$D = 1.60 \times 0.61213 = 0.980$ inch	(16)
7	$D = 1.09 \times 0.26584 = 0.290$ inch	(16)
8	$D = 0.290$ inch	
9	$D = 0.980$ inch	
10	$D = 1.523$ inch	
11	$D = 2.123$ inches	
12	$D = 2.456$ inches	
13	$D = 1.990$ inch	

Example 2—Required, a pair of oval gears; major axis, 6 inches; focus distance, 4 inches; 14 teeth; bore at center of gear.

$$B = \sqrt{36 - 16} = 4.472 \text{ inches} \quad (1)$$

$$C = 1.6464 \times 6 + 1.4952 \times 4.472 = 16.5649 \text{ inches} \quad (6)$$

$$p'' = \frac{16.5649}{14} = 1.1832 \text{ inch} \quad (17)$$

$$r' = 6 - 0.5 \times 4.472 = 3.764 \text{ inches} \quad (4)$$

$$r'' = 0.75 \times 4.472 - 0.25 \times 6 = 1.854 \text{ inch} \quad (5)$$

$$a = \frac{57.295 \times 1.1832}{3.764} = 18.010 \text{ degrees} \quad (8)$$

$$a' = \frac{57.295 \times 1.1832}{1.854} = 36.565 \text{ degrees} \quad (9)$$

Tooth-space Number	x, Degrees	z, Degrees	Tooth-space Number	x, Degrees	z, Degrees
1	80.859	9.141	8	80.859	189.141
2	44.294	45.706	9	44.294	225.706
3	22.512	67.488	10	22.512	247.488
4	4.502	85.498	11	4.502	265.498
5	13.508	103.508	12	13.508	283.508
6	31.518	121.518	13	31.518	301.518
7	62.576	152.576	14	62.576	332.576

Tooth-space Number		
1	$h' = 1.854 \times 0.15888 = 0.294$ inch	(10)
2	$h' = 1.854 \times 0.71569 = 1.327$ inch	(10)
3	$h' = 3.764 \times 0.92377 - 1.528 = 1.952$ inch	(10a)
4	$h' = 3.764 \times 0.99692 - 1.528 = 2.232$ inches	(10a)
5	$h' = 3.764 \times 0.97234 - 1.528 = 2.132$ inches	(10a)
6	$h' = 3.764 \times 0.85249 - 1.528 = 1.682$ inch	(10a)
7	$h' = 1.854 \times 0.46046 = 0.853$ inch	(10)
8	$h' = 0.294$ inch	
9	$h' = 1.327$ inch	
10	$h' = 1.952$ inch	
11	$h' = 2.232$ inches	
12	$h' = 2.132$ inches	
13	$h' = 1.682$ inch	
14	$h' = 0.853$ inch	

Tooth-space Number		
1	$v' = 1.854 \times 0.98730 + 1.146 = 2.978$ inches	(11)
2	$v' = 1.854 \times 0.69842 + 1.146 = 2.442$ inches	(11)
3	$v' = 3.764 \times 0.38295 = 1.442$ inch	(11a)
4	$v' = 3.764 \times 0.07846 = 0.295$ inch	(11a)
5	$v' = 3.764 \times 0.23359 = 0.879$ inch	(11a)
6	$v' = 3.764 \times 0.52275 = 1.970$ inch	(11a)
7	$v' = 1.854 \times 0.88761 + 1.146 = 2.791$ inches	(11)
8	$v' = 2.978$ inches	
9	$v' = 2.442$ inches	
10	$v' = 1.442$ inch	
11	$v' = 0.295$ inch	
12	$v' = 0.879$ inch	
13	$v' = 1.970$ inch	
14	$v' = 2.791$ inches	

Tooth-space Number		
1	$Y'' = \sqrt{(0.294)^2 + (2.978)^2} = 2.99$ inches	(18)
2	$Y'' = \sqrt{(1.327)^2 + (2.442)^2} = 2.78$ inches	(18)
3	$Y'' = \sqrt{(1.952)^2 + (1.442)^2} = 2.43$ inches	(18)
4	$Y'' = \sqrt{(2.232)^2 + (0.295)^2} = 2.25$ inches	(18)
5	$Y'' = \sqrt{(2.132)^2 + (0.879)^2} = 2.31$ inches	(18)
6	$Y'' = \sqrt{(1.682)^2 + (1.970)^2} = 2.59$ inches	(18)
7	$Y'' = \sqrt{(0.853)^2 + (2.791)^2} = 2.92$ inches	(18)
8	$Y'' = 2.99$ inches	
9	$Y'' = 2.78$ inches	
10	$Y'' = 2.43$ inches	
11	$Y'' = 2.25$ inches	
12	$Y'' = 2.31$ inches	
13	$Y'' = 2.59$ inches	
14	$Y'' = 2.92$ inches	

Tooth-space Number		
1	$j = \frac{5.236 - (2.99 + 2.25)}{2} = 0.000$ inch	(19)
2	$j = \frac{5.236 - (2.78 + 2.43)}{2} = 0.013$ inch	(19)
3	$j = \frac{5.236 - (2.43 + 2.78)}{2} = 0.013$ inch	(19)
4	$j = \frac{5.236 - (2.25 + 2.99)}{2} = 0.000$ inch	(19)
5	$j = \frac{5.236 - (2.31 + 2.92)}{2} = 0.003$ inch	(19)
6	$j = \frac{5.236 - (2.59 + 2.59)}{2} = 0.028$ inch	(19)
7	$j = \frac{5.236 - (2.92 + 2.31)}{2} = 0.003$ inch	(19)
8	$j = 0.000$ inch	
9	$j = 0.013$ inch	
10	$j = 0.013$ inch	
11	$j = 0.000$ inch	
12	$j = 0.003$ inch	
13	$j = 0.028$ inch	
14	$j = 0.003$ inch	

Tooth-space Number		
1	$Y' = 2.99 + 0.000 = 2.990$ inches	(20)
2	$Y' = 2.78 + 0.013 = 2.793$ inches	(20)
3	$Y' = 2.43 + 0.013 = 2.443$ inches	(20)
4	$Y' = 2.25 + 0.000 = 2.250$ inches	(20)
5	$Y' = 2.31 + 0.003 = 2.313$ inches	(20)
6	$Y' = 2.59 + 0.028 = 2.618$ inches	(20)
7	$Y' = 2.92 + 0.003 = 2.923$ inches	(20)
8	$Y' = 2.990$ inches	
9	$Y' = 2.793$ inches	
10	$Y' = 2.443$ inches	
11	$Y' = 2.250$ inches	
12	$Y' = 2.313$ inches	
13	$Y' = 2.618$ inches	
14	$Y' = 2.923$ inches	

Tooth-space Number		
3	$\text{Tan } y' = \frac{1.952}{1.442} = 1{,}354; \quad y' = 53.550$ degrees	(21)
4	$\text{Tan } y' = \frac{2.232}{0.295} = 7.560; \quad y' = 82.466$ degrees	(21)
5	$\text{Tan } y' = \frac{2.132}{0.879} = 2.425; \quad y' = 67.591$ degrees	(21)
6	$\text{Tan } y' = \frac{1.682}{1.970} = 0.854; \quad y' = 40.500$ degrees	(21)
10	$y' = 53.550$ degrees	
11	$y' = 82.466$ degrees	
12	$y' = 67.591$ degrees	
13	$y' = 40.500$ degrees	

Tooth-space Number		
3	$w' = 53.550 + 22.512 = 76.062$ degrees	(22)
4	$w' = 82.466 + 4.502 = 86.968$ degrees	(22)
5	$w' = 67.591 + 13.508 = 81.099$ degrees	(22)
6	$w' = 40.500 + 31.518 = 72.018$ degrees	(22)
10	$w' = 76.062$ degrees	
11	$w' = 86.968$ degrees	
12	$w' = 81.099$ degrees	
13	$w' = 72.018$ degrees	

Tooth-space Number		
1	$H'' = 1.854 + 1.146 \times 0.98730 = 2.984$ inches	(23)
2	$H'' = 1.854 + 1.146 \times 0.69835 = 2.654$ inches	(23)
3	$H'' = 2.43 \times 0.97056 = 2.356$ inches	(23a)
4	$H'' = 2.25 \times 0.99860 = 2.248$ inches	(23a)
5	$H'' = 2.31 \times 0.98796 = 2.281$ inches	(23a)
6	$H'' = 2.59 \times 0.95115 = 2.460$ inches	(23a)
7	$H'' = 1.854 + 1.146 \times 0.88760 = 2.871$ inches	(23)
8	$H'' = 2.984$ inches	
9	$H'' = 2.654$ inches	
10	$H'' = 2.356$ inches	
11	$H'' = 2.248$ inches	
12	$H'' = 2.281$ inches	
13	$H'' = 2.460$ inches	
14	$H'' = 2.871$ inches	

Tooth-space Number		
1	$H' = 2.984$ inches	
2	$H' = \frac{2.654 \times 2.793}{2.78} = 2.667$ inches	(24)
3	$H' = \frac{2.356 \times 2.443}{2.43} = 2.370$ inches	(24)
4	$H' = 2.248$ inches	
5	$H' = \frac{2.281 \times 2.313}{2.31} = 2.283$ inches	(24)

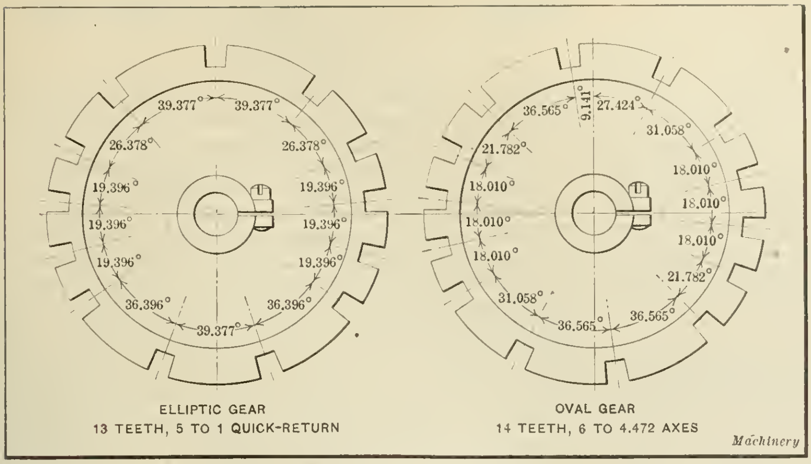


Fig. 9. Index Ratchet Wheels

6 $H' = \dfrac{2.460 \times 2.618}{2.59} = 2.486$ inches (24)

7 $H' = \dfrac{2.871 \times 2.923}{2.92} = 2.874$ inches (24)

8 $H' = 2.984$ inches
9 $H' = 2.667$ inches
10 $H' = 2.370$ inches
11 $H' = 2.248$ inches
12 $H' = 2.283$ inches
13 $H' = 2.486$ inches
14 $H' = 2.874$ inches

Tooth-space Number		
1	$D' = 1.146 \times 0.15889 = 0.182$ inch	(25)
2	$D' = 1.146 \times 0.71576 = 0.820$ inch	(25)
3	$D' = 2.430 \times 0.24087 = 0.586$ inch	(25a)
4	$D' = 2.250 \times 0.05292 = 0.119$ inch	(25a)
5	$D' = 2.310 \times 0.15471 = 0.357$ inch	(25a)
6	$D' = 2.590 \times 0.30874 = 0.800$ inch	(25a)
7	$D' = 1.146 \times 0.46057 = 0.528$ inch	(25)
8	$D' = 0.182$ inch	
9	$D' = 0.820$ inch	
10	$D' = 0.586$ inch	
11	$D' = 0.119$ inch	
12	$D' = 0.357$ inch	
13	$D' = 0.800$ inch	
14	$D' = 0.528$ inch	

Machining the Gears

Of the numerous dimensions and calculations required for the correct design of the gears in the drafting-room, but three are of interest to the operator cutting the gears, after the proper cutter, or cutters, have been selected. These are the angle included between the tooth-space tangent and the major axis of the gear (or the angularity of the ratchet index), the horizontal and the vertical setting for the machining fixture. Any other information given to the machinist is likely to create confusion and lead to errors in his exacting task. A machining fixture secured to the table of the milling machine employed for cutting the teeth is the only special equipment required.

A simple and essentially practical fixture employed by the Bilgram Machine Works carries an arbor that may be set at any predetermined angle, upon which the blank to be cut is mounted on its bore. The angle at which the arbor is set is the angle included between the tooth-space tangent and the major axis, or the complement of such angle, and varies for the different tooth spaces. The distance between the parallel planes of the machining-fixture arbor and of the rotary cutter is adjusted for each individual tooth space so that the distance between the plane of the arbor and the parallel plane tangent to the pitch circumference of the rotary cutter in the cutting plane equals the vertical setting for the machining fixture previously determined. The coordinate setting of the fixture (or the horizontal setting for the machining fixture) is the distance between the plane of the rotary cutter and a parallel plane passing through the arbor of the fixture. This is similarly set, for each individual tooth space, to conform to the calculated value. These three adjustments must be made for each tooth space, and it is this multiplicity of adjustments that makes the cutting of elliptical gears intricate.

The teeth should be cut in consecutive order, so that the angular adjustment of the fixture arbor, though varying in amount from tooth space to tooth space, is always in the same direction. In the multiple production of elliptical gears, this is taken advantage of by mounting on the fixture arbor a ratchet wheel with notches that conform to the angular adjustments for the various tooth spaces. The most convenient ratchet wheel is circular and concentric with the fixture arbor so that the notches in its circumference are of varying pitch, their angular pitch conforming to the angle included between the center line of the rotary cutter and the major axis of the gear blank in successive positions. The 0—180 degree ratchet diameter should conform to the major axis of the gear. The ratchet angle for the normal for any particular notch is referred to in the notation and the examples as the "angularity of ratchet index." For any particular tooth space, this is the complement of the angle included between the tangent at such tooth space and the major axis. This arbitrary fixing of the ratchet angularity is dependent on commencing the cutting of the teeth at the small end of the gear; the first tooth space to be gashed is that on the major axis for elliptic gears, or that immediately to the left of the major axis for oval gears.

Fig. 9 illustrates the location of ratchet notches for the gears proportioned in the examples. The use of such ratchet indexes materially simplifies the question of the angular adjustment of the fixture and at the same time aids in securing uniformity in the product, the operator being relieved of much of the difficulty in making adjustments. Still further accuracy can be secured, when the gears are not of unusually wide face and can be securely bound together, by cutting several blanks at the same time. This is not always advisable, however. If the hubs of the gears are appreciably longer than the face of the gears, little time is saved; and should there be any variation in the metal of the blanks, there is increased danger of error through the work being forced out of alignment.

When the gears do not differ greatly in their major and minor axes—when their pitch outline does not vary much from a circle—the same cutter may be employed for all teeth; but when the ellipse is comparatively flat and there is considerable difference between the major and minor axes, a different cutter should be used for the major-radius segments from the one used for cutting the tooth spaces falling within the minor-radius segments. The cutter is selected, not for the number of teeth in the elliptical gear, but for the number of teeth of the same circular pitch that would be required for a circular gear having a diameter equal to twice the segment radius. For instance, the minor radius of the elliptic gear of Example 1 is 1.854 inch, the major radius is 3.764 inches, and the circular pitch is 1.2742 inch. The cutter for the spaces within the minor-radius segments should then be selected for a circular gear of the same pitch but with from nine to ten teeth ($2 \times 1.854 \times 3.1416/1.2742$); and the cutter for the spaces within the major-radius segments the same as for a circular gear with from eighteen to nineteen teeth ($2 \times 3.764 \times 3.1416/1.2742$).

* * *

Men who strive to build themselves up by tearing down the work of their fellows generally succeed in undermining their own foundations and falling into the common ruin. The secret of success is cooperative effort and giving to everyone credit for that which is his due.

MODERN TOOLMAKING METHODS

Progress is being made rapidly in manufacturing methods, and the mechanic who does not keep posted is likely to be left hopelessly behind the times. Many still have the conception that toolmaking is the making of odd tools from time to time as required in the shop; they do not fully realize that modern toolmaking is a highly developed business, carried along on manufacturing lines. A toolmaking concern that made tools as they are made in the tool-rooms of many manufacturing plants would soon close its doors. By pursuing manufacturing methods, however, a modern toolmaking concern is able to produce a great variety of small tools that are of superior quality at a comparatively low labor cost.

Many of the operations of toolmaking which have been regarded as within the capacity only of an experienced toolmaker are not necessarily those that cannot be performed satisfactorily by apprentices or other beginners. As a matter of fact, an apprentice may be taught quickly to do a variety of lapping operations, for instance. It does not require a great deal of skill and experience to be able to lap the holes in milling cutters after hardening so that a plug gage will fit freely but without shake.

It is by specializing and dividing tool work into its elementary parts and assigning them to mechanics of moderate skill, that the economies of modern manufacturing toolmaking practice are realized.

* * *

CORRECTION

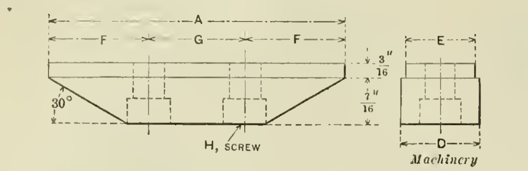
The elevating truck shown in Fig. D on the first page of "Factory Transportation" in the July number is a Stuebing truck made by the Stuebing Truck Co., Cincinnati, Ohio, and not a Barrett-Cravens truck, as stated in the caption.

MISCELLANEOUS STANDARDIZED PARTS FOR JIGS[1]

BY R. F. POHLE[2]

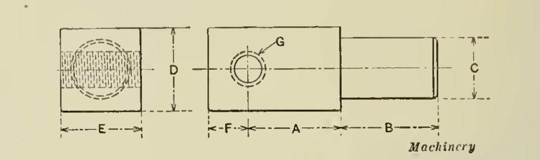
Tongues in the base of small fixtures are generally shaped from the casting itself. At times, however, it is desirable to be able to remove a tongue; for example, to reset it at right angles to its former position, thereby enabling an operator to mill, plane or slot a right angle without disturbing the work. In a fixture of this sort, grooves are milled in the base, into which the tongues are inserted. Tongues of this kind are also used to fasten into the base of long fixtures, say 12 inches or over. They will not collect dirt as readily as a planed tongue, and will thus eliminate the danger of improper seating and enter the platen slots more readily. It is not necessary to mill grooves for these tongues. They should, however, be doweled in place. Tongues are made of steel as shown in Table 1. The 30-degree angle at the lower corners is of no consequence. The tongues may be made square just as well.

TABLE 1. REMOVABLE TONGUES



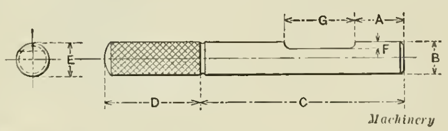
A	D	E	F	G	H
$2\frac{3}{4}$	$\frac{5}{8}$	$\frac{1}{2}$	$1\frac{3}{8}$	..	No. 14–24
$3\frac{3}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	1	$1\frac{3}{8}$	No. 14–24
4	$\frac{5}{8}$	$\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{3}{4}$	No. 14–24
$2\frac{3}{4}$	$\frac{3}{4}$	$\frac{9}{16}$	$1\frac{3}{8}$	..	$\frac{5}{16}$–18
$3\frac{3}{8}$	$\frac{3}{4}$	$\frac{9}{16}$	1	$1\frac{3}{8}$	$\frac{5}{16}$–18
4	$\frac{3}{4}$	$\frac{9}{16}$	$1\frac{1}{8}$	$1\frac{3}{4}$	$\frac{5}{16}$–18

TABLE 2. POPPETS



A	B	C	D	E	F	G Diameter and Number of Threads per Inch
$\frac{5}{16}$ to $\frac{13}{16}$	$\frac{5}{8}$	0.4385	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	No. 10–32
$\frac{5}{16}$ to $\frac{13}{16}$	$\frac{3}{4}$	0.501	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{16}$	No. 14–24
$\frac{5}{16}$ to $1\frac{1}{16}$	$\frac{13}{16}$	0.5635	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{5}{16}$	$\frac{5}{16}$–18
$\frac{3}{8}$ to $1\frac{1}{8}$	$\frac{7}{8}$	0.6265	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{3}{8}$–16
$\frac{3}{8}$ to $1\frac{1}{8}$	1	0.689	1	1	$\frac{3}{8}$	$\frac{7}{16}$–14
$\frac{1}{2}$ to $1\frac{1}{2}$	$1\frac{1}{8}$	0.7515	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{2}$–13

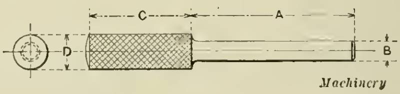
TABLE 3. PUSH-PINS



B	C	D	E	F	G
0.1865	$1\frac{1}{2}$ to $2\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{16}$	$\frac{1}{32}$	$\frac{7}{16}$
0.249	$1\frac{5}{8}$ to $2\frac{5}{8}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{32}$	$\frac{9}{16}$
0.3115	2 to $3\frac{1}{2}$	1	$\frac{5}{16}$	$\frac{3}{64}$	$\frac{11}{16}$
0.374	$2\frac{3}{8}$ to $3\frac{7}{8}$	1	$\frac{3}{8}$	$\frac{1}{16}$	$\frac{13}{16}$
0.4365	$2\frac{1}{2}$ to 4	$1\frac{1}{4}$	$\frac{7}{16}$	$\frac{5}{64}$	$\frac{15}{16}$
0.499	$2\frac{5}{8}$ to $4\frac{1}{8}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{5}{64}$	$1\frac{1}{16}$

Dimension A varies with the part to be held in the jig, and should be given on the tool drawing.

TABLE 4. KNURLED PINS



B	C	D	B	C	D
0.1875 to 0.2187	1	$\frac{5}{16}$	0.6250 to 0.6562	$1\frac{3}{4}$	$\frac{13}{16}$
0.2500 to 0.2812	$1\frac{1}{8}$	$\frac{3}{8}$	0.6875 to 0.7187	2	$\frac{7}{8}$
0.3125 to 0.3437	$1\frac{1}{4}$	$\frac{7}{16}$	0.7500 to 0.7812	$2\frac{1}{8}$	$\frac{15}{16}$
0.3750 to 0.4062	$1\frac{3}{8}$	$\frac{9}{16}$	0.8125 to 0.8437	$2\frac{1}{4}$	1
0.4375 to 0.4687	$1\frac{3}{8}$	$\frac{5}{8}$	0.8750 to 0.9062	$2\frac{1}{2}$	$1\frac{1}{16}$
0.5000 to 0.5312	$1\frac{1}{2}$	$\frac{11}{16}$	0.9375 to 0.9687	$2\frac{3}{4}$	$1\frac{1}{8}$
0.5625 to 0.5937	$1\frac{5}{8}$	$\frac{3}{4}$	1.000	3	$1\frac{1}{4}$

Dimension A varies with the part to be held in the jig, and should be given on the tool drawing.

In Table 5 are shown the proportions of what are generally called "seats." Seats are solid supporting points that come in direct contact with the work. The question of whether a seat should be of cast iron, finished, or of steel, hardened and ground, is decided by the conditions under which the designer is working. Where the number of pieces to be operated upon is not very great, or where the dimensions of the work show that it does not require to be very accurate, a cast-iron seat will probably give satisfaction. When tools are expected to produce duplicate parts within small limits of variation, hardened and ground steel seats, Table 5, may be relied upon.

A device known as a poppet is shown in Table 2. Poppets are used quite extensively; they serve as a lug to support an

[1] The tables of standards given in this article embody the practice of the General Electric Co., at Lynn, Mass. These standards were developed for the company by R. F. Pohle, when in charge of the tool designing department.

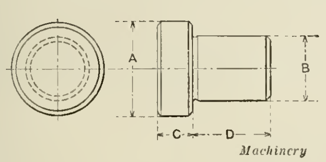
[2] Address: 265 Union St., Lynn, Mass.

adjustment or holding screw when it is preferable not to have a lug on the casting itself. For instance, to facilitate the production of the jig or fixture, one might want to shape or plane a surface, an operation that would be difficult and expensive if a screw-supporting lug was in the way as part of the casting. Also, at times, the hole in the lug may not be accessible for drilling and tapping. Poppets are also used to support drill bushings.

Milled push-pins, as shown in Table 3, are used in small jigs and on very delicate work. They provide a removable supporting point for the work, replacing the screws commonly used, and thus eliminating danger of distortion of the work or jig by the operator. Push-pins can also be more quickly removed than a screw, an advantage which may be borne in mind. They are milled as shown, not only to keep the binding screw from burring the pin, but also to keep the pin from falling out.

The knurled pins in Table 4 are simply hardened and ground pins used either to insure the proper placing of the work (after which the pin is removed), or to pin together two loose parts of a jig. In the latter case, the pin, as well as the bushings that it enters, is tapered. It is used, for instance, in a swinging side leaf or a cover that may not otherwise be

TABLE 5. HARDENED SEATS OR LOCATING PLUGS

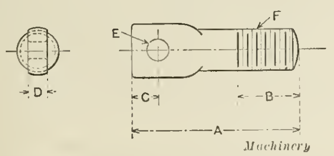


A	B	C	D	A	B	C	D
1/2	0.251	3/16	1/2	7/8	0.5635	1/4	5/8
9/16	0.3135	3/16	1/2	1	0.626	1/4	3/4
5/8	0.376	3/16	5/8	1 1/8	0.6885	1/4	3/4
11/16	0.4385	3/16	5/8	1 1/4	0.751	1/4	7/8
3/4	0.501	1/4	5/8	..	......	..	..

supported. Tables 6 and 7 simply give information as to the proportions of spring posts and knobs. The functions are quite apparent.

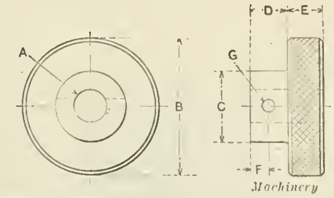
The primary object of this article is to call the attention of designing engineers to the fact that many parts of jigs and fixtures may be standardized, numbered, made by apprentices instead of skilled toolmakers, and kept in stock. It will also do away with the drawing of these parts over and over again by tool designers.

TABLE 6. SPRING POSTS



A	B	C	D	E	F Diameter and Number of Threads per Inch
1/2 to 1 1/8	3/16	3/32	1/16	1/16	No. 8–32
3/4 to 1 1/4	9/32	1/8	3/32	3/32	No. 10–32
1 to 1 3/4	3/8	3/16	1/8	1/8	No. 14–24
1 1/4 to 2 1/4	1/2	1/4	5/32	5/32	5/16–18
1 3/8 to 2 1/2	9/16	1/4	3/16	3/16	3/8–16
1 3/4 to 3	3/4	5/16	1/4	1/4	1/2–13
2 to 3 3/4	15/16	3/8	5/16	5/16	5/8–11
2 1/4 to 4 3/4	1 1/8	7/16	7/16	3/8	3/4–10

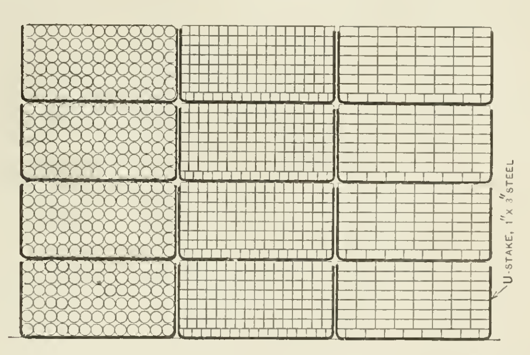
TABLE 7. KNOBS FOR JIGS AND FIXTURES



A	B	C	D	E	F	G
3/16	7/8	7/16	1/4	1/4	1/8	3/32
1/4 to 5/16	1 1/8	9/16	3/8	5/16	3/16	3/32
3/8 to 7/16	1 1/2	11/16	7/16	7/16	7/32	1/8
1/2 to 9/16	1 3/4	7/8	1/2	1/2	1/4	1/8
5/8 to 3/4	2 1/4	1 1/16	9/16	11/16	9/32	3/16

U-STAKES FOR PILING BAR STOCK

Racks for bars, strips, rods, pipe and other long metal stock are costly to construct and inconvenient to use. They are also inelastic and difficult to move when changes in the store-room are necessary. Racks may be avoided in many places by using piling stakes made of 1- by 3-inch steel bars bent to U shape, the U having a flat bottom and square corners, instead of a rounded contour. The stock is piled in these stakes, one being placed near each end of the pile. The width of the U-stake or frame may be from 30 to 36 inches and the height about 18 inches. When the pile has reached the top of the frames, another pair of frames is laid on the pile and the piling continued to any height required. Tiers may be ranged side by side, as indicated in the accompanying illustration, which shows piles of rounds, squares and flat stock, each held securely and neatly by the U-frames. When the stock is removed, there is no unsightly rack left to encumber the spot; the U-frames may be stored until required again, and new stock may be piled elsewhere if more convenient.



Illustrating Use of U-stakes for piling Bar Stock

* * *

The number of establishments making watches, watch parts, and watch movements in this country decreased from thirty-seven in 1869 to fifteen in 1914. The number of employes increased from 1800 to 12,390; the wages, from $1,304,000 to $7,524,000, and the value of the products from $2,819,000 to $14,275,000. In the same period the number of watch-case factories fell from forty-nine to thirty-one, while the value of the products increased from $2,333,300 to $7,831,000. In 1909, however, twenty-nine establishments produced cases to the value of $10,514,850. The imports of watches and watch parts have grown from $2,293,670, in 1911, to $3,362,720, in 1916, while the exports fell from $1,560,870 to $1,524,430. In 1915, only $914,770 worth of American watches and watch parts were sold abroad.

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FARM TRACTORS NOW AND AFTER THE WAR

The world is facing a shortage of food, now and after the war, and it is imperative for the farms to produce the maximum of food products at a minimum of cost. Farmers generally depend on animals for tractive power, but it is evident that in this mechanical age animal power must give way to tractors, which are propelled by engines fed by fuels cheaper than hay and grain—the food of the horse. The tractor is economical of farm labor because of the concentration of power under the control of one man. A tractor capable of exerting the draft power of many horses can be readily handled by one man, with comparatively little mechanical knowledge. The high-powered tractor capable of hauling ten plows at a uniform speed of 2 1/3 miles an hour, and operated by two men, will in a day of ten hours plow as much land as could be turned over by twenty single plows drawn by horses.

The adaptable farm tractor is that which can be used for all agricultural purposes, and which may also be used with a fair degree of efficiency for hauling produce to market. This combination of qualities is difficult to secure in one machine, but it is essential for the small farmers in the East to secure in one machine all the draft qualities of the horse in order to minimize investment.

A difficulty in the development of tractors and other machines driven by internal combustion motors, is the high price of gasoline and the apparent limitation of the world's supply of petroleum. The prospect of cheap alcohol seems remote. There is, it is true, the possibility of making gasoline from oil-bearing shales, but at present the cost of gasoline so produced is greater than that made in the ordinary way.

The future development of transportation methods on land and sea and in the air, and the improvement of agricultural conditions, hinges on the internal combustion motor. The improvement of motors and the development of cheap liquid fuels are fascinating subjects for invention and investigation.

* * *

REPLACING OLD MACHINE TOOLS WITH NEW

Now is the time for owners of manufacturing plants to consider ways and means for increasing the productive capacity of their plants without adding more buildings, which the present high cost of materials and labor will make an excessive burden in future. Never was it so necessary for owners and managers to give close attention to the interior arrangement of their plants, methods of routing work, and efficiency of machines. Many plants have machine shops in which there are machine tools that should have been scrapped years ago. It is not uncommon to find lathes thirty or forty years old that are still in use. These old-timers take up the same area of floor space as a modern machine tool with a productive capacity of fifty to one hundred per cent more. Obviously, the simplest way—and the cheapest in the end—to increase the productive capacity of an out-of-date machine shop is to discard the ancient tools and replace them with modern equipment. The labor cost will be decreased and the productive capacity of the plant, as a whole, materially increased.

There are few manufacturing plants in which the floor space is utilized nearly to its capacity. The use of efficient machine tools is a step in the right direction; efficient transportation means, and methods which prevent congestion on the floors and which keep the operators supplied with work is another. An important matter to be considered when purchasing new machine equipment is the floor space occupied. In some cases it will be found that the vertical type of machine tool is best suited to the product, and that the floor space required is less for a given production than it would be with machines of the horizontal type. If the horizontal type is required—lathes, for example—they should be no longer than necessary to accommodate the maximum length of piece to be produced. It is a mistake to purchase engine lathes with long beds when the maximum length of the pieces to be turned requires short bed lathes only.

* * *

IMPORTANCE OF STUDY OF SHOP MATHEMATICS

Mathematics may be said to be the foundation of all engineering. Without the aid of the processes of arithmetic, even the simplest mechanical work could hardly be done. In the design of machinery, and still more in the design of great engineering structures, calculations of a more or less advanced nature become absolutely necessary. Any mechanic with a limited education who contemplates the study of mathematics should make certain that he has fully mastered arithmetic. Just as mathematics is the basic science underlying engineering, so arithmetic is the basis of all mathematics. Without a thorough understanding of every process in arithmetic, other mathematical studies become difficult, if not impossible.

Many shop men refrain from using handbooks and other mechanical books containing formulas because they believe that an understanding of algebra is necessary in order to make use of such formulas as are given in handbooks. This idea is erroneous. With few exceptions, the formulas given in handbooks intended for machine shops can be used by anyone who thoroughly understands arithmetic. All that is necessary is to spend an hour or two reading an article explaining the purpose and use of formulas. In mathematics, a number of abbreviations, signs and symbols are also used; and it is of considerable value to the man who reads mechanical literature and occasionally uses formulas to memorize the commonly used signs and abbreviations. This will facilitate his progress and make it easier for him to grasp the meaning of a formula which otherwise would be obscure.

Closely allied to the use of formulas is the use of diagrams. A formula records a mathematical statement by means of symbols or letters, while a diagram records a similar statement graphically by means of lines. Many mechanics regard a diagram as something difficult to understand, but this is not the case, as anyone can easily find by studying a few of the diagrams presented in the mechanical journals.

The student who wishes to go further into the study of elementary mathematics should begin with a simple course in the solution of triangles and elementary geometry. If he wishes to proceed still further, he should take up logarithms and the solution of equations, and in connection with the latter subject he would acquire the rudiments of algebra.

THE LAW OF WARRANTIES

BY CHESLA C. SHERLOCK[1]

There are two kinds of warranties under the legal conception of the term, *viz.*, express and implied. An express warranty is a special warranty that expressly binds the maker thereof as to the fitness of a particular thing; while an implied warranty is a guaranty implied from the nature of the thing, the relation of the parties, or the agreement between them. Warranties cover a wide field and take in almost every phase of contractual relations. As applied to machinery, some special rules are in force that do not apply in other cases. Especially valuable and interesting is the rule of law as to which warranty governs a sale; that is, does the fact that a manufacturer expressly warrants a machine exclude or include implied warranties, or must the purchaser stand on the express warranty alone?

The Kentucky courts state the general rule to be that where there is an express warranty, there is no implied warranty. In the case under consideration, the contract provided that the machinery was sold subject "to the following express warranty and agreement, and none other." In Michigan, the rule is held to be that if there is "an express warranty as to the working qualities of machinery, there is no implication that the machinery is fit for the purposes for which it was purchased." In Indiana, the court said that although it is true that when a machine or other article is sold for a particular purpose there is an implied warranty that it is reasonably fit for the purpose for which it was made and sold, this rule does not apply where there is an express written warranty, since, in such cases, implied warranties are excluded. In Georgia, it is said that only in the absence of express warranties can resort be had to an implied warranty that a machine is reasonably fit for the use intended. In Illinois, the rule is: "Where a manufacturer furnishes a heating apparatus designed for heating a specific building, he impliedly warrants the sufficiency of the apparatus for the purpose intended. This implied warranty, however, cannot be availed of if the apparatus is sold upon an express warranty as to the temperature to which it will heat the rooms which it is designed to heat." In a Wisconsin case, it was stated that an express warranty of workmanship and material of cream separators excludes an implied warranty of fitness. In a Maine case, the court said: "The existence of an implied warranty that an automatic governor should be suitable for the purposes of the buyer's plant is negatived by the fact that the contract of purchase contained an express warranty as to quality as well as to speed, and the governors were such as the seller in the ordinary course of his business manufactured for the market, the general rule being that where an express warranty is made upon a sale, no other will be implied." The Missouri courts, however, have taken the other side of the question. They have held that there might be express warranties that do not exclude implied warranties, as there are any number of implied warranties that were never contemplated at the time the express warranties were made. This exception was not held, however, to apply to an implied warranty which in itself formed an integral element of the express warranty, into which it merged and by which its effect was circumscribed. The holding of the Missouri courts is on the theory that the express warranty is as to something wholly independent of the implied warranty. This distinction is as important as the distinction between express and implied warranties themselves.

It is a general rule, then, that an express warranty as to a particular phase of a thing will exclude all implied warranties as to the same thing. This rule is supported by the great weight of judicial authority and is practically universal. There are, however, some exceptions to the rule that are equally well supported by the weight of authority. In order for the general rule to apply, the character of the article warranted, as well as the express warranty thereto, must include all implied warranties on the same subject. The express warranty must also be of such a nature as to negative any contention that the manufacturer intended to assume any other obligation than the one assumed in his express warranty. If such a tendency does clearly exist, the courts are likely to declare that the implied warranties and the express warranties are separate in the particular case.

The law of warranties is so comprehensive a subject that it is possible to state here only the rules in force in cases involving machinery. The rules of law are the guide posts that point the way, and when a man is once familiar with these rules, he may proceed without stumbling through a maze of hazy legal decisions and counter decisions. The things to remember are that an express warranty excludes all implied warranties to the same subject, and that implied warranties will be considered either in the absence of express warranties or where it can be inferred from the agreement of the parties or the nature of the thing warranted that implied warranties were not intended to be included in the express warranty.

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* * *

RELATION OF RATE OF COOLING TO PHYSICAL PROPERTIES OF FORGINGS[1]

Two locomotive driving axles were used in some experiments recently conducted to study the rate of cooling in different medias and to try to connect the rate of cooling with the physical properties obtainable in quenched and tempered forgings. One of these axles was 11 inches in diameter and weighed 1830 pounds; the other was 12 inches in diameter, had a 3-inch hole bored longitudinally through it, and weighed 2000 pounds. In each case, the axles were heated uniformly as for quenching in the usual course of manufacture. The cutting compound used for quenching was composed of mineralized lard oil and soft soap mixed with equal parts of water. It was later diluted to one part of compound and two parts of water, and still later to three parts of water.

The tests show that in air the solid axles cool at a rate of 10 degrees F. per minute; in heavy oil, 26 degrees Baumé, at the rate of 25 degrees per minute; in the oil solution, at the rate of 35 degrees; in light oil, 29 degrees Baumé, at the rate of 45 degrees; and in water, at the rate of 80 degrees. The bored axle cooled in both the heavy oil and the cutting compound at the rate of 40 degree per minute. It was found that the dilution of the compound had little effect on its quenching properties.

In the case of the bored axle, it was found that when the 25 per cent solution of cutting compound was used, the axle cooled from 1450 to 700 degrees F. in 16.1 minutes. Its elastic limit was 40,500 pounds per square inch; its tensile strength was 78,000 pounds; its elongation in 2 inches, 29 per cent; and its reduction in area, 55 per cent. But when placed in the 33 per cent solution, the bored axle cooled in 13.6 minutes; its elastic limit was 43,000 pounds; its tensile strength, 81,500 pounds; its elongation in 2 inches, 30 per cent; and its reduction in area, 53.5 per cent. It was thought, however, that this more rapid cooling was due to some local condition that affected the convection of the bath.

When a jet of compressed air was introduced into the bath to give it a vigorous circulation, the rate of temperature fall was increased 80 per cent. Carbon steel that in the still bath had an elastic limit of 49,500 pounds per square inch, a tensile strength of 95,000 pounds, an elongation in 2 inches of 20.5 per cent, and a reduction in area of 43.5 per cent, when quenched in the agitated bath had an elastic limit of 68,800 pounds, a tensile strength of 105,300 pounds, an elongation in 2 inches of 21 per cent, and a reduction in area of 42 per cent. Chrome-vanadium steel axles quenched in a still bath had an elastic limit of 80,500 pounds per square inch, a tensile strength of 123,500 pounds, an elongation of 20.5 per cent, and a reduction of area of 57.5 per cent. When quenched in an agitated bath, this steel had an elastic limit of 90,000 pounds, a tensile strength of 124,000 pounds, an elongation of 16.5 per cent, and a reduction of area of 61.5 per cent.

* * *

Last year, 4676 automobiles were imported into Argentina, against 1847 in 1915. Most of these were small cars designed particularly for country use, as such cars are becoming popular among the farmers.

[1]Abstract of a paper by Lawrence H. Fry, read before the Iron and Steel Institute of Great Britain, May, 1917.

SNAPSHOTS ON THE ROAD

THE RIGHT SIDE OF A PIECE OF STEEL—ASSEMBLING A CLOCK MOVEMENT IN TWO MINUTES—BROACHING CAST IRON—DUPLICATE FORM TURNING—WHAT'S THE MATTER WITH THE MUNITIONS MAKERS?—HOW A DOUBLE-ANGLE MILLING JOB WAS HANDLED—LAPPING GAGES FOR PROFIT—USING UP HIGH-SPEED STEEL DRILLS

BY THE FIELD EDITORS

"—the bottom side hardened to perfection while the face was as soft as cheese"

THERE are still a few shops in the country that make use of what is known as "composite steel" for blanking die work. Composite steel is formed by rolling together a piece of iron and a piece of tool steel. The result is a plate, one side of which is steel and the other iron. It has been claimed that a die made from this steel could be machined with less trouble than a solid steel die, and with practically no danger from cracking in hardening. While looking around through one of these shops where composite steel had been a great favorite, we heard the following incident, which has a mechanical moral:

"It was in the days when I was toolmaking," said the manager of the jewelry making plant—"and I was considered a pretty good die-sinker, too—that one day we had a little emblem die to make from which but a few strikings were required, so I picked up a scrap of composite steel and commenced to sink the design. After working on this for five or six hours, I tumbled to the fact that it worked too soft, and the horrible suspicion came to me that I had the piece of composite steel wrong side up and was cutting the design in the iron face of the plate instead of the steel. The longer I worked at it, the surer I was that I was wrong, and as soon as I tried to harden the die I was positive, for the bottom side hardened to perfection while the face was as soft as cheese.

"Someone has made the remark that during the few seconds' interval between the time when think you have made a mistake and when you find out whether you have or not, you are getting real experience. Well, I went through those seconds and got the experience, but the next thing was how to get out of the dilemma. It was a rush job and we had no time nor facility for pack-hardening, so I casehardened with cyanide, soaking in the cyanide to get all the depth of case possible. Even then I doubt if the die would have passed, even for the small number of parts required, if I hadn't gotten on the right side of Old Tom, the drop man, and told him that I suspected that die was made of a poor piece of steel and to nurse it along as carefully as possible. Old Tom got out the order, but he did some cussing and declared at the end that that sure was some bum steel in that die."

Assembling a Clock Movement

In going about the field, many examples of manual dexterity are seen, especially in factories where girls are employed. Recently, while in a Connecticut clock shop, the superintendent called attention to the assembling of a movement for a cheap alarm clock. The girls on the job had large compartment trays, each space of which contained a quantity of wheels or shafts of one kind. The assembler dropped one of the frame plates of the movement onto a simple little fixture before her and with her right hand rapidly reached for the various wheels and shafts, located them in the frame, and held them in place with her left hand.

How that right arm did fly! After she had all the wheels in their correct places in the frame plate, still loosely held in her left hand, she fitted on the top plate. With a quick little shake, at the same time rapidly adjusting the various parts with her left hand, she had the shafts and other parts in the proper pivot holes in the two plates. The top plate was held in place by twirling two little nuts on diagonally opposite parts and the job was done—total elapsed time, less than two minutes!

"With a quick little shake . . . she had the shafts and other parts in the proper pivot holes"

Broaching Cast Iron

"We worried a lot over this machining problem," said the chief engineer of the plant that we were visiting, "and you will be interested to know how we finally solved the problem. Now here's what we had to do," said he, as he reached for a piece of paper and rapidly sketched away. "You see, there's an irregular cored slot that runs out of this cast-iron plate, which, by the way, is one inch thick. Of course, you will see we couldn't mill these quickly without a profiler, and our production wasn't great enough to install such a machine. We got through the job very nicely, however, by broaching."

"But we have always considered the broaching of cast iron a rather difficult job on account of the tendency to break out at the end of the broaching cut."

"You're dead right there, and that made the job all the more interesting. See, here's how we overcame that breaking-out tendency. We used three broaches for the job; the first left the outline of the slot in a succession of notches, just as I'm drawing it. We followed this broach by a second one that took 'bites' out of the center of each of the notches. Then we finished up with a plain broach that took the ridges from the slot and left it as finely finished as you could desire and without the sign of a break at the end of the cut."

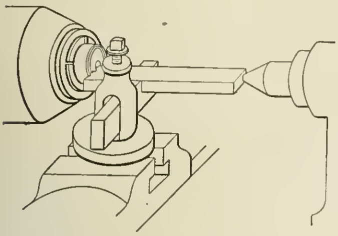
"That's sure a new wrinkle in broaching," said we, "and a mighty good one to remember."

"We used three broaches for the job; the first left the outline of the slot in a succession of notches"

Duplicate Form Turning

It is surprising how often you see a new kink in some little shop where you wouldn't expect to find anything more modern than a grindstone. You may have to unearth it from beneath a pile of obsolete practice, but when you get it out it looks pretty good. Such was the case in a little job button manufacturing concern in good old New England. It seems that this company often has a set of fifteen or twenty sample buttons to turn, or molds for making buttons, or possibly punches for press work. It is necessary to face the molds or punches with the concentrically turned form and the exact form of the rings does not matter as long as they are all alike.

The boss lathe hand is an ingenious Yankee, and he has a "universal" form-turning tool that you can understand better from the sketch than from a page full of words. This form tool is made from a rectangular piece of steel about three-eighths by one inch and the shank is fitted in a slot in a block held in the toolpost, and is operated from the tail-center. The operation is simplicity itself. The lathe hand merely adjusts the tool by means of the cross-slide and feeds it in with the tailstock. The slot in the block of the cross-slide insures each punch, each button mold part or punch being turned exactly the same. A great number of variations are possible by merely moving the cross-slide and hence the tool, and as long as the cross-slide is moved the same amount for each operation, the pieces are exact duplicates.



"The boss lathe hand . . . has a 'universal' form-turning tool"

It is a simple little kink and there ought to be many ways of applying it to general machine shop practice.

What's the Matter with the Munitions Makers?

We recently ran into a fine example of "frenzied buying" as done by one of the mushroom munition plants that have been so much in the limelight of late. It was told to us by an efficiency expert who had been called in to straighten out things after they had run so wild that no one knew where they were "at." One of the grinding-room foremen wanted a diamond for truing grinding wheels, and put in his requisition. He stated the approximate size that was required, and one of the buyers of the purchasing department promptly got busy and bought a pure, flawless, blue-white diamond, for which he paid the meager sum of $900. The interesting part of it is that they did not send the diamond back, but actually put it into service truing grinding wheels.

Another glaring example of inefficiency was in an order of dies that was placed soon after the plant was started. An order for twenty-four duplicate dies for punching one particular part was given to a diemaking concern. The order was delivered promptly by putting every man in the shop on the job. After several months, it occurred to the diemaking concern that there ought to be another order coming for dies if such quantities had been needed before, so the manager went around to interview the purchasing department of the munitions plant. Being somewhat friendly with one of the purchasing agents, he naturally put his proposition to his friend, who simply smiled and said, "Come with me for a minute." Out through the shop they walked and into one of the storehouses, and there, stored in an orderly fashion, were twenty-three sets of the dies. These dies were all slushed with grease just as they had been received and had never seen service.

"Well," said the die manufacturer, "what's the answer?"

"Simplicity itself," was the reply. "The engineering department ordered us to secure twenty-four sets of dies for this part before they were sure that the part was exactly what they wanted. After a few thousand impressions had been made from the first set, they discovered that they were on the wrong track, and consequently these twenty-three sets of dies are scrapped."

How a Double-angle Milling Job was Handled

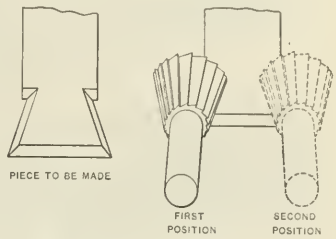
"Say," said the master mechanic, "we've just finished solving a pretty little milling job for producing a piece like this one I'm drawing, and I'll be interested to hear how you would have done it." The piece referred to was made of carbon steel and its end was dovetailed as shown. The complicated part of it was that the edges were not cut straight across, but on an angle of about 5 degrees, similar to a milling cutter tooth.

"I yust pull up mein chair side mit de lapping block, light mein pipe, and make one hand go so and so, while I read mein paper mit comfort"

"And before you decide just how you would have handled this," said the superintendent, "remember that it's a manufacturing job on which we must have thousands of parts, and we can't stand for a special machine, because on munition work the styles are apt to change at ten minutes' notice."

We racked our memory for a similar job without success, and, finding none, had to appeal to the superintendent for the explanation.

"Well, the solution was so simple it was funny we didn't strike it long ago. We simply had a special end-mill made to agree with the dovetail taper, and holding the pieces one at a time in a special fixture on the hand milling machine, ran the work straight up onto the cutter, but not across it; the resulting surface was angular and slightly concave. Next we dropped the work, ran it around the cutter to the opposite edge and milled it in the same way, and we got as pretty a result as you could want.



"the solution was so simple it was funny we didn't strike it long ago"

"Of course," concluded the superintendent, "you'll say we didn't get a perfectly true angle by using the surface left by a cylindrical end-mill, and you're right, but the resulting slightly concave surface was highly satisfactory and made an even better fit in the slot than it would have if it had been straight."

Lapping Gages for Profit

"Before you go," said the tool-room foreman, "sit down here and let me tell you about a big job of gage lapping that we had in the shop some time ago and how we handled it. You see, we only had one good man who could lap work and get away with it, and it was soon evident that we wouldn't be able to get the job out on time if we depended only on his ten-hour-a-day services, so we asked him about taking some of the work home and doing it evenings; we thought it would be pleasanter than staying at the factory, as none of the other men were working overtime.

"Schwarz was a big, good-natured German of a philosophical turn of mind. Every morning he brought in a good number of lapped gages and soon the contract was over. His overtime work did not seem to tire him, so one day, when the work was nearly done, I asked him how it was he could stand so much extra work without tiring, and he replied:

" 'Oh, dot vas easy. I yust pull up mein chair side mit de lapping block, light mein pipe, and make one hand go, so and so, while I read mein paper mit comfort, and pretty soon I look at the gage—maybe he be all right, maybe not; that makes no never minds, I rub him some more and bimeby he sure be done.' "

"And so it was. Schwarz's gage lapping was no tax on his strength, because he reduced his right hand to an automaton that worked while he read—which wasn't so bad."

Using up High-speed Steel Drills

High-speed steel turning tools cost money these days, so anything new in the turning tool line attracts our attention. Not long ago we were walking by the tool stock-room of a shop in Syracuse, where we saw an unusual lathe tool. It seems that the company uses a lot of two-inch high-speed steel drills, and when they are worn down too short for the work, they are forged down and the twist is taken out, turning them into lathe tools. The men say they are the finest kind of turning tools, and they make a saving in the steel bill besides.

GRIDLEY TURRET LATHE EQUIPMENT[1]

CHUCKS, FORMING AND CUTTING-OFF TOOLS, DRILL-HOLDERS, KNURLING TOOL-HOLDERS, TURNERS, BACK-RESTS, ETC.

BY DOUGLAS T. HAMILTON[2]

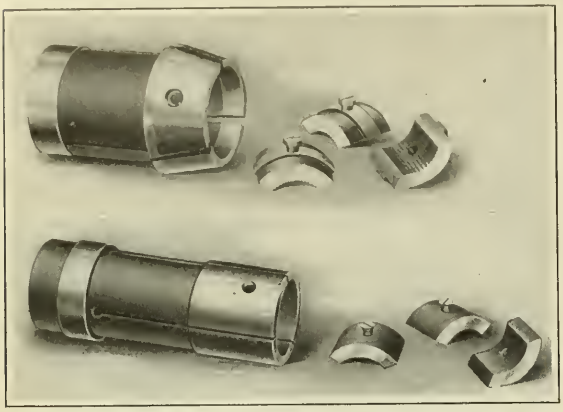


Fig. 1. Master Spring Chuck and Feed Chuck with Gripping Jaws removed

THE tool equipment and attachments used on the Gridley single-spindle automatic turret lathes do not differ essentially from those used on the multiple-spindle type of machine. The tool-holders, however, are held on flat slides instead of on the corner of the turret, as in the multiple-spindle machines. The standard tool equipment consists of spring chucks, feed chucks, vertical and flat forming tools, blade-type cutting-off tools, drill-holders, facing tools, knurling tools, internal necking tools, turners, high-speed drilling attachments, automatic die attachments, releasing tap-holder attachment, and taper turning attachment. Other special tools, of course, can be designed when the character or shape of the work necessitates the performance of operations that cannot be handled with the standard equipment.

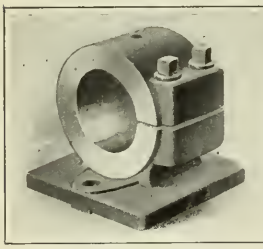


Fig. 2. Standard Type of Tool-holder used on Turret Slide of Gridley Automatic Turret Lathe

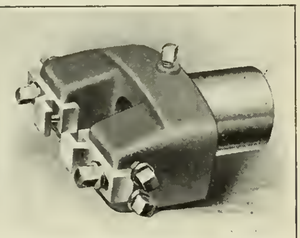


Fig. 3. Standard Type of Knurling Tool-holder for Use on Turret Slide of Gridley Automatic Turret Lathe

Spring Chuck and Feed Chuck

The spring chuck and the feed chuck used in the single-spindle turret lathe are exactly the same as those used on the multiple-spindle machines; in fact, the chucks used on the $1\frac{3}{4}$- and $2\frac{1}{4}$-inch sizes are interchangeable. On the single-spindle turret lathes, of course, the smallest capacity of the machine is such that the master spring chuck and feed chuck are used exclusively, and these are fitted with bushings to suit the size and shape of the work being handled. The illustration accompanying Table 1 shows the design of the spring chuck, and the principal dimensions are given for the $2\frac{1}{4}$-, $3\frac{1}{4}$- and $4\frac{1}{4}$-inch machines. It will be noticed in this connection that the taper on the front end of the chuck is only $14\frac{1}{2}$ degrees on the $2\frac{1}{4}$-inch size, whereas it is 15 degrees on the $3\frac{1}{4}$- and $4\frac{1}{4}$-inch sizes. Another difference that should be noticed is that the chucks used on the $3\frac{1}{4}$- and $4\frac{1}{4}$-inch sizes have four slots and four bushing sections, instead of three, as on the $2\frac{1}{4}$-inch size.

The illustration accompanying Table 2 shows the type of master feed chuck used and the table gives the principal dimensions. These chucks are also interchangeable with those on the same size of multiple-spindle machines, and the number of slots and bushing sections vary on the $3\frac{1}{4}$- and $4\frac{1}{4}$-inch sizes, as mentioned in connection with the spring chuck. On the $3\frac{1}{4}$- and $4\frac{1}{4}$-inch feed chucks, the diameter is not reduced at L, but the diameter A extends from the front back to the shoulder at J; otherwise the feed chucks used on the various sizes of machines are identical in shape. Fig. 1 shows a master spring chuck and a feed chuck with the bushings removed and illustrates clearly the shape of the bushings and the method of holding them.

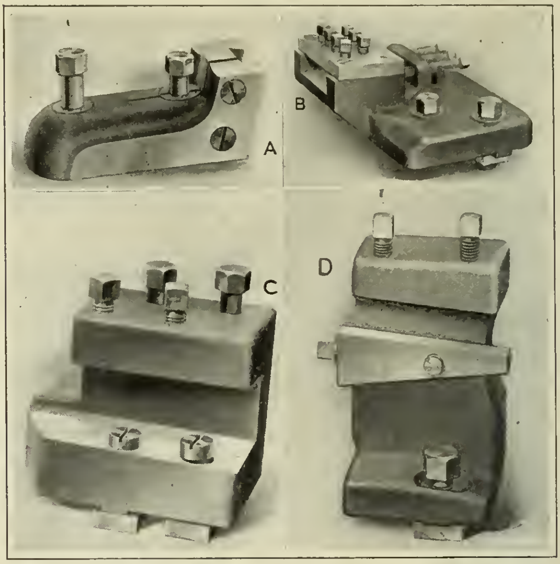


Fig. 4. Forming and Cutting-off Tool-holders used on Gridley Single-spindle Automatic Turret Lathe

Forming and Cutting-off Tools

The forming and cutting-off tools used on the single-spindle turret lathe do not differ materially from those used on the multiple-spindle machine. When an irregular form is to be produced the vertical type of forming tool gives the best results. When several diameters are to be formed and only a small number of parts are to be turned out, individual forming tools consisting simply of blades for covering each diameter are satisfactory. It should be stated, however, that when a large number of parts are to be produced a tool covering the entire form, if possible, is better than a tool made up in separate parts, as it is easier to set up the tool again after

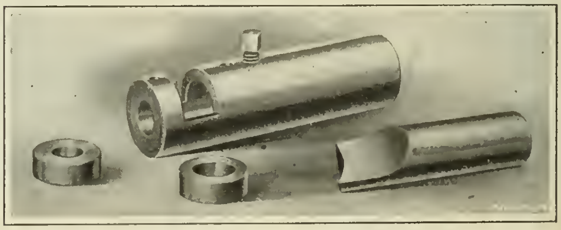
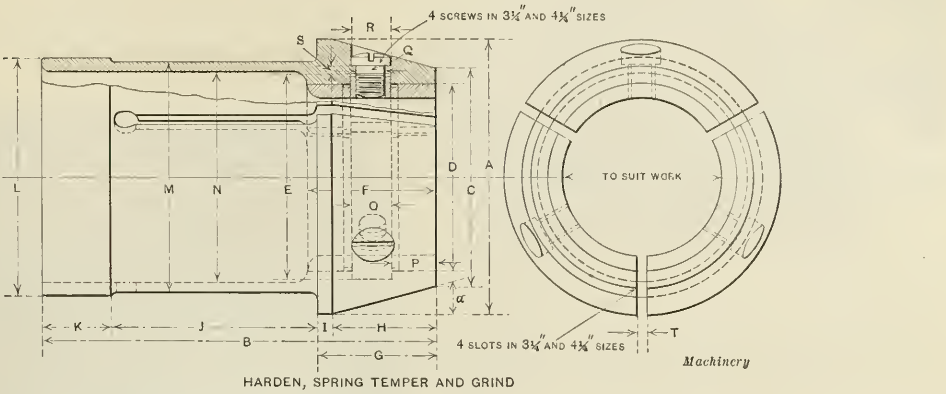


Fig. 5. Facing Tool and Holder used in Standard Tool-holder

[1] For other articles on Gridley automatic screw machine practice, see "Gridley Multiple-spindle Automatic Screw Machines" in the June and July, 1917, numbers of MACHINERY, and the articles referred to in connection with the first installment.

[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

TABLE 1. PRINCIPAL DIMENSIONS OF MASTER SPRING CHUCKS FOR GRIDLEY SINGLE-SPINDLE TURRET LATHES



Size of Machine	Dimensions, Inches																		
	A	B	C	D	E	F	G	H	1	J	K	L	M	N	O	P	Q	R	S	α, Degrees
$2\frac{1}{4}$	$3\frac{1}{2}$	$5\frac{1}{32}$	2.7966	$2\frac{3}{8}$	$2\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{5}{16}$	$\frac{3}{16}$	$2\frac{21}{32}$	$\frac{7}{8}$	3	$2\frac{15}{16}$	$2\frac{11}{16}$	$\frac{1}{2}$	$\frac{9}{26}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{32}$	$14\frac{1}{2}$
$3\frac{1}{4}$	$4\frac{11}{16}$	$5\frac{5}{8}$	3.9173	$3\frac{3}{8}$	$3\frac{9}{16}$	$1\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{7}{16}$	$\frac{3}{16}$	3	1	$4\frac{5}{16}$	$4\frac{1}{8}$	$3\frac{3}{4}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{16}$	15
$4\frac{1}{4}$	$5\frac{3}{4}$	7	4.8625	$4\frac{3}{8}$	$4\frac{9}{16}$	$1\frac{7}{8}$	$1\frac{3}{4}$	$1\frac{21}{32}$	$\frac{3}{32}$	$4\frac{1}{4}$	1	5.495	$5\frac{3}{8}$	$4\frac{7}{8}$	$\frac{1}{2}$	$\frac{11}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{8}$	15

it has been sharpened. The cutting-off tools are generally of the blade type, except when it is necessary to make them perform some part of the forming operation.

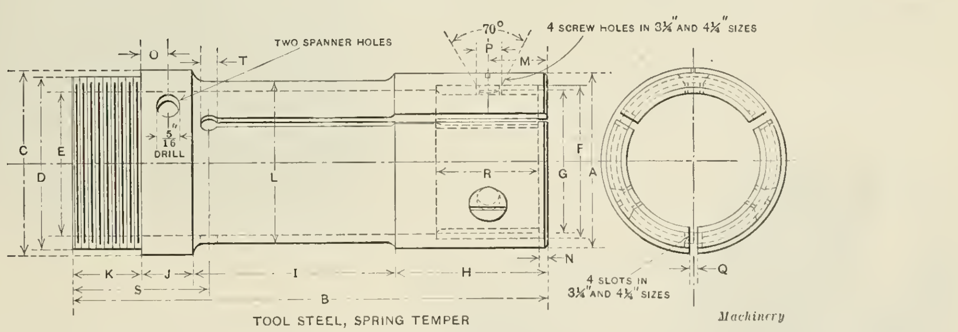
Forming and Cutting-off Tool-holders

Fig. 4 shows types of forming and cutting-off tool-holders used on the single-spindle turret lathe. That shown at *A* is known as the vertical tool-holder and is the type generally used, because the cutting tool can be held much more rigidly than in the other designs. The tool also can be ground on its top face without changing the form on the work, and it has a longer life than the straight forming tool.

When the piece to be formed has several plain diameters, the flat forming tool-holder shown at *B* is sometimes found convenient. This tool-holder, of course, is only used when there are a small number of pieces to be made and when the expense of making a vertical forming tool would not be warranted. It is also used when several narrow forming tools are required, spacing pieces being put in between the tools and the entire number clamped in the holder. Three adjusting screws are provided, as shown, so that three separate tools can be independently adjusted; they are then clamped by the other set of screws.

The plain forming tool-holder shown at *C* is sometimes used for forming back of the head of a screw or for similar work, so that the cutting-off tool is relieved of considerable work. It is also used for beveling the end of the bars before it is fed out, and thus assisting the turner in starting, especially in

TABLE 2. PRINCIPAL DIMENSIONS OF MASTER FEED CHUCKS FOR GRIDLEY SINGLE-SPINDLE TURRET LATHE



Size of Machine	Dimensions, Inches																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
$2\frac{1}{4}$	2.560	7	2.620	$2\frac{1}{2} \times 24$ P. L. H.	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{1}{4}$	3	$\frac{3}{4}$	1	$2\frac{3}{8}$	$\frac{7}{8}$	$\frac{1}{8}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{1}{8}$	$1\frac{1}{2}$	2	$\frac{1}{4}$
$3\frac{1}{4}$	$3\frac{5}{8}$	$7\frac{1}{8}$	3.745	3.580 × 18.P. R. H.	$3\frac{5}{16}$	$3\frac{1}{4}$	$3\frac{1}{8}$	—	—	$\frac{3}{4}$	1	$3\frac{5}{8}$	$\frac{7}{8}$	$\frac{1}{8}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{1}{8}$	$1\frac{1}{2}$	2	$\frac{1}{4}$
$4\frac{1}{4}$	$4\frac{11}{16}$	$7\frac{1}{4}$	4.808	$4\frac{5}{8} \times 18$ P. L. H.	$4\frac{3}{8}$	$4\frac{1}{4}$	$4\frac{1}{32}$	—	—	$\frac{7}{8}$	1	$4\frac{11}{16}$	$\frac{7}{8}$	$\frac{1}{8}$	$\frac{7}{16}$	$\frac{5}{16}$	$\frac{1}{8}$	$1\frac{1}{2}$	2	$\frac{1}{4}$

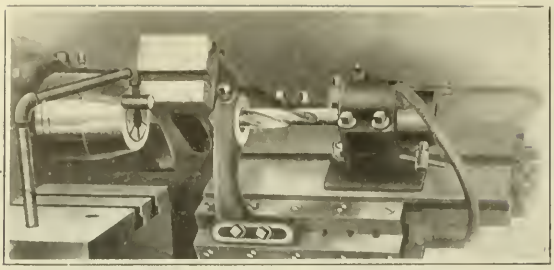


Fig. 6. Standard Type of Drill-holder and Drill-support in Operation

giving the back-rests a chance to support the work when the turning cut starts.

D shows the standard type of cutting-off tool-holder used on the single-spindle machine. This holder, as shown, is fitted with an adjustable taper wedge so that the cutting-off blade can be easily adjusted to correspond with the center of the work. Ordinary forged tools can be held in this holder or almost any type of blade inserted. When a large number of pieces are to be made it is advisable to use a blade-type of cutting-off tool and a holder. This simplifies the sharpening of the tool, as a blade-type tool has clearance all the way back

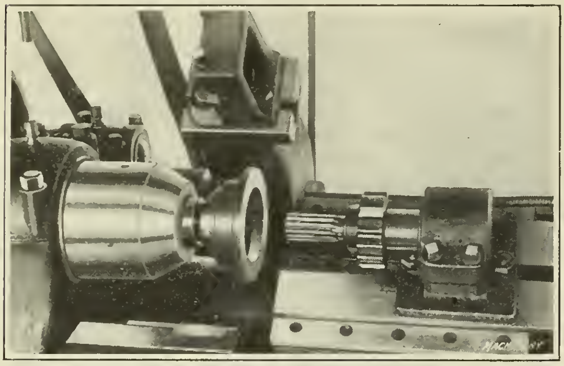


Fig. 7. Standard Type of Reamer-holder at Work

and to sharpen it is simply ground on the front end to the required cutting angle.

Tool-holders

The standard type of tool-holder used on the Gridley single-spindle turret lathe is shown in Fig. 2. This tool-holder is bolted directly to the turret slide and is bored out when in place on the machine so that the hole is in direct alignment with the spindle. It is held in place by means of two T-bolts, which, if desired, can be threaded; an adjusting screw laid in the T-slot in the slide can then be used for accurately adjusting the tool-holder longitudinally along the slide. This screw, of course, is provided with a collet head, and a plate attached to the rear end of the slide acts as a stop for adjusting purposes. The various tool-holders are numbered to correspond with the number of the tool-slide to which they are fastened when finished, and should be used only on the tool-slide having that number. They can be used, of course,

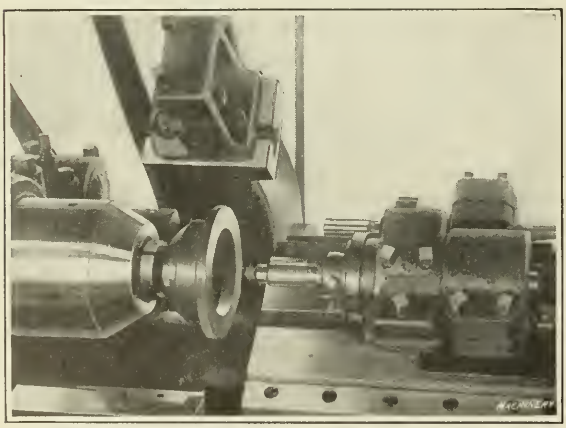


Fig. 8. Standard Holder carrying Reamer and Counterboring Tool

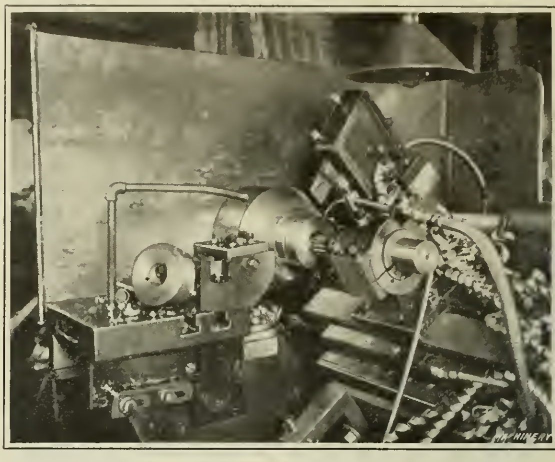


Fig. 9. Standard Tool-holder carrying Boring Tool

by the substitution of bushings and other independent holders for carrying facing tools, drills, pointing tools, etc. Fig. 5 shows a tool-holder arranged to hold a pointing tool. A separate bushing is provided for guiding the bar, and the pointing tool is held in another sleeve, the latter being retained in the holder.

Drill-holder and Support

In Fig. 6 is shown the standard tool-holder carrying a twist drill, which is held in a special chuck fitting in the holder, so constructed that an oil-tube can be inserted for supplying a coolant to the drill. The drill should be of the oil-tube type, so that the oil can flow directly to the cutting point. In addition, the drill is supported close to the cutting point, by means of an arm which is fastened to the turret in such a position

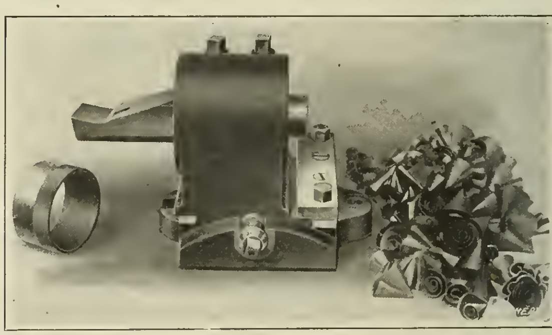


Fig. 10. Offset or Set-over Tool and Holder and Chip produced by it

that it is close to the end of the piece being drilled. The arm holds a bushing which fits the drill and accurately guides it in line with the work. This insures the tool starting concentrically and obviates the necessity of using a starting drill.

Fig. 7 shows a standard tool-holder carrying a reamer. The reamer is mounted so that it can float and is carried in a separate bushing in the tool-holder. In this illustration the screw for adjusting the main tool-holder longitudinally can be plainly seen, as well as the forged type of cutting-off tool, and the tool-holder for carrying separate forming tool blades. In Fig. 8 is illustrated another application of a reamer-holder, which is used in conjunction with a facing and counterboring tool. The reamer is of the shell type. The job shown is a

hub which is chucked by hand. Fig. 9 shows still another application of the standard holder. In this case it is used for carrying a boring tool, operating on a chucking job.

Knurling Tool-holder

The standard type of knurling tool-holder used on the Gridley automatic turret lathe is shown in Fig. 3. This has a

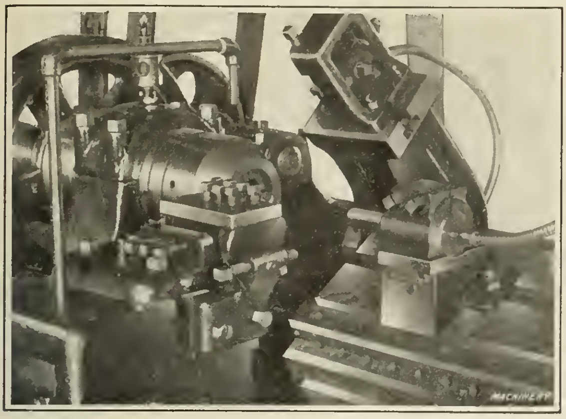


Fig. 11. Internal Necking or Recessing Tool

shank which can be held in the standard tool-holder and carries two adjustable slides that hold the spiral knurls. Two straight knurls can be used when it is necessary to produce a straight knurled effect on the work.

Set-over Tool and Holder

An interesting type of tool which takes the place of a drill for producing shallow holes (not more than one and one-half times its diameter) is shown in Figs. 10 and 12. This is known as a "set-over tool-holder," and it can be used with success on the Gridley turret because of the rigid construction of the latter. The cutting tool works the same as a forming tool, but instead of cutting on the outside surface of the bar, as the forming tool does, it cuts into the end of the bar, and as the holder which supports the tool has a set-over adjustment, the same cutting tool can be used for making holes of various diameters. It is not necessary to use a starting drill

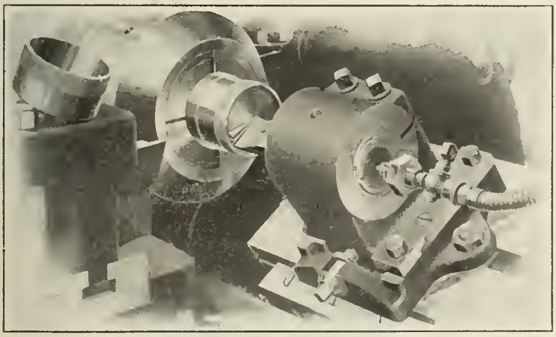


Fig. 12. Set-over Tool-holder in Operation on 3-inch Hole

with this tool and a counterbore can be dispensed with in most cases when the bottom of the hole in the piece is flat.

The cutting tool proper is made from high-speed steel with a hole through its center, so that the cutting edge is thoroughly flooded with cutting oil or compound. This tool is cheaper to make than a drill and can be used for making different sizes of holes, and also as a reamer. Fig. 12 shows the tool in operation, producing a hole that is three inches in diameter. Fig. 10 shows the kind of chips produced with this tool, and the set-over arrangement is also clearly shown. The holder carrying the cutting tool is mounted on a slide which is adjustable at right angles to the axis of the spindle by means of a collar-head screw, as illustrated. This adjust-

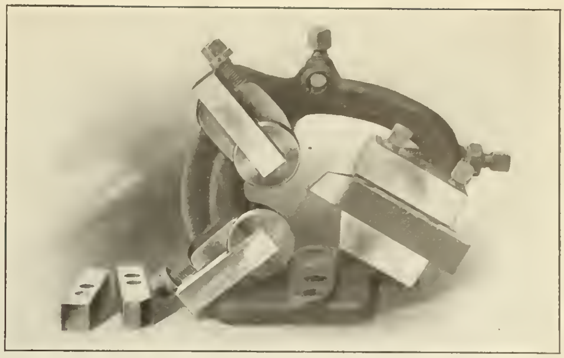


Fig. 13. Standard Type of Turner for Use on Gridley Automatic Turret Lathe

ment is made to secure the desired diameter of the hole in the work.

Internal Necking Tool

When it is necessary to make a recess in a hole so as to obtain a bearing at both ends, an internal necking or recessing tool of the type shown in Fig. 16 is used. This tool consists of a base *A*, which is clamped to the turret slide, as shown, and fulcrumed on this base at *B* is the main tool-holder *C*. This holder carries the recessing tool, which is held by a bushing and a clamping screw, as shown. The recessing tool is centered with the hole by means of the adjusting screw *D*, which has a collar head that comes up against the bracket *E* of the holder, and it also is provided with a nut for locking

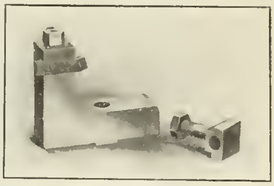


Fig. 14. Knee Turner for Roughing and Finishing Cuts

purposes. The shoulder of screw *D* is kept against the bracket by means of coil spring *F*, and after the tool has finished cutting, and the pressure is removed from the holder, the spring returns the tool to the central position. The recessing tool is fed to depth by means of a roller pusher *G* mounted in a bracket *H* attached to the edge of the forming slide, as illustrated. The roller bears against a hardened block that is held by screws to the side of the internal necking tool-holder proper. In using this tool for enlarging, or boring a hole, it is necessary, of course, to so arrange the forming cam that the forming slide will be advanced at the proper moment, dwell until the length of bore has been completed, and then be withdrawn. In recessing for a thread or internal form, it is necessary to advance the turret slide and dwell until the forming slide has been fed in to the required depth.

An internal forming or recessing tool that differs slightly from that shown in Fig. 16 is illustrated in Fig. 11. The design in this case is not quite so elaborate; the tool is operated from the forming slide in a similar manner to that shown in Fig. 16.

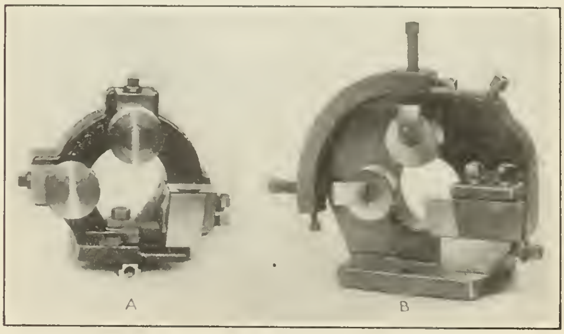


Fig. 15. Standard Turners used on $4\frac{1}{4}$-inch Gridley Automatics

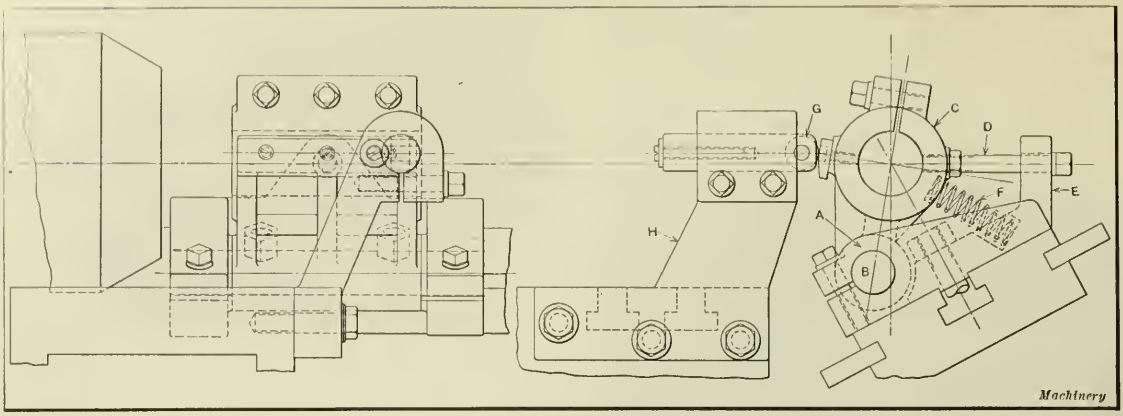


Fig. 16. Another Type of Internal Necking or Recessing Tool-holder

Turners and Back-rests

A noticeable feature of the standard turning tool shown in Fig. 13 is the absence of a shank. This holder is in the form of a yoke having a base that is rigidly clamped to the turret slide. At the front it carries a turning tool and at the rear two supports; the latter can be either of the plain type or of the roller type, as shown. The cutting tool in the turner for the 2¼-inch machine is 1 by ½ inch and is ground on the end, as shown. The roller rests permit the use of heavier cuts and coarser feeds, and a cutting speed of two or three times that which can be maintained when the common type back-rest is used. These back-rests may be used either ahead of or behind the cutting tool, depending upon the character of the work and the cut being taken.

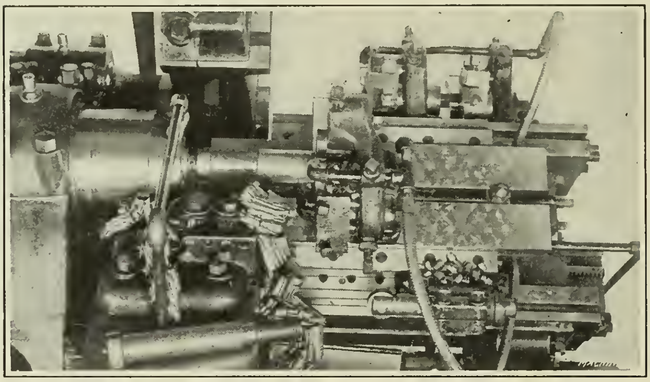


Fig. 17. Standard Turner and Flat Forming Tool working together on Shoulder Screw

Fig. 17 shows one of these standard turners at work producing a shoulder screw with the forming tool at work at the same time. Forming and turning can be done simultaneously with good results, as the desired rigidity can easily be obtained. This particular setting was used to save time on the single-spindle machine, but if the same job were done on the multiple-spindle machine, two or more turning cuts would be made, thus obviating the necessity for the wide forming cut in the first operation. The same illustration also shows the adjusting screw for moving the standard tool-holders in a longitudinal direction along the turret slide, to which reference has been made in the foregoing.

At *A* and *B*, Fig. 15, are shown two types of standard turners used on the 4¼-inch automatic turret lathe. The one shown at *A* uses a dovetail turning tool, whereas that illustrated at *B* uses a forged tool. In both cases adjustable roller supports are used.

Another type of standard turner, known as an "adjustable stud turner," is shown in Fig. 18. This turner is so arranged that three different diameters can be finished at the same time. It consists of a holder proper, which is clamped to the turret slide and carries individual units, one unit for holding the cutting tool and the other for the back-rest or support. Usually the first support of the group is provided with rollers because of the heavier duty required in this position. The turning tools are adjusted by means of a collar-head screw, as illustrated, and adjustment is also provided for the back-rests.

Fig. 19 shows a special stud turner. This is almost of the same design as the adjustable stud turner, except that it is made for a given piece of work and is not adjustable for shoulder distances, that is, longitudinally. The tool-holder proper is solid, as illustrated, and carries, in this case, five turning

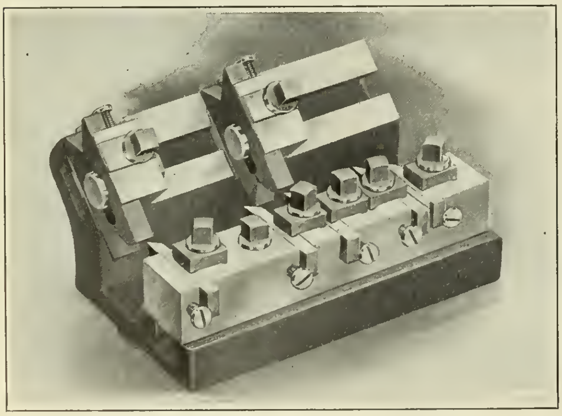


Fig. 18. Standard Type of Adjustable Stud Turner

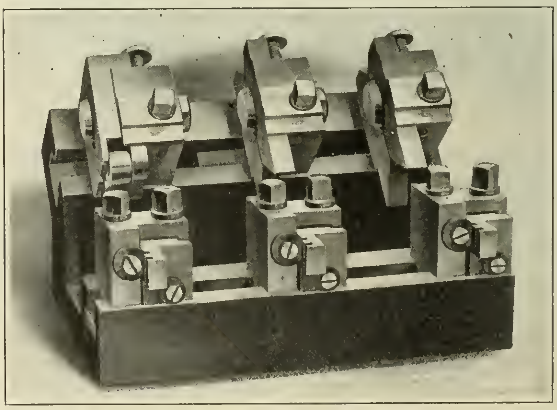


Fig. 19. Special Type of Adjustable Stud Turner

tools. The supports are held so that they can be adjusted along the slide or holder to bring them in the most convenient position relative to the work, that is, where they can give the best support. When the required number of pieces have been made, this tool is put away without disturbing the cutting tools and can be kept until the same piece is to be produced again. In the arrangement shown, it is possible to put the cutting tools much closer together than in the holder shown in Fig. 18.

Knee Turner

Fig. 14 shows a type of tool known as a "knee turner," which can sometimes be used to good advantage for removing scale from the work by preceding the drill, reamer or other tool being used. It is narrow, so that it takes up very little space, and can be used in conjunction with some other tool. It cuts on the back side of the bar, so that the forming tool can be operated without backing off the knee turner from the work to get it out of the way.

Feeds and Speeds for Turning

The feeds and speeds used on the Gridley turret lathe when using the standard turners vary considerably and are governed entirely by the material and nature of the cut. Because of the rigidity of the machine, it is generally advisable to use a coarse feed and a comparatively slow speed. This statement applies especially in the production of studs or other work when the amount of metal to be removed is considerable. When only light cuts are to be taken, however, it is preferable to increase the speed and decrease the feed, although, as a general rule, the speed can be increased without any corresponding decrease in feed and still give satisfactory results, owing to the elimination of chatter. Each different piece, however, requires a careful analysis of the conditions to be met in order to determine exactly what feed and speed should be used.

* * *

GRINDING-WHEEL GRADES

"Grade" is a word used to designate the relative hardness of any given grinding wheel. Different methods of indicating grade are in use, the most common employing the letters of the alphabet. One company uses the first letters of the alphabet for the harder grades, the middle letters for the medium grades, and the last letters for the softer grades. Another company uses just the reverse of this method, while others use a system based upon some particular word. Grade is determined by measuring the resistance which a wheel offers to the penetration of a small steel tool resembling a screwdriver. The wheels under inspection are compared with wheels of known hardness, so that all variable factors are reduced to a minimum. The belief is quite common that a grade is an exact value. A grade is not an exact value—it is a range between limits, and all wheels that come within this range are of one grade and carry the same grade letter. A test was made to determine the hardness of each grade as indicated by the tensile strength. A lot of wheels all of the same dimensions and the same size of grain, but of different grades, were slowly speeded up to a point where centrifugal force became greater than the tensile strength of the wheel, and breakage occurred. The number of points per square inch tensile strength to which each wheel was subjected was calculated, and from these figures the following results were plotted: The tensile strength of grade O, Norton scale, ranges between 2100 and 2050 pounds per square inch; grade N, between the limits of 2050 and 1975; grade M, between 1975 and 1875; grade L, between 1875 and 1790; grade K, between 1790 and 1700; grade J, between 1700 and 1600.—*Condensed from talk by R. G. Williams of the Norton Co.*

* * *

The firm of Isaac Best & Co., Ltd., Newton Heath, Manchester, England, recently made what is claimed to be the longest twist drill ever produced. The length of the drill is seven feet. No statement is made of the object of making so long a drill. The makers are patentees of machines for fluting twist drills and reamers and for backing off such tools, and possibly the drill was made merely for advertising purposes.

THE TUMBLING BARREL

BY G. R. SMITH[1]

One of the oldest and simplest metal-working devices, and perhaps the most useful in its field, is the tumbling barrel. Its operation requires but a small amount of power and the attention of one unskilled workman. The idea involved is not of recent date; it is as old as mankind itself, being simply an adaptation of the oldest of all ideas for cleaning. Have you ever seen your grandmother clean the inside of a stained bottle by shaking in it a few small stones and a little water? That is the principle. The Aztecs cleaned and polished their gold trinkets by placing them in a gourd with a little fine sea sand sifted through bits of porous hides and then shaking the gourd until the gold was clean and bright. The trinkets were brought to a still brighter state by replacing the sand with dry fish scales and again shaking. That is the tumbling barrel in its first form; both the idea and the materials used to help the process and get the desired results are old. In a study of the habits and customs of the savage tribes all over the globe, the same idea is found time and time again; we have simply commercialized it for our use.

About the first tumbling barrel of real commercial value was made by an English inventor, William Lee, between 1585 and 1590; it was used to clean the iron and steel parts of a machine for knitting stockings. The idea was speedily adopted until the tumbling barrel became widely known. Lee's barrel was a crude, hand-propelled apparatus, but the idea was brought out in such a way as to show at once its value. The idea involved, however, is not the product of a certain train of thought, as is the case with many inventions, but rather the development of Nature's own bent. Perhaps the simplest people, the crudest minds, received the idea from seeing the stones whirled around in the pot-holes in the rocks of the streams and rivers receiving a polish by the constant motion caused by the flow of water; be that as it may, the idea is old, simple, cheap and effective.

According to the dictionary, the word tumble or tumbling means to fall suddenly, to roll about, to turn over, a rolling over. That explains the process and is exactly what takes place inside the tumbling barrel when it is in motion and what must take place to make the process a success. This is the one factor the writer wishes to bring out more than anything else. Each piece in the barrel rolls and falls over the other pieces, rubbing and chipping off whatever foreign substance may be clinging to the pieces with which it comes into contact. Whatever material, such as sand, sawdust, etc., may be placed in the barrel with the work is only to aid the process of cleaning; the falling motion of one piece over another is what does the work. If sand and cork, or sawdust, are used with heavy steel work, the sand helps the cleaning process, and the cork, or the sawdust, absorbs the dust that comes from the process and in a way helps to polish the work. If sawdust alone is used, it lessens the severity of the blow of one piece against the others and helps the cleaning process.

Cleaning and Polishing Work by Tumbling

In all cases where tumbling is done to clean and polish the work, it is the falling and tumbling of each piece over the others that effects the cleaning and polishing, not the material that is placed in the barrel with the work. The work would clean itself if nothing were mixed with it; therefore, no matter what may be the nature of the work being tumbled, sufficient space must be left in the barrel for it to do its work. Nothing at all will be accomplished if the barrel is filled too full of work or the work mixed with so much sawdust, sand or cork that it is mechanically impossible for the pieces of work to strike against one another. One rule that may be laid down for all classes of work and all sizes of barrels is that the work to be tumbled and the material used to help the process, such as sawdust, etc., should not occupy more than one-third the space inside the barrel, while one-fourth the space is a better ratio to insure success. Many foremen are making a success of tumbling operations by placing in the barrel nothing but the work to be tumbled.

[1]Address: 19 Pond St., Pittsfield, Mass.

So varied is the procedure to get different results on different classes of work that it is out of the question to lay down a set of prescribed rules. Small work, such as very thin sheet-brass blanks, copper blanks, etc., should not be tumbled at all. The same result may be secured much more quickly and at less expense by pickling or the bright dip. There should be little necessity for tumbling punched parts of this kind, for if the blanking tools are kept in shape and ground, there will be no burr, and certainly they should not need annealing in the blank. Small brass and copper castings or drop-forgings may, if really required, be cleaned by tumbling in sand.

One cause of failure is the allowance of insufficient time in which to obtain the desired results. All work must be run until thoroughly treated, whether it takes one hour or ten. The operation costs next to nothing, but it must continue until the result is reached. Nothing can hurry the process and the results of six hours' tumbling cannot be expected in one hour. Another cause of poor results or failure is the amount of sand or sawdust used in proportion to the work. In tumbling five cubic feet of work the writer would not mix more than one and one-half to two cubic feet of sand, sawdust or cork. This must be measured by volume, or quantity, and not by weight, as that is another cause of failure; the sand, sawdust and work will weigh in greatly varying proportions.

Copper and brass punched parts are successfully tumbled for burrs in soft-wood sawdust in from two to four hours. Steel and iron parts may be tumbled in sea sand for burrs, scale in annealing, etc., in from three to six hours' run. Burrs and annealing scale have been removed from steel blanks, say 4 to 6 inches in diameter and 1/8 inch thick, in a five-hour run, with a mixture of sea sand and scrap cork (say two parts cork to two parts sand, by volume, not weight), and this mixture run dry in a ratio of 1 to 4 or 1 to 5 of the steel blanks. Steel blanks 6 inches in diameter and 1/8 inch thick have been tumbled to a good bright finish in a five hours' run in a barrel of one cubic yard capacity, using one-third as much pure sand as work and the whole load being but three cubic feet. Punched copper commutator segments have been successfully tumbled for burrs in a three hours' run in a barrel of one cubic yard capacity, using one-third as much pine sawdust as work and loading the barrel about half full. Machine-steel punched hinge parts that have been annealed and formed have been tumbled for burr and annealing scale and brought to a bright finish in a six hours' run in a one-cubic-yard barrel, using one-fourth as much pure sand as work and limiting the load to three cubic feet. Green-clay and sand molded castings have been successfully cleaned in a four hours' run in a two-cubic-yard barrel, nothing being placed in the barrel but the castings, and loading to one-third its capacity.

Partly finished or partly polished steel goods are often successfully tumbled in scrap leather to get a higher polish; this is simply an adaptation of the Aztecs' idea of shaking gold trinkets in a gourd with dry fish scales. The waste shavings and dust that come from the manufacture of fiber parts are also used for tumbling steel goods. In fact, all materials used to help the tumbling process should be, and generally are, wastes from other manufactures.

Silver plating has been done in the tumbling barrel by mixing a heavy mixture of chloride of silver, water and common salt with granulated cork. Small brass parts tumbled in this mixture take a very good plate in from one to three hours. The process is simply the rubbing of this mixture on the brass goods by the granulated cork.

The polishing or glaze mill used in the manufacture of rifle powders is nothing but a tumbling barrel. It is a polished, maple-lined barrel, into which is placed a quantity of powder as it comes from the corning mill; the falling motion of each grain over the others gives it the deep glazed luster.

Wooden handles, knobs, etc., are successfully cleaned and smoothed by tumbling with bits of torn sandpaper, a common oil barrel hooked up on a shaft being generally used. The writer has given a good manufacturing finish, in two hours' run in a sixty-gallon oil barrel, with twenty-four sheets, 10 by 12 inches, of torn sandpaper, medium grade, loading the barrel to one-third its capacity. This gives a good finish for dipping in asphaltum or white enamel broken up in gasoline. Horn goods, clam- and oyster-shell novelties, bone products, etc., are cleaned and polished by tumbling. They are seldom mixed with any other materials.

All woods, most metals and many compositions may be successfully tumbled for cleaning and polishing. The type of tumbling barrel used has little to do with the process, as one barrel is as good as another, except perhaps in convenience The speed of the barrel is, of course, an important item; it must not be run so fast as to carry the work around in a solid mass, and it must be run slow enough for the pieces to fall and tumble over one another. To be effective, the barrel should make from thirty to sixty turns a minute. Personal judgment and experience must establish the rule in each individual case. In no case should work be tumbled if the same result can be reached more quickly and cheaply by other means, nor should work be dipped, pickled, scratch-brushed or polished that can be satisfactorily tumbled.

* * *

USE OF FORMED SOLDER

In manufacturing articles having many soldered joints difficult to reach, it is good practice to furnish the solder punched or formed to fit the seam, as the time, labor and solder saved are important considerations; moreover, the formed solder is more likely to reach every part of the seam and insure a tight joint.

Fig. 1 shows a solder link stamped from a thin sheet of solder which is used by the Ford Motor Co. in making radiators of the tubular type. The radiator element is built up of vertical rows of tubes pressed through thin copper plates. The ends of the tubes must be soldered tightly into the water chambers. The solder links are dropped over the ends of the rows of tubes and are melted with a blow-torch, as shown in Fig. 2. The solder, being applied all around the tube in link form, runs down the tube to the tube sheet and makes a practically perfect soldered joint on five tubes simultaneously. It is obvious that much time is saved by the use of formed solder links in confined spaces like this; in fact, it would be practically impossible for the workman to apply solder to all the tubes in a reasonable length of time unless it were furnished him in the stamped shape.

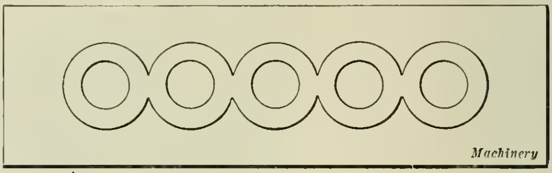


Fig. 1. Solder Link used in making Ford Radiators

Fig. 2. Soldering Vertical Tubes in Water Chambers of Ford Radiators

SPECIAL-PURPOSE TURRET LATHE WITH BALL-BEARING SPINDLE

BY T. S. MACEWAN [1]

A heavy-duty, 32-inch turret lathe, recently designed by Charles H. Hollup and built by the Vilter Mfg. Co., Milwaukee, Wis., is shown in Fig. 1. The details of the headstock design were given the most careful consideration, with the result that ball bearings were used on the spindle and a cone clutch was provided for quickly throwing the back-gears in and out.

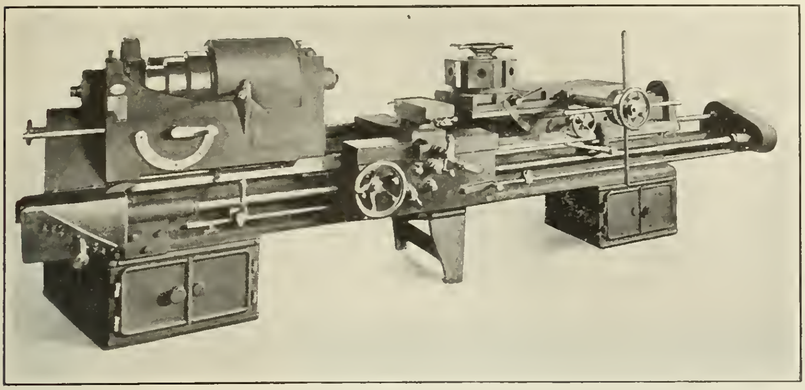


Fig. 1. Heavy-duty 32-inch Turret Lathe

A lathe, to be a profitable investment, must be capable of producing properly machined pieces day in and day out with the minimum of attention. This means that the working spindle must be held rigidly and must be free from chatter under operating conditions, and it must be mounted to withstand the tool pressure and thrust imposed. To produce good work, a spindle bearing must be free from shake and hold the spindle tight. A great many people claim that it is impossible to keep a bearing in this condition for any length of time without adjustment, and that wear begins at the time of starting, soon resulting in looseness. While a countershaft bearing, or a bearing for any kind of shaft that does not carry a cutter or work that is being cut, can be slightly loose without serious effect, in a spindle where smooth work is expected, absolute tightness must be preserved. This rigidity of the spindle not only eliminates chatter where heavy cuts are taken with single-point tools, but permits a light finishing cut to be taken with a wide shaving tool. Further, any shake during the cut due to the varying cutting depth of the tool is prevented.

In Fig. 2 it will be seen that the front bearing surfaces of this turret lathe comprise two S K F double-row, radial, self-aligning ball bearings mounted in a through bored housing, with end caps bolted to the frame to make an enclosed type of bearing combination. The machining of parts is simplified and greater ease in erection is secured through the use of ball bearings. Two ball bearings are also located in the three-step cone pulley, which is bored to correspond with the outside diameter of a standard bearing. When running loose, the gear load for the driven gear mounted on the lathe spindle is taken by one of these bearings.

The operating thrust load, of which there is a small component in turning and a heavy one in boring work, is taken on the set of balls of the double thrust bearing mounted at the rear of the spindle. Where the turning is done toward the direction of the tailstock, the thrust is in the opposite direction to the forward thrust, and the load is properly taken care of by the reversal of the double thrust bearing and the assumption of the load by the other set of balls. When the back-gears are to be brought into play the clutch is thrown in so that gear A drives the corresponding back-gear. With direct drive the clutch is thrown in the opposite direction, so that the cone pulley drives directly through the spindle to the work. The cross-feed screw of the carriage is provided with a thrust ball bearing, by means of which undue wear and the resulting lost motion are eliminated.

[1] Address: S K F Ball Bearing Co., Hartford, Conn.

* * *

Methods employed in manufacturing are sometimes directly opposite in principle to those that would naturally be followed when making the parts by hand one at a time. These manufacturing methods have been adopted because they overcome difficulties of handling and promote rapid production. For instance, in making motor car top curtains, the Ford Motor Co. follows the practice of sewing the celluloid windows to the fabric before cutting the openings. The fabric holds its shape during the sewing operation and there are no holes to catch on the machine and interrupt the operation. When the sewing is done, the openings are cut with a sharp forked knife which slides over the celluloid and cleanly cuts or rips the fabric close to the seam. This method not only saves the sewing operator's time, but also permits the openings to be cut much more evenly and expeditiously than would be possible by following the reverse and natural process.

* * *

In order that German letters patent issued to American citizens shall not lapse because of the non-payment of taxes, or other necessary fees, a recent presidential proclamation permits such payments to be made throughout the duration of the war.

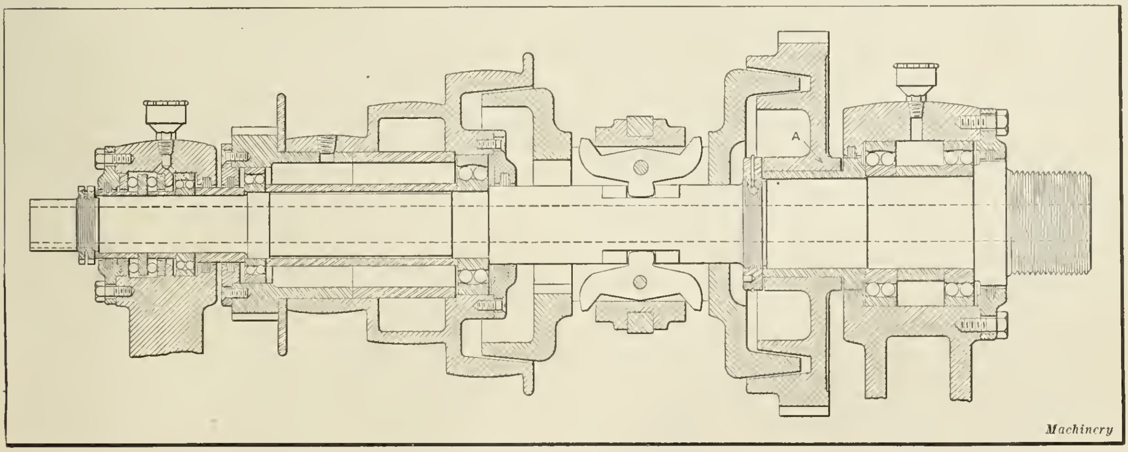


Fig. 2. Spindle of Special-purpose Turret Lathe

INDUSTRIAL OXYGEN EXPLOSIONS

CAUSES OF RUPTURE OF STORAGE CYLINDERS USED IN WELDING AND CUTTING OPERATIONS

BY EDWARD K. HAMMOND[1]

During the period in which oxy-acetylene welding and cutting were in process of development, the explosion of an acetylene generator was not an unusual occurrence, accidents of this kind being due to generators of unsuitable design and improper methods of handling the gas. An increase of knowledge on this subject was the means of practically eliminating these sources of danger. Recently there have been several serious explosions of oxygen used in connection with acetylene in the welding and cutting of metals. It has become a matter of general knowledge that acetylene must be handled with care, but many users of oxy-acetylene torches do not realize that there are dangers connected with the use of oxygen of unknown purity, and, as a result, serious accidents are likely to occur. This is due in part to the fact that some manufacturers of electrolytic oxygen generators have unwisely advertised the statement that their machines are fool-proof and can be safely operated by laborers of average intelligence. This may be the case so long as everything goes properly, but it requires a particularly intelligent attendant to detect an abnormal condition of operation before a lot of dangerous gas has been generated and sent out to the welding shop. An inquiry made by MACHINERY to ascertain the different sources of danger connected with the use of commercial oxygen or the operation of electrolytic oxygen generators, and the precautions that should be taken to avoid accidents from these causes, has revealed the information outlined in the following article.

In starting upon this discussion, attention is called to the fact that commercial oxygen may be produced by either of two processes. The first is generally known as the liquid air method, which consists of liquefying air by the application of pressure and reducing the temperature, and then separating the oxygen from the nitrogen by taking advantage of the difference in boiling points of the two liquids. Oxygen produced in this way cannot explode through the presence of impurities, because these impurities are nitrogen and other gases which are chemically inert. The second method of obtaining oxygen is by the electrolysis of water, and here there is a possibility of accidents due to hydrogen being present in sufficient quantity to make a mixture that is highly explosive. This danger is theoretical rather than practical, so long as the proper precautions are taken in the operation of electrolytic generating plants; but where there is lack of care in attending to generators or where the generators are of unsuitable design, this danger may prove serious.

Theoretically, the explosion of a mixture of hydrogen and oxygen results in the combination of two volumes of hydrogen gas with one volume of oxygen; but while this is the mixture required for a complete explosion, experience has shown that there is a wide range of mixtures that constitute what may be called a danger zone, *i. e.*, mixtures that may explode with violence under certain conditions. This question was considered of sufficient importance to warrant an investigation being undertaken at the Pittsburg Laboratory of the Bureau of Mines, where it was found that mixtures ranging from 9 per cent of hydrogen and 91 per cent of oxygen up to 92 per cent of hydrogen and 8 per cent of oxygen were likely to give trouble. This is more liberal than limits established by the Davis-Bournonville Co., Jersey City, N. J., a well-known manufacturer of welding and cutting equipments, including oxygen generators. In this company's laboratories the danger zone was found to cover a wider range, extending from 6 per cent of hydrogen and 94 per cent of oxygen down to 97 per cent of hydrogen and 3 per cent of oxygen. The idea of this danger zone will be best understood by reference to the tabulated figures, the brackets representing the range of explosive mixtures. Here it will be evident that mixtures of hydrogen and oxygen represented by the high and low limits, and all mixtures coming between these limits, may be made to explode under suitable conditions.

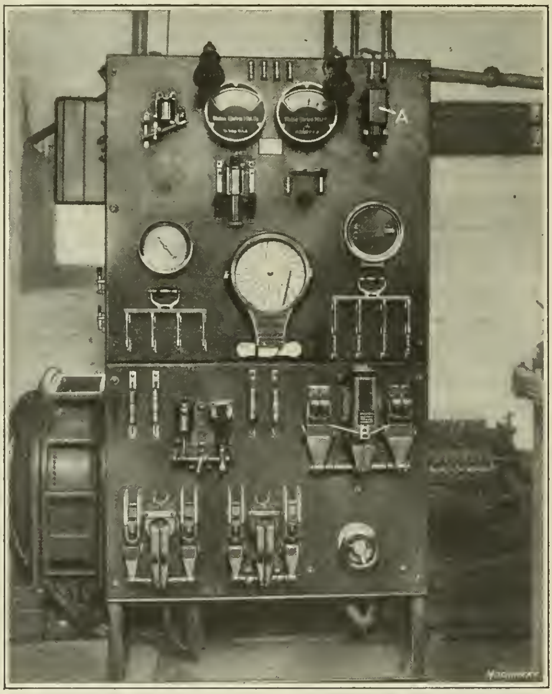


Fig. 1. Switchboard equipped with Automatic Switch to prevent Reversal of Polarity of Generator

Oxygen	Hydrogen
100	0
98	2
96	4
94	6
91	9
8	92
6	94
3	97
2	98
0	100

Note—Brackets inside the columns represent range of explosive mixtures, as determined by Bureau of Mines; and brackets outside the columns cover range of mixtures found to be explosive by the Davis-Bournonville Co.

Investigations conducted with the view of determining the cause of oxygen explosions that have resulted disastrously have led to certain important modifications in the design of electrolytic generators and auxiliary equipments to prevent the recurrence of such accidents. In the operation of an electrolytic cell, decomposition of water results in liberation of hydrogen at the negative electrode of the cell, while oxygen passes off from the positive electrode. The cells are so arranged that gas collected from each of these electrodes is passed into containers provided for the hydrogen and oxygen, respectively. Should it happen that the polarity of the generator is reversed, it would result in a corresponding reversal of the polarity of the cells, so that oxygen would be collected in the container provided for hydrogen, and *vice versa*.

As a matter of fact, this has been the cause of some serious accidents, and a study of the subject led to the provision of safety devices which make it impossible for trouble of this kind to occur. The safeguard consists of an automatic switch, which makes connection with the electrolytic cells only after the generator has reached normal speed and is developing its normal electromotive force. The necessity for this provision arises from the fact that at any time when the operation of a generator is stopped there is a tendency, while the armature is still turning over by inertia, for a counter-electromotive force to be built up in the cells. This may reach sufficient proportions to overcome the magnetic force of the field windings

[1]Associate Editor of MACHINERY.

of the generator, so that when it is again started the generator will operate with its polarity the reverse of normal and supply energy of a correspondingly reversed polarity to the electrolyzers.

Should such a condition exist, it is obvious that hydrogen would be delivered to the oxygen gas-holder and oxygen to the hydrogen gas-holder, thus forming a dangerous mixture with the gas already in these holders. But with the automatic switch referred to, there is no danger of this trouble, because the generator will have assumed a normal speed and developed its normal electromotive force before the switch can be closed to allow current to pass through the cells. This method of safeguarding the connecting of the electrolyzers to the power supply makes it impossible for a counter-electromotive force in the cells to overcome residual magnetism in the windings of the generator. In the switchboard illustrated in Fig. 1, the switch shown at A is for making connection between the generator and cells, and is automatically closed by magnetic coils B when the generator speed and voltage have reached the normal figure. When the electric generator is stopped, the circuit through the electrolytic cells is automatically broken.

To further assure against trouble from a counter-electromotive force in the electrolytic cells due to causes outside the plant, such as the reversal of phase in the motor supply circuit, transposition of connections at the electrolytic cells, etc., use is made of a polarized relay connected to a special shunt. This provides for opening a single-pole relay in the control circuit, and the only way in which this circuit may be re-established is to close the relay by hand, provided the polarity has been restored to normal. If a plant is equipped with this system of control, reversal of polarity is indicated by failure of the electrolytic cells to operate. It is important to note that the generator used in connection with electrolytic cells should be of the shunt-wound type, because with compound-wound generators there is greater danger of reversal due to the counter-electromotive force in the cells passing through the series turns.

In addition to danger of the generation of explosive mixtures of oxygen and hydrogen through a reversal of polarity of the generator, trouble may also be experienced through improper connection of the terminals of electrolytic cells. As a

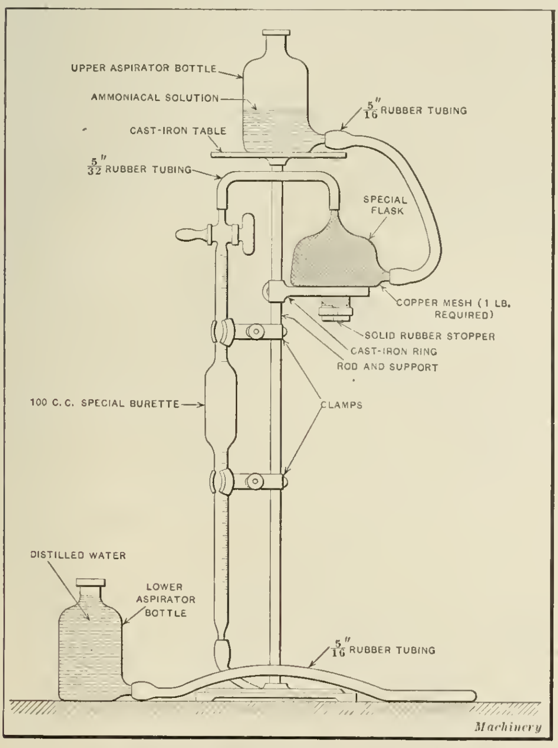


Fig. 2. Apparatus for determining Purity of Oxygen by Absorption with Metallic Copper

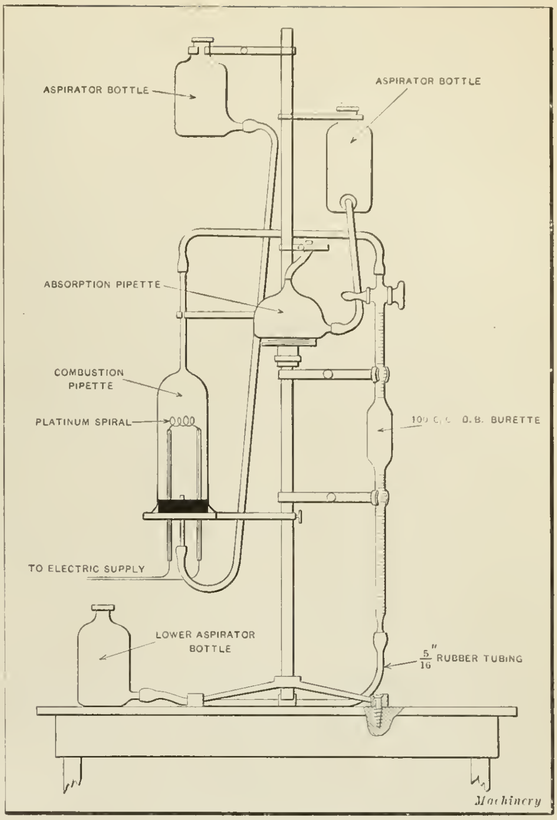


Fig. 3. Apparatus for determining Percentage of Hydrogen by Combustion Method, and Percentage of Oxygen by Absorption with Metallic Copper or Sticks of Phosphorus

matter of fact, this was the cause of a serious explosion which occurred in St. Louis some time ago. With the view of preventing accidents of this kind, the Davis-Bournonville Co. and other manufacturers of electrolytic cells have designed their electrical connections in such a way that it is impossible to connect them with the wrong polarity.

There is only one way to be sure that the purity of oxygen generated in electrolytic cells is up to the required standard, and that is by making chemical analyses at intervals of at least two hours. As a matter of fact, these analyses are simple to make and do not call for extensive technical knowledge of chemistry. Several methods are employed, the most common one being that of measuring one hundred cubic centimeters of gas into a burette and then running this gas over into another burette in which the hydrogen is burnt out by a platinum coil, which is raised to a red heat. The gas is then returned to the first burette and again measured, the contraction in volume expressed in cubic centimeters representing the percentage of hydrogen in the gas.

Other methods of determining the purity of oxygen consist of running the measured volume of gas into a second burette containing either pure metallic copper or sticks of phosphorus. Both these materials have the power to absorb oxygen from the mixture of oxygen and hydrogen, and after this absorption has been completed, the hydrogen is returned to the burette and measured. The contraction in this case represents the percentage of oxygen present. Standard apparatus can be purchased for making all these tests. In practice, it is customary to get a purity of 99.7 to 99.8 per cent for hydrogen and a purity of about 99.5 per cent for oxygen. If the purity of hydrogen runs below 99.5 per cent or the purity of oxygen is found to be below 99 per cent, it is considered that the generator is operating unsatisfactorily, and the man in charge of the station immediately proceeds to look for the cause. Where this precaution is taken, there is little danger of trouble from the use of electrolytic oxygen, because a high factor of safety is provided.

Experience has shown that in the presence of oil there is danger of an oxygen cylinder "exploding" from what may properly be termed "spontaneous combustion" of the cylinder, although the gas is pure oxygen without any trace of hydrogen. This is due to the fact that the action of oxygen under high pressure—usually about 1800 pounds per square inch—results in oxidation of the oil, thus raising the temperature sufficiently to start the oxygen acting upon the iron cylinder, which is burnt away and allows the high-pressure gas to expand rapidly. This could not properly be called an explosion, because an explosion is usually understood to mean rapid combustion accompanied by rapid expansion. However, the condition that exists when the high-pressure oxygen is allowed to expand suddenly is similar to a true explosion, and the results have been serious in some cases. In this connection it is of interest to note that oxygen produced by the liquid air process and oxygen generated in electrolytic cells are equally likely to give trouble. Recently, the statement was made that this source of trouble could be eliminated by substituting graphite as a lubricant in place of oil, but experiments conducted by the International Oxygen Co., the Davis-Bournonville Co. and others show that graphite is just as dangerous as oil.

Still another hypothesis has been advanced as to a source of danger from the explosion of hydrogen. Reference has already been made to the fact that experimental data show that there must be at least 6 per cent of hydrogen in the oxygen to make the mixture explosive. This refers to 6 per cent of hydrogen uniformly mixed through the entire volume of oxygen. Readers of MACHINERY are doubtless familiar with the so-called kinetic theory of gases, otherwise known as the theory of uniform diffusion. According to this theory, the constituents of mixed gases are kept uniformly distributed, due to the kinetic action of molecules of the gas. For instance, a mixture of hydrogen and oxygen containing 3 per cent of hydrogen would have the hydrogen uniformly mixed through the 97 per cent of oxygen, and as it has already been mentioned that a minimum of 6 per cent of hydrogen is required to make the mixture explosive, it will be apparent that there would be no danger with this gas under normal conditions.

In practice, accidents have occurred through the explosion of oxygen cylinders in which the head has been blown out of the cylinder, and investigations conducted to determine the cause of these accidents have led to the belief that under the high pressure which exists in an oxygen cylinder—amounting to approximately 1800 pounds per square inch—the theory of uniform diffusion is not effective; it is assumed that under these conditions of pressure the gases settle out into strata, according to their specific gravities, the result being that the hydrogen rises to the top of the cylinder. This action may not be complete, but if there were a tendency for such settling out to occur, it could easily result in producing an explosive mixture of hydrogen and oxygen at the top of the cylinder, even though there were not sufficient hydrogen to make the entire mixture explosive. If such conditions can be developed, it is apparent that flashback or other cause of ignition would immediately ignite the mixture and result in the explosion of the gas in the cylinder. The theory is interesting, although it has not been definitely established by a carefully conducted scientific experiment. An accident of the same kind might also be produced through the action of oxygen on the oil used to lubricate the valve.

In handling oxygen cylinders, it should always be borne in mind that the gas is under high pressure, and as a result it requires intelligent care to prevent accidents. Cylinders should not be dropped or handled roughly, and they should not be placed so that they can be easily overturned either by collision with some other object or by the reaction due to the violent escape of their contents through the safety outlet with which each cylinder is provided. The valve regulating devices and other attachments should not be lubricated with oil for reasons to which reference has already been made. Discharge valves should be opened slowly and special care should be taken to avoid twisting or straining the valves by the use of hammers or improper wrenches.

Much valuable information has been gathered by members of the Committee on Production of Electrolytic Oxygen and Hydrogen which has been appointed by the Compressed Gas Manufacturers' Association, Inc., 120 Broadway, New York City, concerning possible dangers connected with the use of oxygen in the operation of cutting and welding torches. Distribution of information concerning the proper way to use oxygen and the safeguards that should be taken to avoid accidents will doubtless be the means of overcoming much trouble from this source.

* * *

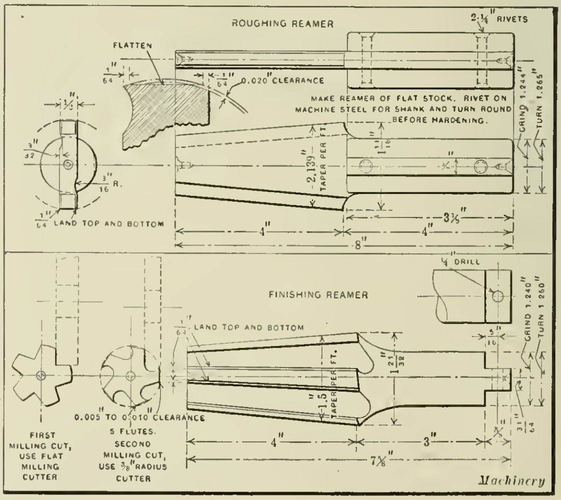
TAPER MACHINE REAMERS

The taper machine reamers shown herewith have been successfully used by the Brown-Lipe-Chapin Co., Syracuse, N. Y., by whom they were developed. The roughing reamer has two cutting edges, and the main body is made from a flat bar of steel, approximately ½ inch thick. After being cut to length, it is centered and turned to the desired contour. Two flat pieces of machine steel are riveted to the body to form the shank, and turned, leaving a sufficient amount for grinding. The chief difference between this taper roughing reamer and other types is the way in which it is ground and backed off. Just in front of the cutting edge a liberal radius is milled to a depth of 3/32 inch. This not only gives adequate clearance, but furnishes a well shaped surface for chips to slide upon. The taper is first ground accurately until the large end is of the correct diameter. After this, the curvature of the two flutes is flattened, leaving only 1/64 inch of the curved surface produced by grinding. Next the reamer is oscillated on the centers by hand and a clearance is ground radially on the edge back of the flute. The clearance in this case is 0.020 inch, as shown in the upper view of the illustration.

Finishing Reamer

The finishing reamer is five-fluted and is milled from a solid forging. Two cutters are used in milling the reamer. The first is a plain right-angle cutter, which is followed by one of ⅜ inch radius. The latter produces the under-cut, which makes these reamers so effective. After the reamer is ground, the flutes are flattened the same as in the roughing reamer. The radial clearance, however, on the back of each tooth is less than in the former case, varying from 0.005 to 0.010 inch. This reamer is fitted at the driving end so that it may float freely when in use.

An advantage that these reamers have over many others is the fact that they actually cut the metal rather than scrape it. Another advantage is the fact that it is impossible to crowd the reamers into the work enough to damage them, since the clearance is a known factor. The economy of the construction of the roughing reamer is worthy of note because of the high price of steel. V. B.



Details of Roughing and Finishing Reamer

PUMPS FOR OPERATING HYDRAULIC PRESSES

FORMULAS FOR DETERMINING SIZES OF ONE-, TWO- AND THREE-PLUNGER PUMPS

BY A LEWIS JENKINS[1]

THE pressure required on the ram of a hydraulic baling press increases as the density of the bale increases. The pressure at the beginning of the stroke depends upon the density with which the material is packed in the baling box, and at the end, upon the amount that the bale is compressed. A similar variation takes place throughout the run of an unbalanced hydraulic lift, the required pressure increasing directly as the run of the ram.

Presses for baling cotton, hay and similar materials are usually supplied with water or some other liquid by a belt- or motor-driven pump. The speed and width of the belt are constant, and this means that there is a constant amount of power available, and the plungers of the pumps run at a constant speed. When the pump is provided with only one plunger, its diameter or area is determined by the final pressure required, its velocity and the available horsepower obtained from:

$$\text{H.P.} = \frac{pvz}{33{,}000 \times 12}$$

where H.P. = available horsepower;
p = maximum or final pressure in pounds per square inch;
v = velocity of plunger in inches per minute;
z = area of ram in square inches.

At the beginning of the stroke of the press ram, a very low pressure is sufficient to move it. Hence, it will be seen from the preceding equation that the power required to deliver the water at the beginning of the ram stroke is very small compared with the power required in producing the final pressure; and the time for one operation is much longer than it would be if the maximum available horsepower could be utilized throughout the entire stroke. This condition could be realized for all positions of the stroke of the baling press if it were possible to make pv a constant, where p is the pressure at any position of the stroke. This has been done to some extent by using a mechanism similar to the Stephenson link, which varies the length of stroke of the pump, making it shorter as the pressure increases, and thereby maintaining a constant required power. Other methods have been tried, such as placing two pump plungers in the same plunger box and adjusting their relative positions by shifting their eccentrics in such a way as to vary the effective displacement. The design of a pump which maintains a constant value of pv is more or less complicated, and such pumps are expensive to construct. The result is obtained by automatically varying the length of stroke or by changing the relative positions of the two plungers working in the same plunger box.

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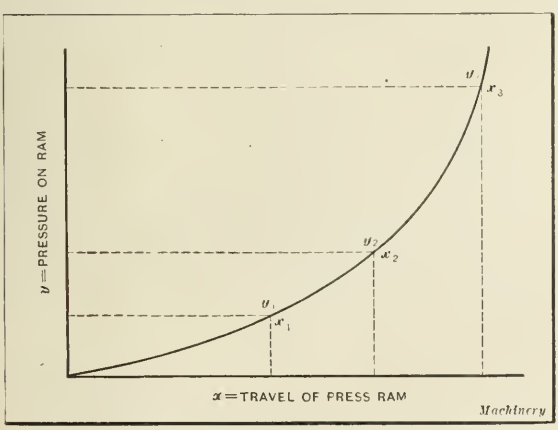


Fig. 1. Diagram illustrating Relation between Pressure of Pump Plungers and Travel of Ram of Press

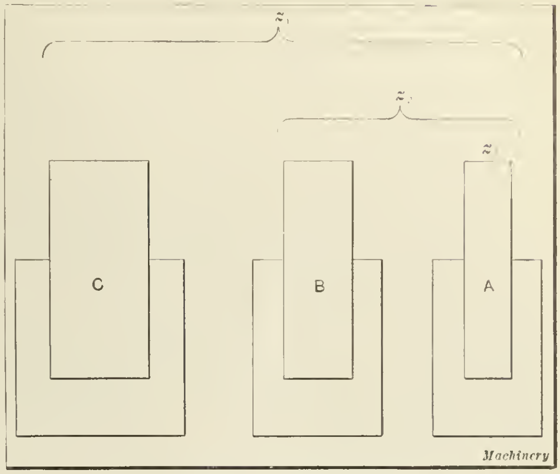


Fig. 2. Arrangement of Multiple-plunger Pump

Another method of maintaining a constant horsepower throughout the stroke of the press is effected by making pz constant; but this cannot be thoroughly accomplished in a commercial machine. An approximation of this method, however, has proved to be the most satisfactory solution. The time required for one operation may be decreased by using more than one plunger and automatically cutting out one at a time as the increasing pressure raises the power required to drive the pump with the active plungers in operation. Thus, a pump provided with three plungers having areas A, B and C, respectively, may have all three plungers in operation for a portion of the stroke of the press ram, and when the pressure times the area of all three of the plungers becomes sufficient to require all the available power, plunger C "knocks out" and A and B continue to operate until the power again becomes equal to the maximum and B "knocks out," allowing the plunger A to finish the operation, which requires the maximum pressure.

All of the plungers A, B and C may be made equal in area, and the pressure at which they should knock out may be determined; but for ordinary baling operations this is not the most economical proportion of plunger areas from the standpoint of available power and the time required to compress a bale. For baling cotton and similar materials the relation between the pressure per square inch on the ram and the travel of the ram in inches may be expressed by the equation:

$$y = kx^3$$

where y = pressure per square inch of the water acting upon the ram of the press after it has traveled a distance x from the beginning of the stroke, and k is a constant depending upon the area of the platen and nature of the material pressed.

Proportions of Plungers for Three-plunger Pump for Baling Cotton

It is desirable to have the plungers of such proportions that they will raise the ram of the press in a minimum time when a given power is available. The relation between pressure y and travel x is shown in Fig. 1, and a diagram showing the arrangement of the plungers of the pump is shown in Fig. 2.

Let z_1 = area in square inches of the three plungers A, B and C;
z_2 = area in square inches of the two plungers A and B;
z_3 = area in square inches of the plunger A;
v = velocity of the plungers in inches per minute;
y_1 = pressure in pounds per square inch at which C knocks out;
y_2 = pressure in pounds per square inch at which B knocks out;

y_3 = pressure in pounds per square inch at which A knocks out, or the final pressure required;
x_1 = distance in inches ram of press has traveled when C knocks out;
x_2 = distance in inches ram of press has traveled when B knocks out;
x_3 = distance in inches ram of press has traveled when A knocks out, or total travel of press ram;
M = area of press ram in square inches;
t_1 = time in minutes the plunger C operates, or time the area z_1 is in action during working stroke of the press ram;
t_2 = time in minutes the area z_2 is in action during the working stroke of the press ram;
t_3 = time in minutes the area z_3 is in action, or the period during which only the ram A is operating during the working stroke of the press ram;
T = total time in minutes required for the working stroke of the press ram $= t_1 + t_2 + t_3$.

The volume displaced by the press ram for any position, a distance x from the beginning of the stroke, is Mx. The volume displaced by area z_1 of the pump plungers for a travel x_1 of the press ram is Mx_1. The pump plunger area z_2 is in operation while the press ram travels from x_1 to x_2; hence, the volume displaced by z_2 is equal to $M(x_2 - x_1)$. Similarly, the volume supplied by z_3 is $M(x_3 - x_2)$.

Substituting the values of x given by the following equation:

$$y = kx^3 \text{ or } x = \sqrt[3]{\frac{y}{k}}$$

we have:

$$Mx_1 = M\sqrt[3]{\frac{y_1}{k}} = \text{volume supplied by area } z_1;$$

$$M(x_2 - x_1) = M\left(\sqrt[3]{\frac{y_2}{k}} - \sqrt[3]{\frac{y_1}{k}}\right) = \text{volume supplied by area } z_2;$$

$$M(x_3 - x_2) = M\left(\sqrt[3]{\frac{y_3}{k}} - \sqrt[3]{\frac{y_2}{k}}\right) = \text{volume supplied by area } z_3.$$

The time t in minutes required to raise the press ram a distance x with one plunger having an area z and velocity v is:

$$t = \frac{\text{volume displaced by press ram}}{\text{rate of flow of water from pump}} = \frac{Mx}{zv}$$

By substituting the value of x given by the equation

$$x = \sqrt[3]{\frac{y}{k}}$$

we get:

$$t = \frac{M}{zv}\sqrt[3]{\frac{y}{k}} = \frac{m}{z}\sqrt[3]{y}$$

where $m = \dfrac{M}{v\sqrt[3]{k}}$ = constant;

Similarly,

$$t_1 = \frac{m}{z_1}\sqrt[3]{y_1} = \text{time area } z_1 \text{ is in action}$$

$$t_2 = \frac{m}{z_2}(\sqrt[3]{y_2} - \sqrt[3]{y_1}) = \text{time area } z_2 \text{ is in action}$$

$$t_3 = \frac{m}{z_3}(\sqrt[3]{y_3} - \sqrt[3]{y_2}) = \text{time area } z_3 \text{ is in action}$$

Hence, the total time T required to raise the press ram is:

$$T = t_1 + t_2 + t_3 = \frac{m}{z_1}\sqrt[3]{y_1} + \frac{m}{z_2}(\sqrt[3]{y_2} - \sqrt[3]{y_1}) + \frac{m}{z_3}(\sqrt[3]{y_3} - \sqrt[3]{y_2}) \text{ minutes}$$

In order to have the power equal at pressures y_1, y_2 and y_3:

$$y_1z_1 = y_2z_2 = y_3z_3$$

By multiplying the numerators and denominators of respective terms on the right of the equation for T by y_1, y_2 and y_3 gives:

$$T = \frac{my_1}{z_1y_1}\sqrt[3]{y_1} + \frac{my_2}{z_2y_2}(\sqrt[3]{y_2} - \sqrt[3]{y_1}) + \frac{my_3}{z_3y_3}(\sqrt[3]{y_3} - \sqrt[3]{y_2})$$

Since the denominators of these fractions are equal:

$$\frac{T}{m} = \frac{y_1\sqrt[3]{y_1} + y_2(\sqrt[3]{y_2} - \sqrt[3]{y_1}) + y_3(\sqrt[3]{y_3} - \sqrt[3]{y_2})}{y_3z_3}$$

But
$$y_1 = \frac{y_3z_3}{z_1} = by_3$$

and
$$y_2 = \frac{y_3z_3}{z_2} = ay_3$$

where
$$b = \frac{z_3}{z_1} = \frac{A}{A + B + C}$$

and
$$a = \frac{z_3}{z_2} = \frac{A}{A + B}$$

Substituting the values of y_1 and y_2 in the above equation gives:

$$T = \frac{m}{y_3\,z_3}\left(y_3^{\frac{4}{3}}b^{\frac{4}{3}} + y_3^{\frac{4}{3}}a^{\frac{4}{3}} - ab^{\frac{1}{3}}y_3^{\frac{4}{3}} + y_3^{\frac{4}{3}} - y_3^{\frac{4}{3}}a^{\frac{1}{3}}\right)$$

Simplifying this equation, we get:

$$T = \frac{my_3^{\frac{1}{3}}}{z_3}\left(b^{\frac{4}{3}} + a^{\frac{4}{3}} - ab^{\frac{1}{3}} + 1 - a^{\frac{1}{3}}\right)$$

The relation of a to b that will give a minimum value of T may be found by making $\dfrac{dT}{da} = 0$ and $\dfrac{dT}{db} = 0$, and solving the two resulting equations as follows:

$$\frac{dT}{da} = \frac{my_3^{\frac{1}{3}}}{z_3}\left(\frac{4}{3}a^{\frac{1}{3}} - b^{\frac{1}{3}} - \frac{1}{3a^{\frac{2}{3}}}\right) = 0$$

Since
$$\frac{my_3^{\frac{1}{3}}}{z_3} \text{ is not } = 0$$

$$\frac{4}{3}a^{\frac{1}{3}} - b^{\frac{1}{3}} - \frac{1}{3a^{\frac{2}{3}}} = 0$$

$$\frac{dT}{db} = \frac{my_3^{\frac{1}{3}}}{z_3}\left(\frac{4}{3}b^{\frac{1}{3}} - \frac{a}{3b^{\frac{2}{3}}}\right) = 0$$

Hence
$$\frac{4}{3}b^{\frac{1}{3}} - \frac{a}{3b^{\frac{2}{3}}} = 0$$

$$4\,b = a$$

By substituting $a = 4\,b$ in the equation:

$$\frac{4}{3}a^{\frac{1}{3}} - b^{\frac{1}{3}} - \frac{1}{3a^{\frac{2}{3}}} = 0$$

$$a = 0.474 \text{ and } b = 0.1185$$

From the equation:

$$a = \frac{A}{A + B}$$

$$B = A\left(\frac{1 - a}{a}\right)$$

From the equation:

$$b = \frac{A}{A + B + C}$$

$$C = \frac{A}{b} - A - B = \frac{A}{b} - A - A\left(\frac{1 - a}{a}\right)$$

$$C = A\left(\frac{1}{b} - \frac{1}{a}\right)$$

By substituting $a = 0.474$ and $b = 0.1185$ in the preceding equation:

$$B = 1.11A \text{ and } C = 6.33A$$

Since the area varies as the square of the diameter, diameter of ram B is $1.05 \times$ diameter of A; and the diameter of C is $2.52 \times$ diameter A. Hence, for baling a material which obeys the law $y = kx^3$, the diameters of plungers A and B may be made equal and the diameter of C should be about 2.5 times that of A.

Time Required to Form Bale

The time required to run a press ram through its entire stroke when $y = kx^3$ and a three-plunger pump is used, having the diameters of the plungers in the ratio of 1, 1.05 and 2.52, may be found by substituting $a = 0.474$ and $b = 0.1185$ in the equation for total time T, which gives:

$$T = \frac{m y_3^{\frac{1}{3}}}{z_3}\left(0.1185^{\frac{4}{3}} + 0.474^{\frac{4}{3}} - 0.474 \times 0.1185^{\frac{1}{3}} + 1 - 0.474^{\frac{1}{3}}\right)$$

$$= \frac{0.42 m y_3^{\frac{1}{3}}}{z_3} = \frac{0.42 m p^{\frac{1}{3}}}{A} = \frac{0.42 M}{vA}\sqrt[3]{\frac{p}{k}} = \frac{0.42 M x}{vA}$$

General Case for Three-plunger Pump

The diameters of plungers for pumps designed to operate any baling machine, regardless of the material to be baled, should be based on the assumption that $y = kx^3$. This value may be considered an average for the materials commonly operated upon; but if it is definitely known that a pump is to supply water to a press for compressing any given material, such as tankage, apples, grapes, olives, hay, tin cans, etc., the exact relation between pressure and travel may be easily determined by experiment. The pressure per square inch of the liquid in the cylinder is read from a gage for a number of positions of the ram, and these data plotted on log-log paper or the values of n and k are determined by substituting values of x and y in the equation $y = kx^n$, which may be used for practically any material.

By using $y = kx^n$ instead of $y = kx^3$, it is found for a three-plunger pump that:

$$a = (n+1)b$$

and

$$b = \frac{1}{(n+1)^2 - n(n+1)\dfrac{n-1}{n}}$$

From these equations, values of a and b and the areas and diameters for given values of n are shown in Table 1.

TABLE 1. RATIOS OF PLUNGER DIAMETERS FOR THREE-PLUNGER PUMP

n	b	a	Area of B / Area of A	Area of C / Area of A	Diam. B / Diam. A	Diam. C / Diam. A
1	0.333	2b = 0.666	0.50	1.50	0.70	1.22
2	0.179	3b = 0.549	0.84	3.69	0.92	1.92
3	0.118	4b = 0.474	1.11	6.33	1.05	2.52
4	0.085	5b = 0.429	1.33	9.33	1.15	3.05
5	0.067	6b = 0.406	1.46	12.29	1.21	3.51

Machinery

General Case for Two-Plunger Pump

In the case of a pump having two plungers with areas A and B, it may be shown that:

$$a = \frac{A}{A+B} = \frac{1}{n+1}$$

from which

$$B = An$$

The relative values of A and B and their corresponding diameters are shown in Table 2 for different values of n.

TABLE 2. RATIOS OF PLUNGER DIAMETERS FOR TWO-PLUNGER PUMP

n	Area of B / Area of A	Diam. B / Diam. A
1	1	1.00
2	2	1.41
3	3	1.73
4	4	2.00
5	5	2.24

Machinery

Determination of "Knock-out" Pressures

The method of finding the "knock-out" pressure is illustrated by the following example: A three-plunger pump having a piston velocity of 50 feet per minute, diameters of plungers 1.5 inch, 1.5625 inch, and 3.75 inches, gives a maximum pressure of 1500 pounds per square inch. The efficiency of the pump is 70 per cent.

The maximum horsepower required is:

$$\text{H.P.} = \frac{1500 \times 50 \times 1.76}{33{,}000 \times 0.7} = 5.72$$

This is found by using the maximum pressure and the area of the plunger giving that pressure. The maximum horsepower is reached when the product of the pressure into the area is equal to:

$$1500 \times 1.76 = 2640$$

The area of all three plungers is $1.76 + 1.91 + 11.04 = 14.71$ square inches, which gives $\frac{2640}{14.71} = 180$ pounds per square inch for the first "knock-out" pressure. The sum of the areas of the second and third rams is $1.76 + 11.04 = 12.80$ square inches, and the second "knock-out" pressure is $\frac{2640}{12.80} = 206$ pounds per square inch.

These pressures are lower than those generally found on pumps for baling presses; but in view of the fact that fibrous materials, such as cotton, approximately compress according to the equation $y = kx^3$, and the ram is at $\sqrt[3]{\frac{180}{1500}} = 0.49$ and $\sqrt[3]{\frac{206}{1500}} = 0.52$ of its total run when these pressures are attained, the advantage of the low "knock-out" pressures is readily appreciated.

* * *

IGNORANCE IN STARTING A MANUFACTURING BUSINESS

A large percentage of business failures are due to the lack of knowledge of the business entered and the equipment and organization required. Men engage in retail selling with little or no business experience. They buy goods unwisely, acquire ill-balanced stocks, and finally fail with a lot of bad accounts which can never be collected. The manufacturing business is no exception to the rule, and many heedless, ill-advised ventures are often met with in manufacturing. It is stated by a machine tool salesman of broad experience in selling new machinery and dealing in second-hand tools that a large percentage of the men who start small manufacturing enterprises know practically nothing of manufacturing principles and are almost totally ignorant of the equipment required to produce their products efficiently. They buy lathes, planers, drilling machines, milling machines, and other standard machines with little discrimination and set them up in orderly rows in their new quarters. Power is turned on and the wheels start in motion, but machinery running does not necessarily result in turning out marketable carbureters, gas engines, egg beaters or anything else. The important elements of directive skill and sales organization are too often lacking. After struggling along miserably for a few months, a lot of machine tools, somewhat the worse for wear, are offered to second-hand dealers.

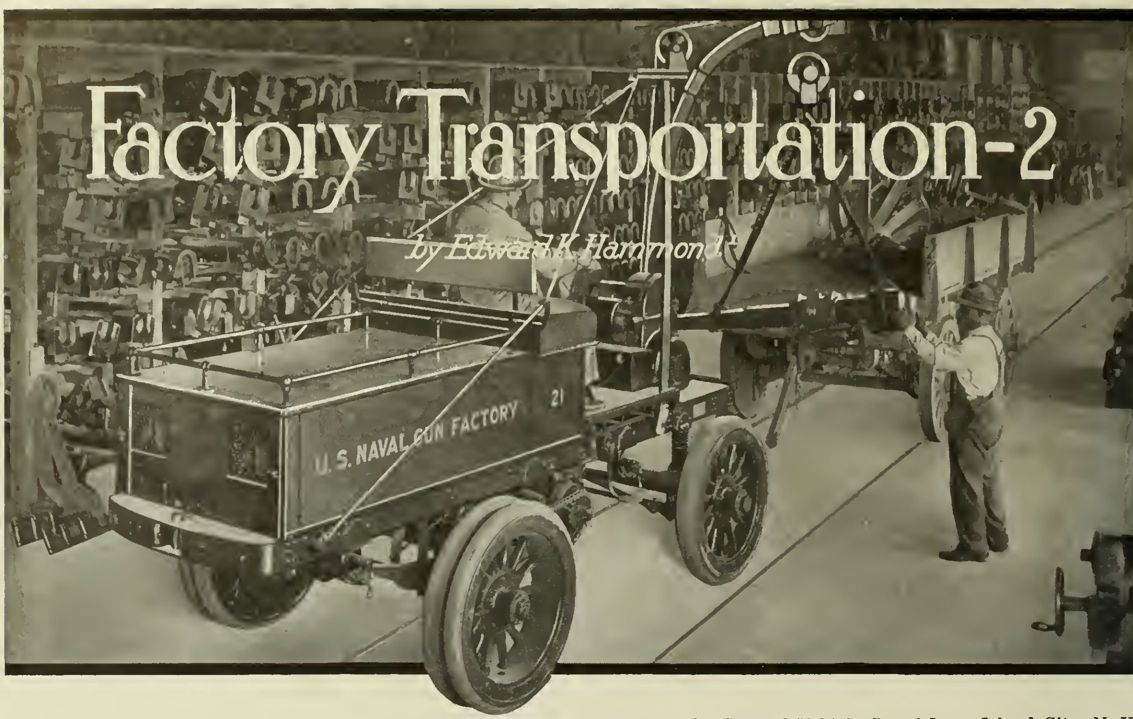
* * *

ENGINEERING COUNCIL

The first meeting of the Engineering Council was held in the Engineers' Bldg., New York City, June 27. This body is a department of the United Engineering Society and has recently come into being as a medium of cooperation between the four national engineering societies. The function of the council is to speak authoritatively for all member societies on all public questions of a common interest or concern to engineers. It is composed of twenty-four members, five being appointed from each of the four founder societies and four by the United Engineering Society; the founder societies are the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. At the organization meeting, Dr. I. N. Hollis was elected president of the council; H. W. Buck and George F. Swain, vice-presidents; and Calvert Townley, secretary. Ways and means were discussed by which the societies through the council might be of use to the national government. A resolution was adopted instructing the executive committee to cooperate with the government in procuring the services of engineers, and a committee was appointed to consider the best means of utilizing the inventive ability of members of the founder societies.

Factory Transportation-2

by Edward K. Hammond[1]



MOTOR-DRIVEN trucks, provided with their own power plant in the form of an electric storage battery and motor, are now being used in many industrial plants in the United States. Trucks of this type naturally cost considerably more than any of the trucks which are driven by manual labor, and the only justification for investing in equipment where the first cost is higher is if conditions of operation are such that a greater amount of service might be obtained from motor-driven trucks. It is difficult to make statements to cover general conditions, but in the present case it may be stated that the particular field of usefulness of motor-driven trucks is where the length of haul is sufficiently great so that a material saving of time and labor may be obtained through the increased speed. Running on hard level surfaces, the speed of these trucks will be about seven miles an hour, and the average truck has a capacity for running about twenty-five miles on a single battery charge.

The driver stands erect on a platform at the end of the truck, with his hands on the controller and steering levers, respectively, and one foot on the brake pedal. Simplicity of operation does away with the necessity of hiring high-priced operators for these trucks. Where motor-driven trucks can be kept busy, the General Vehicle Co. of Long Island City, N. Y., claims that with hauls ranging from 200 to 800 feet each truck will take the place of from four to six men. An idea of the rate at which these trucks operate will be gathered from the fact that a time study made in unloading bags of cement at a New York pier showed that it took thirty minutes to unload thirty-eight bags of cement and transport them a distance of 500 feet, where four men were employed operating hand trucks. With an electric truck, two men handled seventy similar bags in seventeen minutes and carried them 750 feet instead of 500 feet. It is not claimed that any such saving may be expected in all cases. There are many classes of work where better results will be obtained with hand trucks; but for those classes of service for which motor-driven trucks are adapted, they give highly satisfactory results.

A manufacturer who contemplates the installation of motor-driven trucks will naturally ask himself, "What will it cost to operate such equipment?" For the benefit of such men it may be stated that the average cost of running an electric truck and the necessary charging equipment—including maintenance, interest, depreciation, taxes, insurance and charging current—is $2.50 per working day, exclusive of operator's wages. A single charge of the battery during the preceding

[1]Associate Editor of MACHINERY.

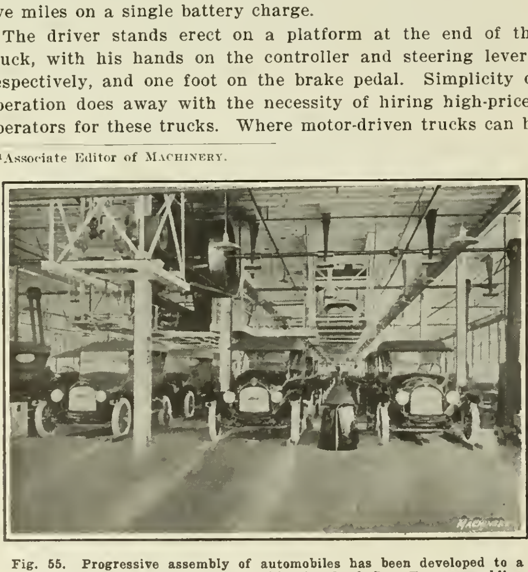


Fig. 55. Progressive assembly of automobiles has been developed to a high degree by engineers of the Willys-Overland Co. Four assembling tracks are provided in the factory, down which cars are run, and conveyors running at right angles to these tracks carry all the different parts to the assemblers. This system has been brought to a high degree of perfection and work is handled very rapidly

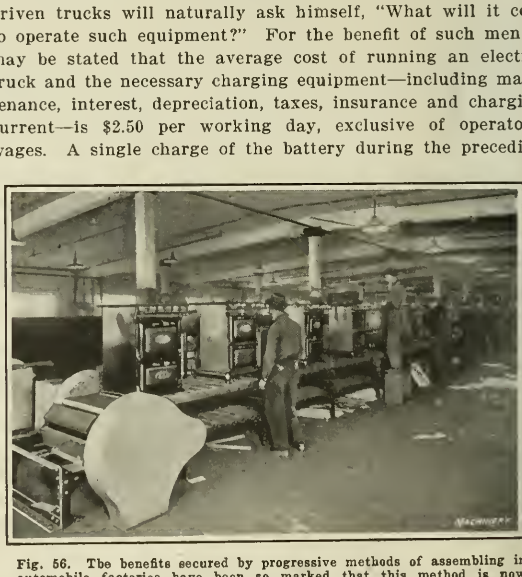


Fig. 56. The benefits secured by progressive methods of assembling in automobile factories have been so marked that this method is now finding application in other industries. The Detroit Stove Works is making use of a conveyor system installed in its plant by the Palmer-Bee Co. of Detroit, Mich., for use in the progressive assembly of gas ranges

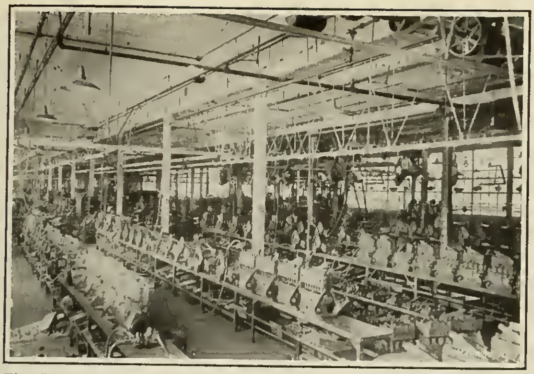


Fig. 57. Overhead conveyors are used in the motor assembling department of the Willys-Overland Co., Toledo, Ohio, for carrying the larger parts of the motors to the assembling benches. Small parts are held in New Britain tote boxes underneath the benches, where they are within convenient reach of the operator

Fig. 58. In the Ford Motor Co.'s plant every possible saving is effected in production. In assembling motors, as fast as one man finishes his task he pushes the motor along to his companion and receives a new motor from the man on the other side. This is another example of the progressive method of assembling

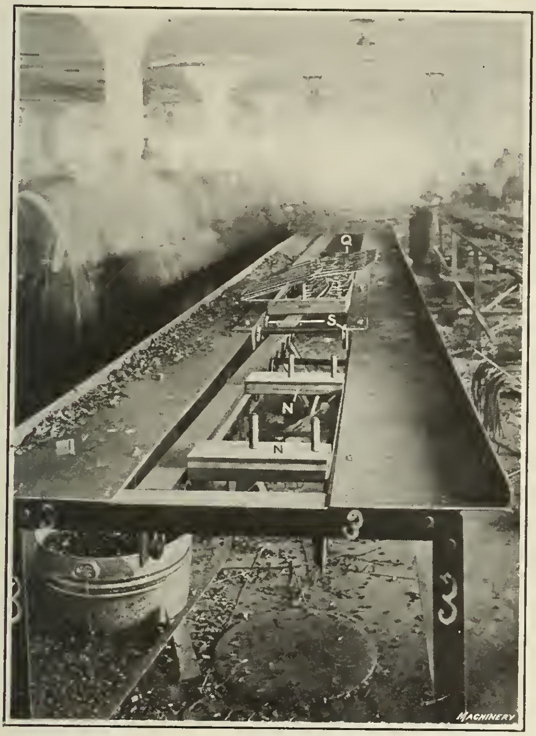


Fig. 59. Progressive methods of assembling are used in manufacturing automobile cushion springs. In the Detroit Wire Spring Co.'s factory, the Palmer-Bee Co. has installed equipment for handling this work. The spring frames are placed on small trucks, on which they are carried along the bench from man to man, and the various parts of the spring are put together

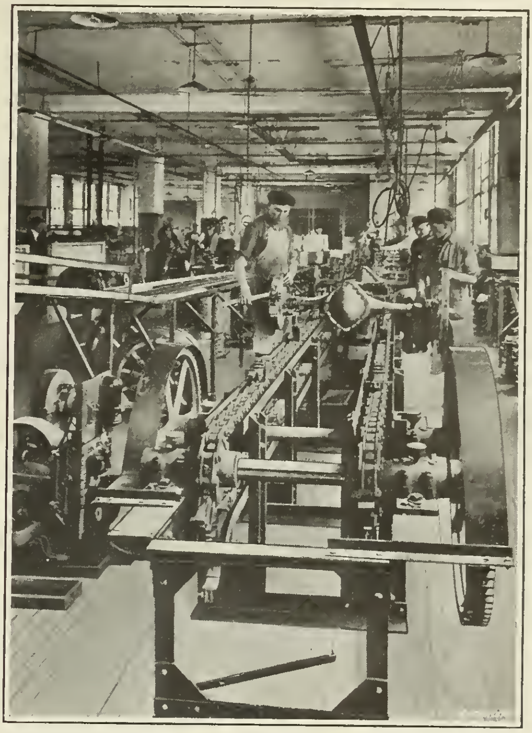


Fig. 60. The Palmer-Bee Co. of Detroit, Mich., makes a specialty of designing and installing time- and labor-saving equipments for handling material in course of manufacture. This illustration shows an outfit installed by this company for assembling automobile transmissions. Two strands of endless chain carry brackets which support the work at each end

Fig. 61. In this case the magnetic generator unit of the motor is carried on an endless belt conveyor, and men with power-driven wrenches are screwing up the nuts. Attention is called to the large number of men at work; this is typical of the intensive production methods in the Ford Motor Co.'s shops

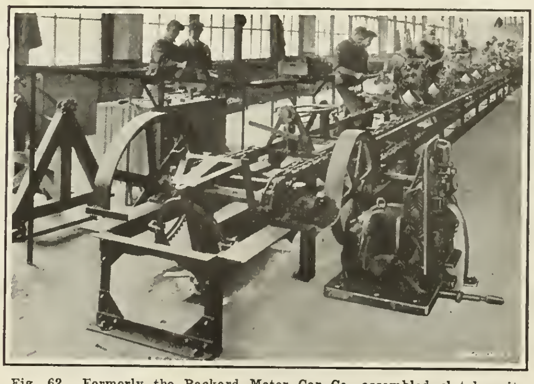


Fig. 62. Formerly the Packard Motor Car Co. assembled clutch units on stands that were distributed over the floor of the clutch assembling department. The Palmer-Bee Co. suggested that the progressive method of assembly be employed in handling them, so a conveyor system was installed, which carries stands similar to those formerly employed

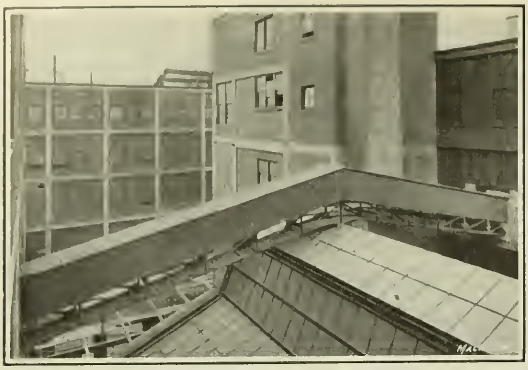


Fig. 63. Where it is necessary to transfer work from an upper floor in a building to an upper floor in another building, much time is lost in taking the work down and up in elevators in the ordinary way. Sometimes it is possible to have a conveyor carry the work right across from one building to the next, as here shown

Fig. 64. In the Studebaker Corporation's factory in Detroit it is necessary to transfer automobile frames from one building to a floor two stories higher up in an adjacent building. For this purpose a conveyor system was installed by the Palmer-Bee Co. It consists of a structural steel frame with rails, over which the automobile frames are pulled by an endless chain conveyor

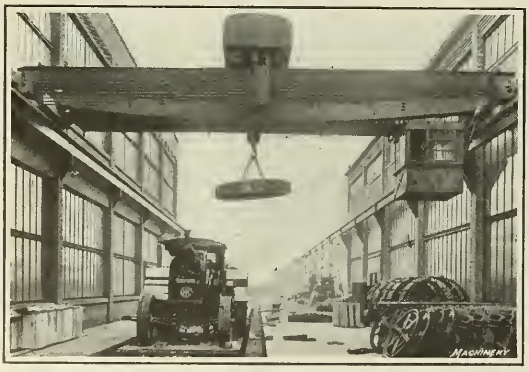


Fig. 65. Factories engaged in building heavy machinery, structural iron work, etc., find it necessary to have cranes for loading finished product onto cars. This illustration shows the work of loading a kerosene tractor onto a flat car. The crane was built by the Northern Engineering Works of Detroit, Mich.

night is sufficient to run the truck with its full load of two tons for 90 to 100 round trips of 1000 feet. Batteries may be charged while in the truck or a complete change of batteries may be made in five minutes. A laborer of average intelligence can be taught to drive one of these trucks in a few hours, and automatic safety control features make it practically impossible to damage the load or for the operator to be injured.

One point that stands out in favor of the use of motor-driven trucks is that when a man can ride, little difficulty is experienced in keeping him at work; but when he is required to pull a heavy truck, which is a tiresome job, he is not likely to stay long. Hence the motor-driven truck may be said to constitute a means of saving employers the expense of breaking in new help. In conclusion, it may be stated that motor-driven trucks may be furnished with flanged wheels for operation on rails, or with rubber tired wheels to travel on the floor. Signal systems of various kinds may be used—such as electric lamps or flags—to show when aisles are clear for the passage of trucks, or when one truck is likely to meet another before reaching the opposite end of an aisle. Electric trucks are built in many designs to meet the requirements of different classes of work. Elevating trucks are made for use in connection with platforms, boxes, etc., and plain trucks are made for carrying loads directly. In addition, there are the so-called tractors designed for pulling one or more cars on which the load is piled.

Demountable Body Trucks

Motor trucks may be employed to advantage in many shops for carrying shipments from a factory to the main line of a railway, shipping dock, etc., or for making quick deliveries within twenty or thirty miles of the plant. Where the tonnage to be handled is large, it may be desirable to use one or more trailers in connection with a truck in order to increase its carrying capacity. A good grade of motor truck is quite costly, and this makes it necessary for the firm employing one or more of these trucks to take advantage of every opportunity to secure the greatest possible return on its investment. One way of greatly increasing the amount of service obtained from motor trucks is to use what are known as "detachable" bodies. Two or more of these bodies may be used in connection with each truck, so that when a truck comes in loaded the removable body can be lifted off and carried away by trolley hoists, after which an empty body is substituted so that it may haul away a new load or go out after a fresh load, as the case may be. While the truck is away from the plant the load brought in on the previous trip—which has been removed with the detachable body—is taken to its destination by the trolley hoist, and the empty body is brought back ready to be exchanged for a full body when the truck returns with its next load. This method is said to be the means of increasing the capacity of motor trucks from 50 to 100 per cent when used under conditions that enable maximum efficiency to be attained. In the case of very heavy loads, the detachable body may be furnished with nests so that the load may be divided to bring it within range of the trolley hoists. In some cases the bodies are mounted on auxiliary casters or wheels upon which they may be moved.

Progressive Machining Operations

Where machining operations to be performed on a given part are of such a nature that a battery of planers, milling machines, drill presses, boring machines, etc., is required to finish a piece, it is of the utmost importance to have these machines so grouped that the work passes continuously from machine to machine without delays. In many well organized factories the equipment has been so arranged that conveyors, trucks or some other form of device can be used to carry the work from machine to machine with the least amount of time and labor.

An example of this kind is seen in the milling operations on aluminum crank-cases in the plant of the Buick Motor Co., Flint, Mich. The first four milling operations are performed on Ingersoll planer-type milling machines, which provide for handling five upper and five lower halves of the crank-cases at

a time. In operation, the table is run forward under the cross-rail, and castings placed ready on the floor are dropped into position in the milling machine fixtures without any attempt to tighten the clamps on the fixtures. Then as the table starts to feed back, the operator starts with the fixtures nearest the cross-rail and tightens up all bolts so that the work is secured for machining. After all the work has been secured, he goes to a position back of the cross-rail and starts taking out the milled cases, which are swung over onto gravity carriers and rolled down to a position ready to go on the next Ingersoll milling machine. In this connection it is important to note that the gravity carriers are made the same height as the milling machine tables so that the work can be transferred from the carrier to the table and *vice versa* with the minimum effort.

A more highly developed method of progressive machining consists of having tracks laid between different machines on which trucks run that support jigs and fixtures for carrying the work. Fig. 38, in the first installment, shows a view in the plant of the Packard Motor Car Co., Detroit, Mich., where crank-cases are being drilled. There are 200 holes to be drilled in these cases and the complete drilling operation is finished in forty-two minutes; the actual drilling time is thirty-eight and one-half minutes and three and one-half minutes are allowed for setting up and removing work from the jig. The machine tool equipment consists of seven Baush multiple-spindle drilling machines with various numbers of spindles and different types of heads, and one radial drilling machine. The jigs are arranged so that they can be pivoted to bring different surfaces of the work into the operating position. Index-pins enter hardened steel bushings in the jigs, locating them accurately for each successive operation, and clamps are provided which secure the jig trucks in place on the tracks. Handled in this way, a high rate of production may be obtained, because the workman is relieved of all physical strain in lifting work on and off machines, it being merely required for him to set the work up in the jig at the beginning of the row and remove it when the job is finished. One workman follows a single casting right down the line, performing all the machining operations required on it.

For boring, milling and other operations where the fixtures are of such a type that it would not be feasible to use a single fixture for a number of operations, a somewhat similar idea may be employed. Instead of having the work and fixture taken from machine to machine on tracks, a roller type conveyor is run parallel to the line of machines, with switches branching off to individual machines, as was illustrated in Figs. 44 and 45 in the July installment. With an equipment of this kind the operator can push a heavy casting along on the conveyor and run it in on the switch to a given machine. The conveyor and the machine table are the same height, so that the operator merely swings the work over from the conveyor and puts it in position in the fixture for machining. When the operation has been completed, the casting is put back on the switch and run up to the main line, upon which it is carried to the switch leading to the next machine. Where this method has been adopted it has been found the means of saving a great deal of time in the performance of machining operations.

Laying Out Gravity Carriers

As the name implies, the pitch of a gravity carrier is relied upon to enable the force of gravity to run the load along the conveyor without the application of power from an external source. In designing this type of equipment it is the practice of the Mathews Gravity Carrier Co., Elwood City, Pa., to make the pitch of conveyors from 2 to 8 per cent, but most of the conveyor systems installed by this company have a pitch of 4 per cent. In the construction of conveyor systems of this type, there is a good deal of variation in the lay-out, according to the nature of the work to be carried. Packages with smooth, flat bottoms may be run on these carriers without guard rails, but where the load is irregular in shape some form of guard rail is necessary.

Various expedients are adopted to keep the load running on these conveyors. The most obvious way is to place a guard

Fig. 66. In foundries where moderate loads are to be handled at fairly frequent intervals, it is convenient to use a crane in which the trolley and bridge are operated by hand, and the hoist is driven by power. Cranes of this type are shown here, equipped with "Imperial" pneumatic motor hoists built by the Ingersoll-Rand Co., New York City

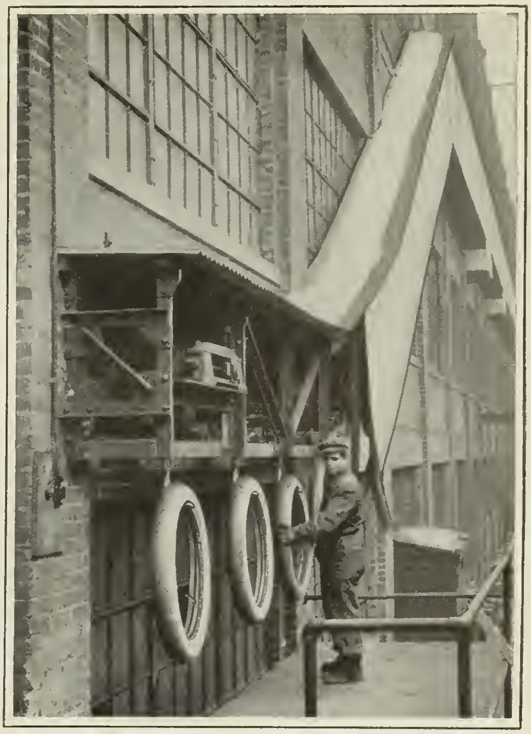


Fig. 67. Where there is considerable congestion in a shop, it may be desirable to hang conveyor systems and similar equipment on the outside of buildings. A case in point is seen in the accompanying illustration, which shows a view of a conveyor system installed in the Studebaker Corporation factory for handling tires, wheels and hubs. The conveyor is an endless chain with hooks for carrying the work

Fig. 68. One 200-ton and one 20-ton electric traveling crane with a span of 75 feet, 6 inches are here shown in use in a railroad shop. These cranes were built by the Niles-Bement-Pond Co., New York City. The weight of the suspended engine is 270 tons. Attention is called to the method of lifting the locomotive from four corners

Fig. 69. This illustration shows a bin at the side of the railroad at the Ford Motor Co.'s plant in Detroit for storing coal, coke, limestone, scrap metal, etc. The Shaw Electric Crane Co., Muskegon, Mich., installed a gantry crane equipped with a grab bucket for handling this material

Fig. 70. Gantry cranes are generally used where the amount of service is not great enough to warrant the construction of an overhead runway for a traveling crane. Gantry cranes are more expensive to operate, however, and this may offset the lower first cost. The crane here shown was built by the Northern Engineering Works, Detroit, Mich.

Fig. 71. In large power plants it will often be found necessary to provide special equipment for the handling of fuel, as manual labor is too slow. This illustration shows a monorail bucket hoist built by the Northern Engineering Works for charging coal into boiler hopper storage tanks in a large power plant

Fig. 72. In foundries where there is a lot of sand, coke and limestone to be handled, it will sometimes be found advantageous to employ a grab bucket. This illustration shows a trolley hoist built by the Sprague Electric Works of New York City, equipped with a grab bucket for use in a foundry. Such an outfit operates at a high rate of efficiency

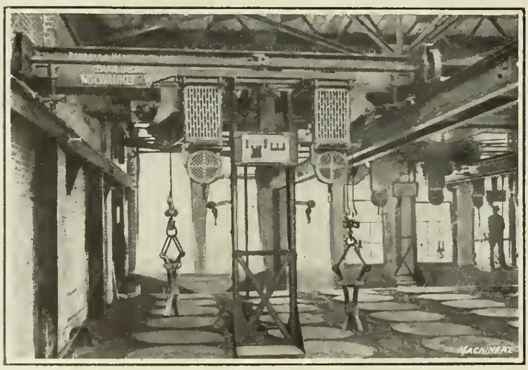


Fig. 73. Crane builders are often called upon to construct special equipments to meet the requirements of various industries. The illustration shows cranes built by the Pawling & Harnischfeger Co., Milwaukee, Wis., especially for handling work in the annealing shop of a car wheel foundry

Fig. 74. Lifting magnets are used for handling various iron and steel products. This illustration shows an electromagnet built by the Cutler-Hammer Clutch Co., Milwaukee, Wis., lifting long steel bars. A special arrangement of a beam and two hoists prevents the magnet and its load from rotating

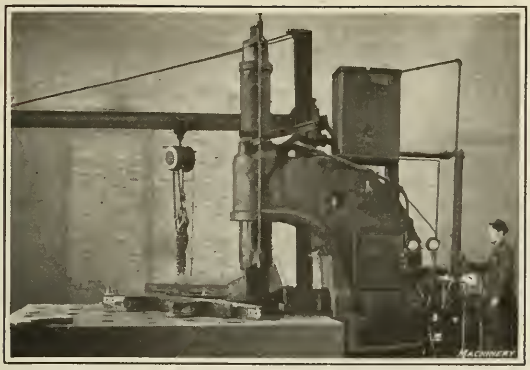


Fig. 75. There are many pieces of work that are a little difficult for one man to handle alone, and if he attempts to do so, he is likely to waste a considerable amount of time in setting up. This illustration shows the use of a jib crane equipped with a Yale & Towne chain block for handling such work

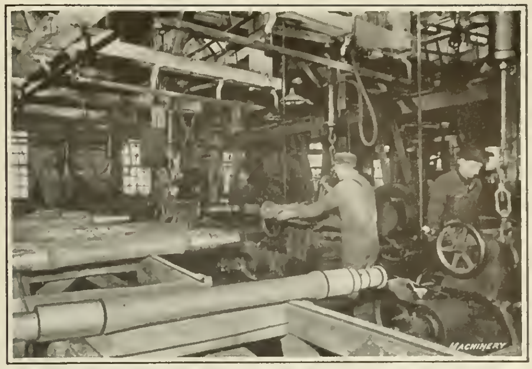


Fig. 76. Car axles are too heavy to be handled by one man. This illustration shows a view in the Griffin Wheel Co.'s plant in Chicago, where each axle lathe is equipped with an air cylinder hoist for setting up work and removing it. Turned axles are rolled on rails to the hydraulic wheel press

Fig. 77. A locomotive crane is useful for handling materials in factory yards where there is a lot of space to be covered. This equipment may be employed as a switch engine when there is no lifting to be done. The illustration shows a locomotive crane and lifting magnet used by the Griffin Wheel Co., Chicago, Ill., for handling car wheels

Fig. 78. An "Imperial" pneumatic motor hoist built by Ingersoll Rand Co., New York City, is used to assist the operator in setting up heavy work on a turret lathe and to remove completed work from machine. Having an individual hoist for a machine avoids loss of time by the operator and machine in waiting for assistance

Fig. 79. To facilitate pouring metal into molds in the Ford Motor Co.'s foundry, molds are brought in on a conveyor and transferred to a carousel on which each mold is supported by a pendulum. This swinging support eliminates vibration and prevents molds breaking. Molds are carried away by a second conveyor

Fig. 80. One jib crane can often be arranged to serve a number of machines, molds, etc. In the Griffin Wheel Co.'s foundry, car wheel molds are arranged in a circle, with a jib crane at the center, equipped with an air hoist built by the Curtis Pneumatic Machinery Co., St. Louis, Mo.

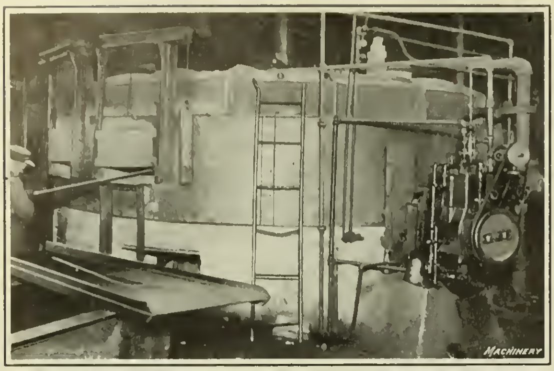


Fig. 81. In the Timken-Detroit Axle Co.'s plant special furnaces with a rotary hearth are maintained at such a temperature that forgings are raised to the proper temperature for heat-treatment by one revolution. These furnaces save space and keep operator busy

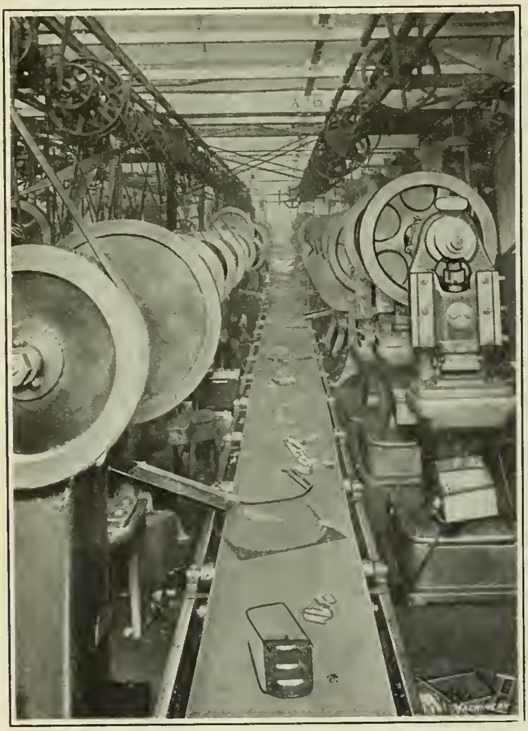


Fig. 82. In the Ford Motor Co.'s plant, use is made of belt conveyors for carrying away the product of power presses. Chutes are provided by means of which the product is transferred from the machines to the belt conveyor which carries it away. This is the means of saving the time ordinarily required for removing the product in trucks

Fig. 83. An elevator raises the work to the upper floor in the Willys-Overland Co.'s plant. This equipment, installed by the Link-Belt Co., Chicago, Ill.; consists of an apron-type conveyor with cleats to prevent the work from slipping back. A chute at the left returns the tote boxes to the lower floor

rail at each side so that it is impossible for the load to run off. A simple method and one that is highly satisfactory where the packages or parts to be carried are of fairly regular shape, is to have a small flange at both ends of each roller. This flange rotates with the roller so that there is no loss of efficiency through the retarding action of a fixed guard rail, and still it is effective in preventing work from running off. A still simpler method and one that is effective in cases where the work has a smooth surface to run on is to make the conveyor with two sets of rollers. These rollers are arranged in pairs, with the rollers of each pair inclined at a slight angle, so that the two rollers have a form somewhat similar to the letter V (the angle is much less acute) with the apex pointing in the opposite direction to that in which the load is to travel. The effect of this inclined double roller construction is to keep the load on the conveyor, the tendency of each of the inclined rollers being to force the load toward the center. For handling pig iron and other irregular shaped pieces of this kind, the only way to be sure of keeping the load on the conveyor is to use a guard rail at each side.

Use of Revolvator

A machine known as a "revolvator" is built by the New York Revolving Portable Elevator Co., Jersey City, N. J. This is a portable elevator mounted on a revolving base so that the elevator platform may be faced in any direction to receive or discharge a load, as the case may be; ball bearings in the revolving base enable the elevator to be easily swiveled when carrying its maximum load. This type of equipment is used for a variety of different classes of service in industrial plants, but a typical case is where it is desired to raise or lower a load and turn the elevator in the direction in which the load is to be deposited. For instance, suppose that a stock-room is arranged with aisles running over to the wall and the necessity for economizing in the use of space makes it necessary to stack material up almost to the ceiling. Here the revolvator may be used to excellent advantage, as the material is brought on elevating trucks or in any other convenient way and deposited on the platform of the revolvator. The load is then raised to the desired height and the platform turned so that the load may be run off at either side of the aisle onto the top of the material already stacked.

A similar use is where sheet metal and other material is being stacked in racks; the revolvator carries the load down an aisle, and when it reaches its destination, the platform is raised and turned through one-quarter revolution to allow the load to be slid off onto the racks. Another similar example is where heavy dies for use on power hammers and presses are kept in storage racks. These dies are so heavy that they are hard to handle, and work of this kind can be done conveniently by pulling them out on the platform of the portable elevator, which is then lowered to a convenient height. The entire elevator then serves as a truck on which the die is pulled to the machine on which it is to be used. Here the platform of the elevator is adjusted to bring it to the same height as the bed of the machine, so that the die may be easily slid off the elevator platform, into place on the machine.

Portable elevators of this type are made in two standard sizes, with capacities for handling loads up to 800 pounds and 1800 pounds, respectively. By the use of special bracing, elevators have been made for carrying loads up to 2500 pounds. Elevators up to and including seven feet in height are made with the structure in a single piece; but when the height exceeds seven feet, the structure is hinged so that no difficulty is experienced in pulling the elevator through doors from one department to another. The platform is raised by hand by means of gearing turned by a crank. When it is necessary to lower the load, the first step is to take the crank off the squared end of the shaft; the crank is then fitted onto a lowering brake, and until this is done the platform cannot be lowered. By means of the crank, the brake may be adjusted to any required degree while lowering the load.

In revolving the entire structure of the elevator, the first step is to withdraw a locking pin that holds the elevator in one of four 90-degree positions around the complete circle.

When this pin has been withdrawn, the elevator is usually turned by hand, taking hold of the elevating crank. Some users of portable elevators employ them as a means of transporting material from one department to another located on a higher or lower floor. This is done by having a trap door in the upper floor through which the elevator platform may be raised or lowered with the material. Such an arrangement would only be recommended where departments are not laid out in the normal way; ordinarily, where there is a demand for equipment to transfer work from one floor to another, some permanent form of elevator would be more desirable.

Portable Scoop Conveyor

For handling coal of all grades, coke, ashes, crushed stone, sand, gravel, small castings and a variety of other similar material, the Portable Machinery Co., Inc., Passaic, N. J., is now building the portable scoop conveyor shown in Fig. 87. This equipment consists of a scoop which can be buried in the material to be handled, and an endless traveling belt which carries the material up and discharges it into a wagon, chute or other receiver. The conveyor belt has transverse cleats to prevent the material from slipping back down the incline. One man and this scoop conveyor can handle coal or similar material at the rate of one ton in one and one-half minute, *i. e.*, forty tons per hour. This outfit can be equipped with an electric motor or gasoline engine for driving the belt, and as it weighs only 900 pounds and is mounted on wheels, it may be easily taken to any desired place. The amount of power required to drive the conveyor is $1\frac{1}{2}$ horsepower.

A special machine is used at the plant of the Boss Nut Co., Chicago, Ill., to charge tumbling barrels with blank punched nuts, take these nuts from the tumbling barrels, and distribute them in bins located convenient to the tapping machines. This apparatus consists of a modified form of the standard tiering machine built by the Economy Engineering Co., Chicago, Ill. It has a cantilever type of platform, open on three sides. The main uprights extend into a pit about three and a half feet below the floor level.

The platform consists of two arms, on which run the flanged wheels of a small transfer car; the latter, in turn, carries a pair of rails at right angles to its direction of movement. On these rails is placed a small hopper-bottomed car with a capacity of about 2000 pounds of punched nuts. The pit extends under the tumbler, and at the bottom are rails to allow the transfer car with the hopper car to be moved to a position directly under the tumbler. A steel frame is also provided above the tumbler so that the transfer car can be moved over the tumbling barrel. At one side of the machine is a row of bins, over the tops of which runs a track on which the hopper car moves.

To charge the tumbler, the platform of the machine, with the transfer and hopper car, is lowered to the bottom of the pit, bringing the top of the hopper car on a level with the floor. The punched nuts are then dumped into it from the kegs in which they have been deposited at the punchers. The platform with its load is then raised to the top position and the transfer car with the loaded hopper car moved to a position over the tumbling barrel, where the gates at the bottom of the hopper are opened and the nuts drop into the tumbling barrel. Here they are tumbled with sawdust until polished. The tumbling barrel is provided with perforations and a wooden tray is placed under it while the tumbling operation is being carried on, so that the sawdust gradually works out and is entirely eliminated by the time the polishing is completed. To empty the tumbling barrel, the transfer car is again moved into the elevator platform and lowered to the position in the bottom of the pit, where it is moved under the tumbler and the polished nuts are deposited in the hopper car. It is then returned to the elevator and hoisted to the level of the track over the bins and then pushed by hand to the proper bin, where the load is deposited by opening the gates in the bottom of the hopper.

The elevator is operated by means of a three-horsepower General Electric motor, through silent chain drive to a series of machine-cut spur gears connected to a drum upon which the steel hoisting cable winds. Automatic top and bottom

Fig. 84. A jib crane must be provided with support for the outboard end of the beam. This is often done by means of tie-rods. In this case the ceiling is too low to permit of this construction, so the outer end of the beam is furnished with a trolley which runs on a semi-circular rail

Fig. 85. In automobile tire factories there are a lot of heavy molds to be handled, and some means of assisting the operators must be provided. This view shows a chain hoist built by the Wright Mfg. Co., Lisbon, Ohio, in use in the Knight Tire & Rubber Co.'s plant. The molds are being placed in a vulcanizer

Fig. 86. Combinations of equipment are often necessary. This view in the Detroit Wire Spring Co.'s shops shows a conveyor and elevator. Assembled cushion springs are carried to the crating department, where they are packed, and the elevator carries crates to shipping department

Fig. 87. For handling loose material, such as coal, sand, etc., a scoop conveyor is made by the Portable Machinery Co., Inc., Passaic, N. J. This consists of a scoop and a power-driven belt conveyor that carries the material up an incline and delivers it into a chute

Fig. 88. There is often lack of system in handling metal goods which are to be heat-treated; this results in an unusually heavy charge against the work. The Chain Belt Co. of Milwaukee, Wis., has installed a special apron-type conveyor with chutes for carrying heavy drawn steel shells

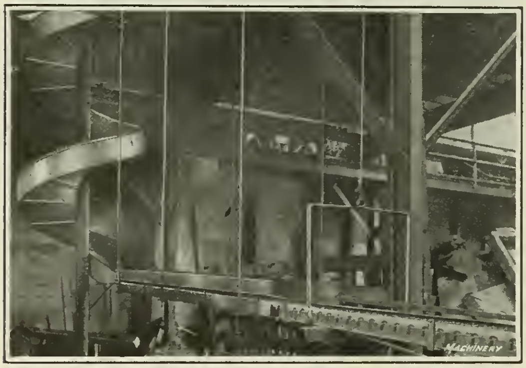


Fig. 89. For unloading flywheel castings from freight cars, the Cadillac Motor Car Co. of Detroit, Mich., has a spiral steel chute leading down from the platform on which the load is discharged. The castings are ejected from the chute onto a gravity carrier

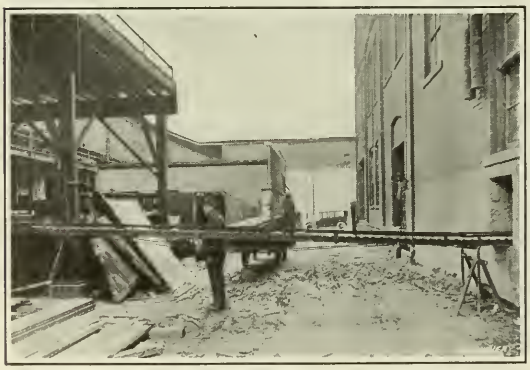


Fig. 90. This illustration shows the gravity carrier leading from the spiral chute shown in Fig. 89 to the machining shop. The carrier is suspended on cables so that it may be raised to provide the necessary head room for a team to go underneath

stops and other safety features are provided, making the machine largely automatic in its action, one ordinary laborer being all the help required.

Bringing the Saw to the Shafting

The Mechanical Appliance Co., Milwaukee, Wis., has developed a novel method of handling the steel shafting that it uses in the manufacture of its product. Shafting of from ½ to 3½ inches in diameter is used. It was found that a great amount of time and labor was consumed in bringing heavy shafting to the hacksaw from the racks onto which the shafting was loaded from the trucks. Instead of bringing the heavy shafting to the hacksaw, the motor-driven hacksaw is brought to the pile of shafting. The shafting is stacked onto the racks from the trucks. The hacksaw is raised to the correct level of the shafting by means of a tiering machine built by the Economy Engineering Co. One operator is able by means of this arrangement to take care of the complete operation of cutting off shafting from ½ to 3½ inches in diameter. As many as six men were formerly employed to carry the long pieces of the heavier sizes of shafting to the saw.

Adapting Transportation Methods to Requirements of Shop

In working out methods of progressive assembly for use in his factory, a manufacturer must bear in mind the volume of work which is to be handled. It would not pay to install a complex equipment of conveyors, trolley systems, etc., to facilitate handling work unless the volume of product was sufficient to keep equipment of this kind employed so that a reasonable return would be earned on the investment. Even in highly organized shops handling a moderate volume of product each day, little attempt is made to employ a complete outfit of mechanical contrivances for handling the work, because it is realized that there would be little likelihood of obtaining a satisfactory return on the investment. Recently we have seen some exceptions to this rule that are probably due to the condition of the labor market. Unskilled labor has been so scarce and has commanded such exceptionally high prices that some manufacturers have substituted mechanical means of handling as far as possible. This has been particularly true in shops engaged in certain munitions work where the necessity for making deliveries at an early date has demanded the employment of every possible means to increase production rates.

Plants handling an extremely large volume of product are best suited for the installation of complete systems of conveyors, trolleys, gravity carriers, chutes and other forms of equipment arranged in combination, so that as soon as one workman or group of men have completed their task on a given piece of work it may be placed on a mechanical carrier that will convey it to the department where the next operation is to be performed. Aside from the reduced cost of production made possible through the reduction in help, the employment of mechanical carriers has another important feature which commends it to the attention of manufacturers operating large factories in which there is likely to be a congestion of machines and product. Unless mechanical carriers are used, the alternative is to make transfers on trucks pushed by hand or by power, and the handling of a large amount of work in this way is bound to create confusion—especially when aisles are blocked or there is other interference with the movement of the trucks.

In an article of this kind it is the aim to explain fundamental principles and describe methods which the average manufacturer can employ in his own shop. On this account, the methods of handling material and product in extremely large plants are not entered into in detail, inasmuch as they require complete installations of mechanical transporting facilities and an engineering staff capable of laying out all kinds of equipment. Nevertheless, all manufacturers will be interested in reading of the equipment employed in the factory of the Willys-Overland Co., Toledo, Ohio, for the final work of assembling parts of automobiles.

General Arrangement of Equipment

The department in which the final assembly is conducted is laid out with four tracks, down which the automobiles are

pulled by chain conveyors that were installed by the Link-Belt Co., Chicago, Ill. The automobile frame is placed on this track and a hook on the chain conveyor takes hold of the front axle to draw the frame along. Features of the progressive method of assembly have been explained previously, so they need not be considered here. The point of greatest interest is the arrangement of the auxiliary carrying systems that bring parts to the main assembling track at the different points where the parts are to be assembled onto the car. There are four of these tracks that run lengthwise down the shop, and a large number of conveyors running crosswise. Each of these cross conveyors brings such parts as lamps, mud guards, radiators, etc., to the four main assembling tracks at those points where the different parts are to be added to the car; and all the time that this continual stream of parts is running across the shop, the automobiles in course of assembly are running lengthwise, so that as each car passes down one of the assembling tracks the different parts which go to make a complete car are brought over to the assembling track and secured in place. This system has been carried to such a degree that when the gasoline tank is delivered to the assembling track by one of the cross conveyors, it contains sufficient gasoline to allow the completed automobile to run out of the assembling department on its own power.

In the various manufacturing departments, as well as in the assembling department, use is made of conveyor systems for handling work in course of manufacture and finished parts. For the parts of a product as complex as a modern automobile, it will be evident that a great variety of carrier systems must be provided, and in the Willys-Overland plant use is made of practically all the standard conveyors, trolleys, etc. For instance, completely assembled motors are handled on apron-type conveyors or on trolley systems, from which they are suspended in a suitable sling. Advantage is taken of the circular form of wheels and tires, and they are rolled down gravity carriers. Gravity is also employed for carrying certain forms of castings and similar parts, but it is necessary to provide some form of roller conveyor, because the castings could not be rolled. In the case of lamps, mud guards and many other parts of a like nature, there is no better method of carrying than on a trolley system, and extensive use is made of this form of equipment. In addition to standard conveyors, many special forms of equipment have been provided for handling parts of unusual form, and a general idea of the diversity of the carriers that have been installed by the Willys-Overland Co. will be gathered from the illustrations presented in this and the preceding installment, showing views in this company's plant. These are by no means complete, but they serve to give an idea of the great variety of methods of handling that have been adopted to meet different conditions and the care that has been taken by this company's engineering department in studying all the available methods and adopting those that have the greatest number of features to commend them.

Development of Special Forms of Carriers

In working out the transportation system for any factory, the engineer in charge of the work has at his disposal numerous forms of standard equipment that are manufactured by plants making a specialty of this work, and it is desirable, whenever possible, to adopt the use of standard forms of equipment, because a plant specializing in such work can usually furnish equipment at a price considerably lower than that at which special equipment could be made for a given service. There are many cases, however, where the nature of the work to be handled is such that it demands the use of special equipment, and under those circumstances the engineer who is laying out the transportation system would be called upon to design suitable equipment for the work. This may involve the development of special methods of handling, but in many cases it will be found possible to use standard equipment and add special features to adapt it for a given service.

Where it is found that standard equipment cannot be obtained for handling the work, the next step of the engineer should be to ascertain whether certain standard forms of equip-

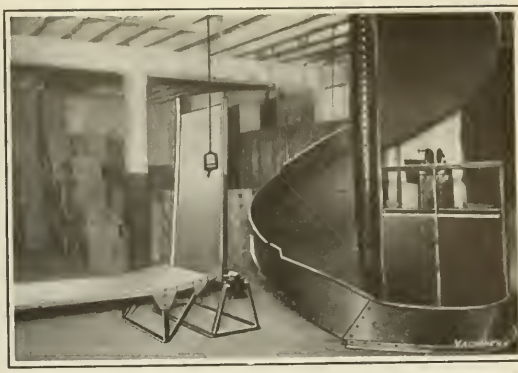


Fig. 91. Where spiral chutes are employed to carry work through a building, it is often desirable to discharge the load on some of the floors through which the chute passes. The chute shown (Mathews Gravity Carrier Co., Elwood City, Pa.) has a branch for this purpose

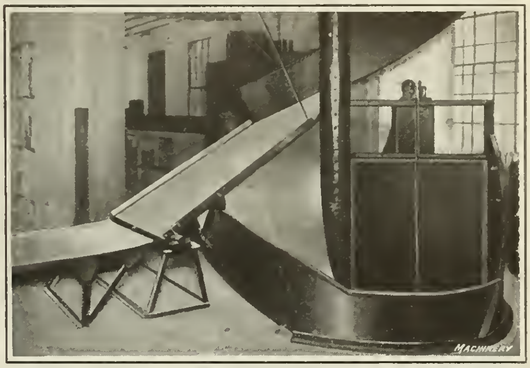


Fig. 92. This illustration shows the same equipment shown in Fig. 91, but here connection is made with the branch chute. Attention is called to the fire door; this is held open by a fusible link, which will melt and allow the door to close automatically in case of fire

Fig. 93. In the Detroit Wire Spring Co.'s shops extensive use is made of chutes for carrying work from upper to lower floors. Here we see chutes down which coiled springs are delivered to the department in which these springs are assembled into strips

Fig. 94. Where gravity carriers are used it is desirable to provide for discharging the load at different points in the shop. In the illustration provision is made for raising sections of the carrier at different points, so that the load may run under the rollers and slide down the chute

Fig. 95. In some machine shops compressed air is preferred to electric power. Such a case is shown in this illustration. Attention is called to the way in which the hose connection to the pneumatic motors is hung in festoons so that there will be plenty of length to enable the crane to run to the far end of the building

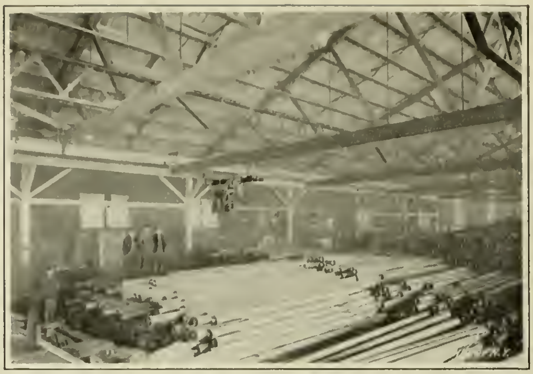


Fig. 96. When a number of trolley hoists are used on rails running parallel to each other, it is desirable to provide means of transferring trolleys from one rail to another. This can be done with a transfer bridge carrying a section of rail that may be lined up with some one of the main rails. The hoist is run onto the rail on the transfer bridge

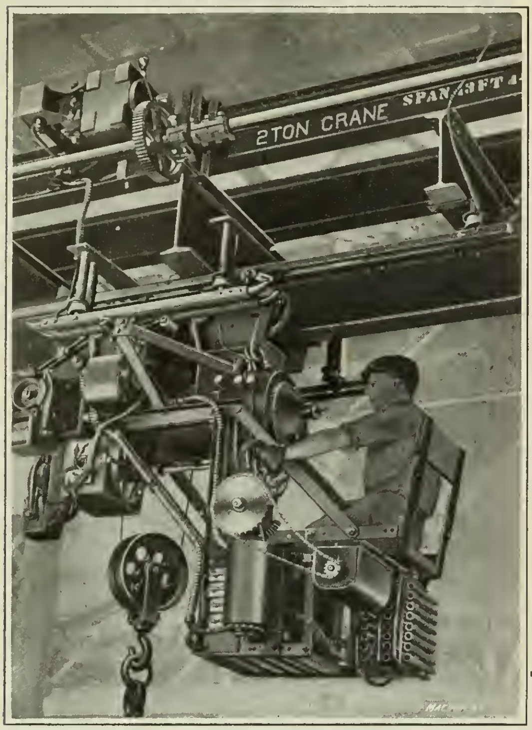


Fig. 97. This illustration shows a close view of the trolley in place on the rail of one of these transfer bridges. The trolley is locked while the bridge is in motion so that it cannot run off the rail. This equipment was built by the Sprague Electric Works, New York City

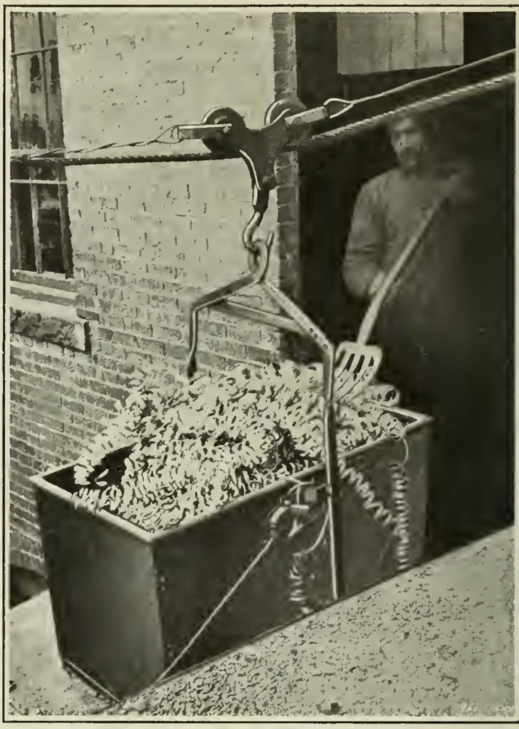


Fig. 98. In machine shops that produce large quantities of chips means may must be provided for hauling these chips away to the scrap pile. The illustration shows a skip loaded with chips, which is pulled over to the scrap pile by a laborer, who removes the contents with a pitchfork

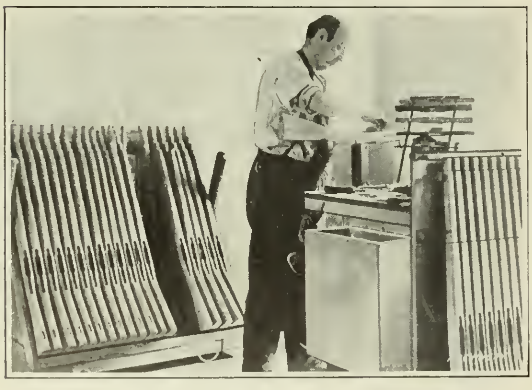


Fig. 99. In manufacturing military rifle stocks, each stock must be finished so as to present a good appearance. In the United States arsenals special trucks are used to carry the finished rifle stocks to prevent marring finished surfaces

Fig. 100. Durability is one of the most important features of any form of factory equipment. The Timken-Detroit Axle Co. makes steel boxes for use in connection with elevating trucks for carrying heavy metal parts, which are practically indestructible

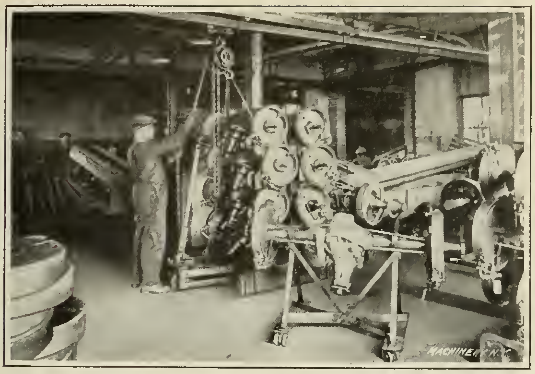


Fig. 101. In the Timken-Detroit Axle Co.'s factory axles are delivered to local factories on special motor trucks. A trolley hoist lifts an axle off the small truck onto a stand; when eight axles have been put on the stand it is picked up on an elevating truck and carried to the motor truck

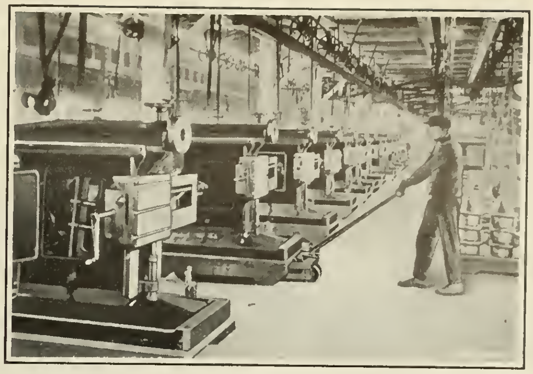


Fig. 102. This illustration shows how elevating trucks built by the Stuebing Truck Co., Cincinnati, Ohio, are used for handling the product of the Cincinnati Shaper Co. Machines are placed on skids so that they may be handled in the minimum time. The elevating truck enables the machines to be easily picked up and taken to exactly the desired spot

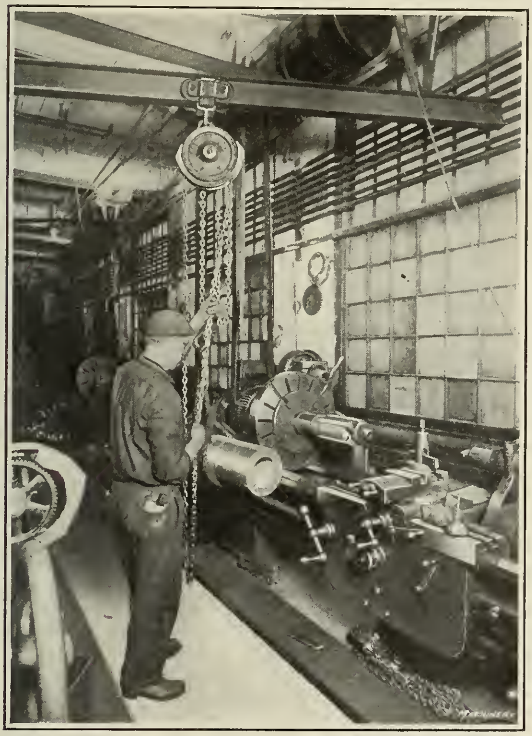


Fig. 103. In setting up heavy work on machine tools, it is desirable to use a trolley hoist in connection with each machine to conserve the operator's time. This illustration shows a chain hoist built by the Ford Chain Block & Mfg. Co., Philadelphia, Pa.

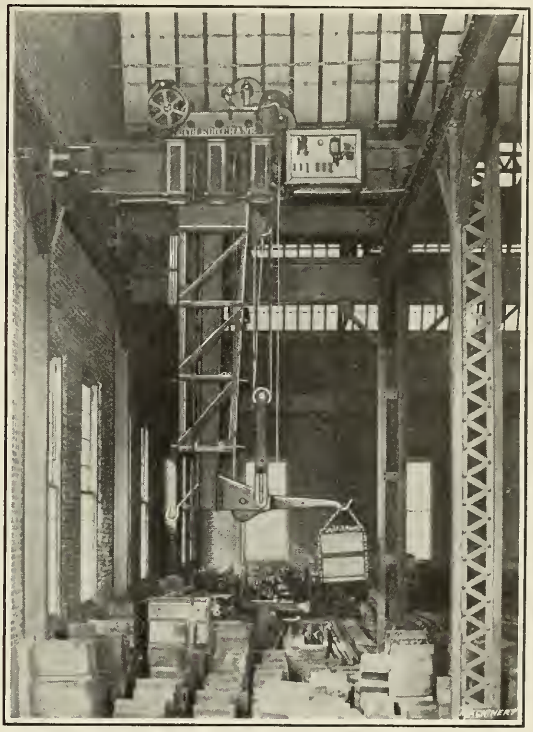


Fig. 104. The crane built by the Toledo Bridge & Crane Co., Toledo, Ohio, is used for placing dies on hammers or presses and transferring them to and from the storage department. The arm that carries the lifting hook is raised and lowered by means of cables

Fig. 105. For handling lumber, the Covel Mfg. Co., Benton Harbor, Mich., manufactures what is known as the "Ross" lumber truck. A load is built up to the desired size, after which the truck is driven over it and the load picked up. It is claimed that the cost of handling is six cents per 1000 board feet

Fig. 106. This illustration shows how steel balls are handled in the New Departure Mfg. Co.'s plant in Bristol, Conn. Balls are placed in steel tote boxes made by the New Britain Machine Co., New Britain, Conn., and stacked up on the platform of an elevating truck built by the Elwell-Parker Electric Co., Cleveland, Ohio

Fig. 107. In handling the progressive assembly of automobiles, the Willys-Overland Co. has tracks down which the cars are run during the process of assembly. Overhead trolley systems running at right angles to the line of travel of assembling tracks carry various parts to the assemblers

Fig. 108. Reference has already been made to the desirability of using combinations of equipment for handling material and produce which is being passed through a factory. This illustration shows the combination of an elevator, a gravity carrier and an apron-type conveyor for raising work from the lower floor and transferring it through the shop

ment furnished with special attachments for holding work, etc., cannot be made to meet his requirements. If so, it will be more desirable to use such equipment than to attempt to produce a complete special outfit. For instance, the Detroit Wire Spring Co., Detroit, Mich., recently laid out a complete new plant for the manufacture of automobile cushion springs. It was a point of great importance to provide methods that would enable the large volume of work constantly going through the shops to be passed along with the greatest possible dispatch. Certain features of this company's equipment are illustrated in this article, and it will be seen that mechanical carriers are employed for dipping work into japanning tanks, carrying the work into baking ovens, and many other purposes where manual labor would ordinarily be employed.

A bundle of coiled wire springs does not weigh very much, but it is of necessity quite bulky and calls for some special method of handling. The Detroit Wire Spring Co.'s transportation equipment consists largely of trolley systems, and to provide for carrying wire springs on trolleys it was necessary to develop special forms of carriers which could be used in conjunction with standard trolleys. This was worked out by arranging baskets for handling bundles of coiled springs and long racks on which a number of assembled cushion springs could be suspended. The adoption of this method enabled the engineering department of the Detroit Wire Spring Co. to buy standard hoists, trolleys and rails from manufacturers of this type of equipment, and then merely make its own racks, so that there was little special work to be done in getting everything ready for use. Needless to say, this was a less expensive installation than would have been a special outfit built for a particular class of service.

* * *

AFTER THE WAR—WHAT OF MACHINERY EXPORT?[1]

Opinions regarding the export of machinery after the war range from extreme pessimism to broadest optimism. England and Germany have been the most potent competitors of America in the machinery market, but Germany is arrayed against us, and it is reasonable to premise that the nations now at war will later cooperate with their present allies along economic lines. Further, for a considerable period at least, the products of Germany will find little favor among the Allies, with the possible exception of Russia. It would thus appear that for some time we may reasonably anticipate having only England as a serious competitor. Later, Canada may become an important factor in the machine-tool industry.

Although the present great demands on the resources of Europe have encouraged in England the highest possible development of those classes of machinery that have a direct bearing on the war, there has probably not been a similar development of automatic and other types of machines that until a few years ago were peculiarly American. Therefore, in many of these lines we may expect to occupy a commanding position in the industry.

Another factor that will loom large in our machine-tool industry is the labor question. While there may be no reduction in wages in this country for a number of years, because of the labor shortage, etc., wages abroad will so increase as to materially aid our export business. Further, the return of those soldiers, from the less enlightened sections, who have been prisoners in Germany will create among their people desires for the better things of life, and they will be satisfied with nothing short of an approximate fulfillment of these desires. However, regardless of the apparently favorable competitive conditions and the essential needs for the work of restoration, as well as the meeting of normal demands, our prosperity following the war will be largely dependent on the restoration program. Will our allies inaugurate a "pay-as-you-go" policy, which contemplates reconstruction through their own resources, or will they avail themselves of America's credit so that the devastated districts may utilize to its fullest capacity the labor of their remaining populations?

Indications are not lacking that Europe contemplates an eventual industrial development far beyond that attained prior to the war, thereby utilizing a large proportion of that great army of metal workers that during the present crisis is supporting the armies at the front. Heavy purchases of machinery are being made, largely for use after the war. Besides, many difficulties have developed during the war which seriously interfere with satisfactory financial arrangements; this has been most evident as affecting sales to Russia. Also for some time after the war we may expect to be handicapped through a lack of shipping facilities.

Assuming that the views here expressed as to the immediate future in Europe are far too optimistic, are there other fields wherein we may develop an outlet for our surplus product? Canada has but recently experienced the prosperity that comes from intensive industrial effort; nothing short of continued development along these lines will satisfy these "Yankees of the North." South America, which has purchased German goods so heavily, is now looking to us for supplies. India, South Africa and Australia will favor England whenever possible, but China, although regarded by Japan, from a commercial standpoint at least, as her rightful heritage, strongly favors American things in her industrial upbuilding.

One factor that will decrease industrial unrest and materially improve our export business is the establishment of fair standards of production and wages. If this problem is correctly solved, one of the greatest handicaps to an aggressive seeking of world trade will be removed. There is also a feeling on the part of the foreign buyer that when our business is good at home, scant attention is given business abroad; as soon as business is less prosperous, there is a rush to dispose of our products in the foreign market. If the foreign buyer of machinery is given value received in the goods purchased and the attention necessary to produce the results to which he is entitled, he will be loyal to his source of supply.

[1]Abstract of a paper read at the Export Conference, Springfield, Mass., June, 1917, by C. O. Smith, sales manager, Norton Grinding Co., Worcester, Mass.

GAGES FOR TIME-FUSE PARTS[1]

PROBLEMS IN THE MANUFACTURE OF GAGES FOR RUSSIAN TIME FUSES AND METHODS BY WHICH THEY WERE SOLVED

BY DONALD A. BAKER[2]

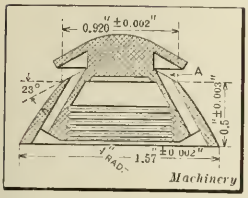


Fig. 1. Cap of Russian Time Fuse

MANY of the gages and jigs used in the manufacture of Russian time fuses present unusual problems to the toolmaker. In order that the use of the gages and jigs may be clearly understood, the parts of the fuses are illustrated; Fig. 1 shows the cap, Fig. 2, the top ring of the fuse, and Fig. 3, the body. In Fig. 4 is shown a gage for testing the relation of the various holes in the top ring. As a number of these gages are required by the inspectors, and as they wear rapidly, a master gage, Fig. 5, is used for testing them and keeping them standardized. This consists of a piece of annealed tool steel, bored out to fit over the center plug of the working gages and having the necessary holes properly located for testing the gages. The special tools and fixtures required for making the master gage were so designed that they could be used in the manufacture of the working gages. The master gage is made as follows: After a piece of steel is roughed out and a 5/16-inch hole reamed in its center, it is placed on a mandrel and turned and faced to the proper size, enough material being left on the faces to grind them perfectly parallel. After grinding, hole *A* is bored, the work being strapped to an angle-plate, swung on the bench lathe faceplate. The angle-plate is located the proper distance below the center by plug *A*, Fig. 6. One end of the plug passes through the hole in the faceplate, and is held in a spring chuck, while the other end is turned to the proper diameter for locating the angle-plate when the plate is brought against it, as shown.

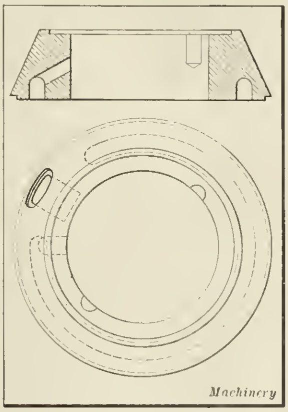


Fig. 2. Top Ring of Russian Time Fuse

The work is then located approximately on the angle-plate, and the lathe spindle is turned until the face of the plate, with the work attached, is at right angles with the top of the lathe bed; this is tested by placing a parallel across the ways of the lathe and using a square from the surface of the parallel. An indicator attached to a surface gage is then used to set the work central, being brought first against one edge and then against the other, the lathe faceplate being turned a half revolution for this purpose. After the work is securely strapped, it is tested to see that its position was not changed when tightening the clamps. The work is then center-drilled with a combination drill and counterbore. It is drilled a little smaller than the desired size, and a small boring tool is used to enlarge and true up the hole sufficiently to start a reamer; the starting hole must be of the proper size for the reamer to fit into it. This operation of boring and reaming is repeated several times; for instance, 0.002 inch may be removed with the first reamer, about 0.001 inch with the second, and 0.0005 inch with the third—the last being more of a burnishing than a cutting operation. The finishing reamer should leave between 0.0002 and 0.0005 inch to be removed with a solid lap. The lap is made of either brass or copper, preferably the latter, charged with washed flour of emery. It is held in the fingers and the work revolved against it.

Boring Angular Hole in Master Gage

For the next operation, boring the angular hole *B* and the two half holes *C* and *D*, Fig. 5, a special angle-plate is used on the bench lathe faceplate. This consists of a flat plate *A*, Fig. 7, which is ground perfectly parallel, and a plate *B*, shaped up and ground accurately on the faces and edges, and having accurate angles. An accurate angle-plate and sine bar are used to make the angles correct. The master gage is placed over a plug inserted in a 5/16-inch hole *C* bored and reamed near the center of this plate. The plate also contains two holes *D* and *E* for locating and boring the two half holes in the master gage; while this is being done, plate *B* is used separately from plate *A*. These two holes are carefully located by the following method: First a hardened, ground and lapped plug *A*, Fig. 8, is made. One end of this plug fits the center hole in plate *B* and the other end is ½ inch in diameter; near the middle is a disk-like section. The diameter *C* of the disk is such that when two ½-inch standard jig buttons are placed directly opposite, one on each side of the center plug and against its edge, as shown, their center distances will be equal to the center distance of the two holes to be bored.

The position of the buttons having been laid out roughly and the holes for the button screws having been drilled and tapped, the buttons are put in place and held lightly by their screws. The plate is then placed on its edge, as shown, and the sine of the angle having been found by calculation, the tool *D* is used to set one of the buttons in position. This tool consists of a tool steel base *A*, Fig. 9, which is hardened, ground and lapped on the bottom, and several lengths of drill rod, the ends of which have been hardened, rounded off and lapped smooth. These rods are held in the body and can be clamped securely in place by screw *C*, the body being split at *B*. The rods are first set to the proper distance from the base of the tool by the aid of a micrometer, one rod being set to the distance from the bottom of the plate to the edge of a button, and the other to the distance from the side of the plate to the edge of a button. The rods are adjusted by lightly tapping them, as when setting an ordinary firm-joint caliper. Sometimes the rods are threaded, when they are adjusted by screwing in or out. To locate the buttons, the plate is set first on one edge, then on the other, using the tool as a feeler by sliding it along the surface plate underneath the button, and tapping the button in the direction that the feeler shows it should go, until the "feel" is just right. This method applies to the setting of any button, but as in this case one dimension is supplied by the central plug, only one dimension is needed—that from the bottom of the plate to the edge of the button.

The second button on the plate can be adjusted by using a knife-edge straightedge to get the two buttons and the plug dead in line. The straightedge is tried first on one side and then on the other, and the screw of the second button is tightened, when finally adjusted, so that the straightedge no longer "rocks." After the buttons are set in the proper position, the plate is strapped lightly to the lathe faceplate and one of the buttons indicated until it runs true. Then the straps are tightened and the button again indicated to make sure the clamping has not disturbed the setting; if it still runs true, the button is removed and the hole bored, reamed

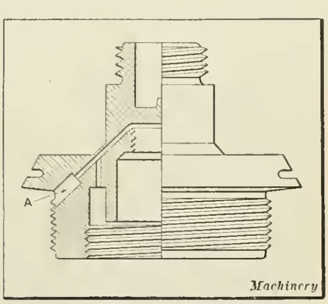


Fig. 3. Body of Russian Time Fuse

[1] For other articles on making fuses, see "Manufacturing Parts of Type 80 Time Fuses," in the December, 1916, number of MACHINERY, and other articles there referred to.

[2] Address: Williams Mfg. Co., Ltd., Montreal, Canada.

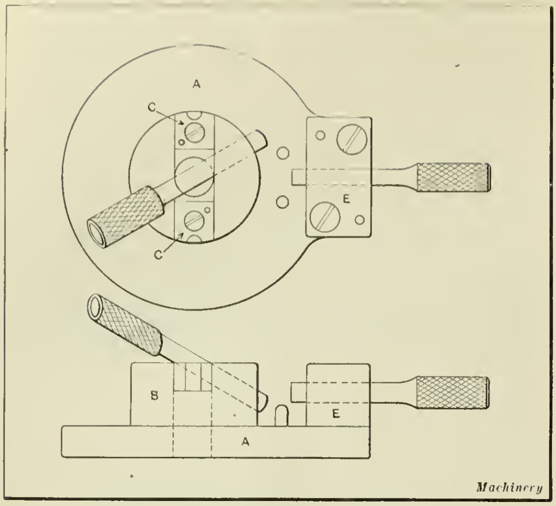


Fig. 4. Gage for testing Holes in Top Ring

and lapped as described for the master gage. After the first hole is finished, the second is treated in a like manner and the plate completed.

To use this master plate, a plug is placed in the center hole and the master gage is placed over this, being held in position by putting a few drops of solder around the edge. Next a special collet with a hole bored through it is placed in the lathe, as shown in Fig. 10. In the end of the collet is placed a piece of 5/16-inch hardened drill rod A, the end of which is ground and lapped to fit the holes in the master plate. After this collet is in place and the end of the plug is ground, the faceplate is put on and indicated on its face, to make sure that it runs true; then the master plate, carrying the master gage, is located by putting it over the center plug in the lathe, and strapped fast in the proper position for one of the two half holes to be bored. The remainder of the operation is the same as described for the other holes. The second half hole is treated in the same manner.

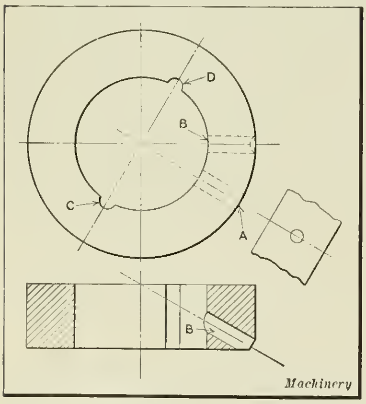


Fig. 5. Master Gage for testing Gage shown in Fig. 4

The method of boring the angular hole B, Fig. 5, is one seldom used. Although the locating of this hole is usually considered one of the things that must be found by the most unsatisfactory cut-and-try methods, it may be accurately done as follows: The two plates A and B are screwed and doweled together, as shown in Fig. 7, converting them into a special boring fixture, or master angle-plate. Then a special plug having a hardened steel ball F at one end is made up. Commercial steel balls are used, as they are readily obtainable and are usually accurate as to sphericity. This plug is placed in the 5/16-inch hole in the plate and the ball is adjusted with micrometers until its center is as far from the face of the plate as the sine of the angle of the hole to be bored. The boring fixture is then strapped to the lathe faceplate and the ball indicated until it runs true, after which the ball and plug are removed, a short, straight plug substituted, and the master gage located in place again over this plug, being held by solder, when it is ready to have the hole B finished in the usual way.

Finishing Center Hole of Master Gage

The last operation on the master gage is finishing the center hole to size, stock having been left so as to bore the two half holes through solid steel. The gage is held in a cast-iron spring chuck of the "step" variety, and the hole is roughed out. But as these chucks are not absolutely accurate, the finishing is done in a brass chuck like that shown in Fig. 11. This chuck consists of a special lathe collet A, to one end of which is screwed and soldered the piece of brass B. The collet is placed in the lathe and the brass piece bored out to within a couple of thousandths inch of the size of the outside diameter of the master gage. It is heated with an alcohol lamp

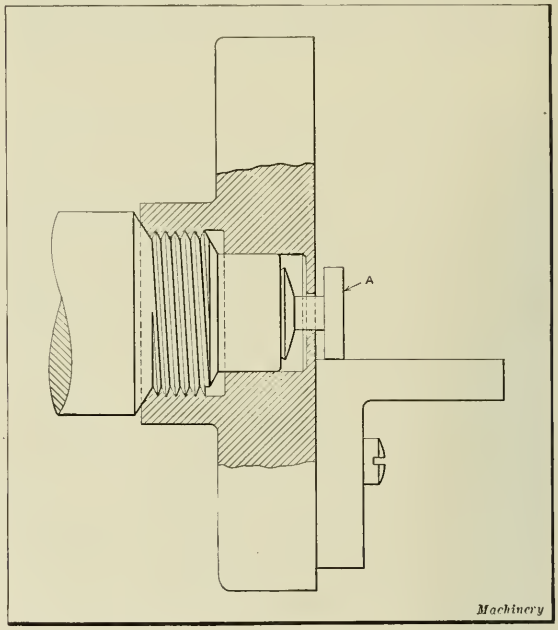


Fig. 6. Angle-plate used to support Master Gage when it is being ground

until the gage will slip into it, and is then cooled with a piece of waste dipped in water; the shrinkage of the brass will hold the gage securely and accurately. The gage is then bored in the regular way, care being taken on the last few cuts not to break down the corners of the two half holes. In boring, 0.01 inch is left for finishing with the bench lathe grinder, and in this operation from 0.0002 to 0.0005 inch is left to be taken out with a lap. When lapped, the gage is ready for use.

Making Working Gages

In making the working gages, practically the same methods are used. These gages consist of a base A, Fig. 4, a hardened tool steel locating and gaging nose B, to which are screwed and doweled the half-hole gaging parts C, and hardened steel block E, which is screwed and doweled to the base.

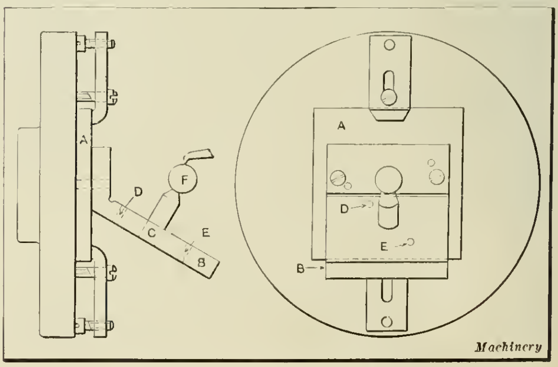


Fig. 7. Special Master Plate for holding Master Gage

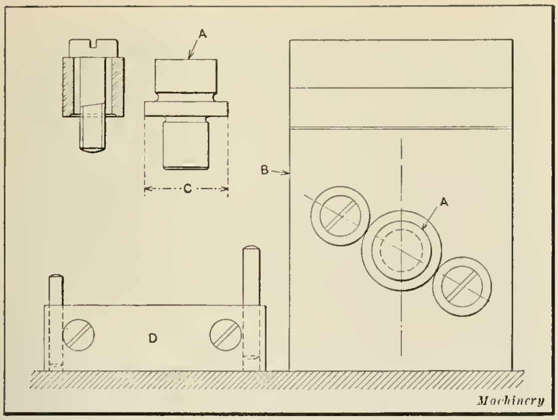


Fig. 8. Plugs for locating Half Holes in Master Plate

In addition there are four hardened, ground and lapped plugs, only two of which are shown; the other two are double ended "Go" and "Not Go" gages for the half holes.

To make this gage, the base A is first machined, the two flat sides being ground parallel and smooth; then the 5/16-inch hole in the center is bored, after which the block E is made in the usual way, placed on the base and located approximately. After the screw holes are located, drilled and tapped, the piece is fastened lightly in place and lined up properly with the center hole in the gage base. It is then fastened securely by the screws, and the dowel-pin holes are drilled and reamed and the dowels placed in them.

The next step is machining the center plug, or locating nose B, which is done in practically the same manner as was described for the master gage, using the same master plate and master angle. A piece of tool steel is roughed out and a hole 0.002 inch less than 5/16 inch is bored and reamed in the center. The piece is then placed on a mandrel and the outside turned to within 0.01 inch of size and the top and bottom are faced off. The bottom, being slightly under-cut, leaves a rim 0.004 or 0.005 inch around the edge. This edge makes it impossible for any bulging, caused in hardening, to prevent the bottom from being lapped to a true surface again without grinding on the surface grinder. After the piece is turned and faced, it is removed from the mandrel and placed on the milling machine, and a 5/16-inch slot, 1/4 inch deep, is milled across the face to take the two pieces that are to gage the two half holes. Screw and dowel holes are then made in it. In boring the angular hole, the same methods and fixtures are used as in making the same hole in the master gage. After this hole is bored and reamed, the piece is hardened. The scale is then lapped out of the center hole, and a short piece of drill rod is caught in the lathe chuck and ground in place until the piece can be wrung onto it. In this position the piece is ground to within 0.0005 inch of size and then lapped, to remove the remainder. Next, the two pieces of soft tool steel are fitted to the 5/16-inch slot milled across the face of the plug, leaving enough projecting at each end so that when the half holes are being made there will be stock all around to support the reamers, etc. In making these holes, the master plate used in making the master gage is again used. In boring, about 0.002 inch is left in the holes, so that after they are hardened and replaced, they can be again set up and ground with a diamond-charged lap used in the bench lathe traverse spindle grinder. Afterward the surplus stock on the ends of the inserted pieces is ground off on the tool grinder freehand, the final finish being given by placing the piece that carries them over a plug, previously ground in the lathe chuck, and finishing with the bench lathe grinder.

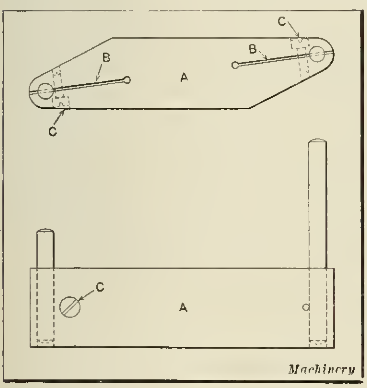


Fig. 9. Tool for locating Plugs shown in Fig. 8

The gage is then ready to assemble. This is done by placing the gage over a 5/16-inch plug that is inserted in the hole in the base. Then the master gage is placed over it and the two plugs of the proper size are inserted in the two half holes and in the corresponding holes in the working gage, while a third plug is put through the block E and entered into the proper hole in the master gage. In this position, the center plug, or locating nose of the working gage, is ready to have the dowel and screw holes transferred to the base. After these holes are finished, the dowels inserted and the nose secured by the screws, the gage is ready for use. The angular hole, and all others that are likely to become out of true in hardening and which cannot readily be trued up by other means, are ground out by using a diamond lap where they are too small for an emery wheel to be used.

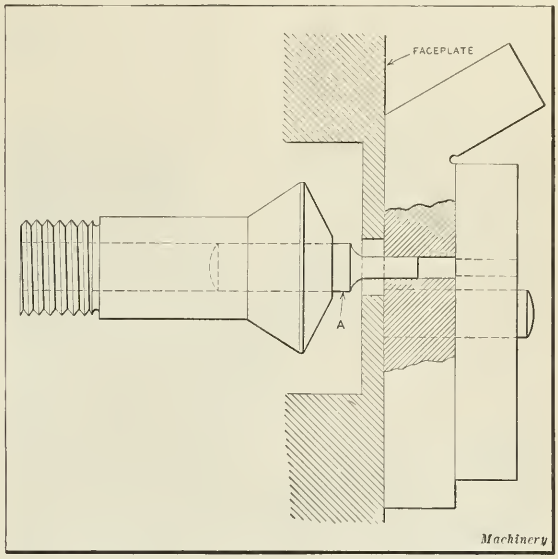


Fig. 10. Special Collet used in making Master Gage

Height Limit Gage

At B, Fig. 12, is shown a limit gage for testing the height of the under-cut A in the fuse cap, Fig. 1. For the benefit of those who like to work out interesting and practical problems in toolmaking that require a knowledge of simple shop trigonometry, the dimensions of the gage and the cap are given here just as the workman gets them. The gage consists of five pieces; A and B form the body and are doweled and riveted together by the pin D, which is a snug-fitting piece of drill rod. Pins C are driven into body B, the center hole being for clearance to allow the pins to be driven out.

Fig. 15 shows the master plate on which the two parts forming the body were made. This consists of a flat plate A ground parallel on the sides and two long edges. In it are

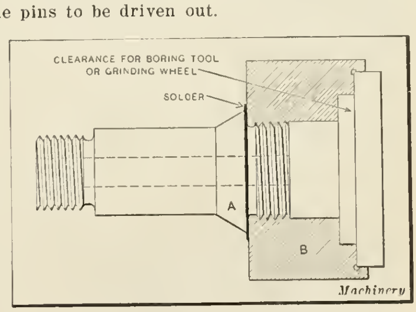


Fig. 11. Brass Chuck for holding Master Gage

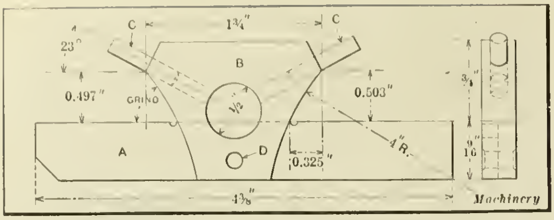


Fig. 12. Gage for testing Under-cut in Fuse Cap

bored four holes *B*, *C*, *D* and *E*, and two pins *F* and *G* are located on it. The positions of the holes, of course, are found by calculations involving trigonometry. After the dimensions have been found, the plate can be laid out roughly, the holes drilled and tapped, and jig buttons screwed in place and then located accurately by using micrometers, a height gage, or other convenient means. In this case, the hole *B* was first located approximately and the center punched. Then the plate was swung on the faceplate of a lathe, and the hole drilled, bored and reamed to size, but without taking any particular pains to keep it in exact relation to any other part of the plate, as it was afterward to be used as a starting point.

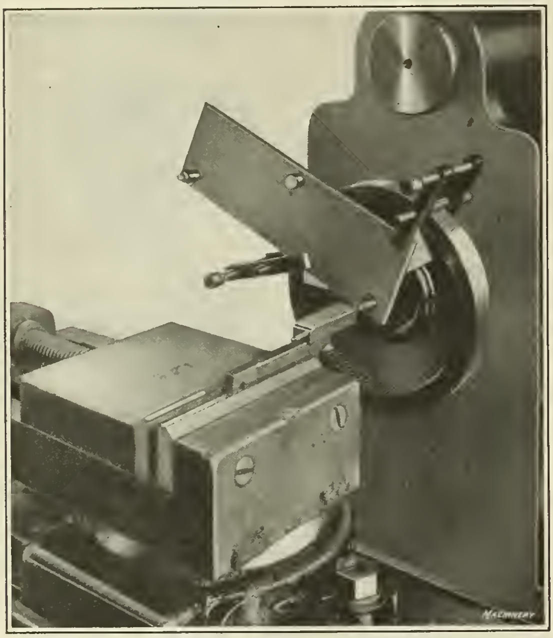


Fig. 13. Locating Holes on the Master Plate

After hole *B* was finished, the jig buttons were put in place and accurately located for holes *C* and *D*. As we had no engine lathe large enough to swing the plate when these holes were being bored, a milling machine was used, as shown in Fig. 13. Lacking a proper faceplate for this machine, a large internal gear that was part of a high-speed milling attachment was put in place on the machine and a light cut taken off its inside face to make sure that it ran true, holding a lathe tool in the miller vise. Two blocks that had been ground square on the surface grinder were then placed against the trued face of the gear, and the master plate was clamped back against them as shown; then the buttons were trued up by the indicator, which was held fast in the miller vise. After truing them, the work was clamped more securely, again indicated, and the buttons were removed; a boring tool was put in the miller vise in place of the indicator, and the holes were bored true, using the milling-machine feeds.

After the end holes *C* and *D*, Fig. 15, were finished, plugs were inserted and the button for hole *E* was put in place and trued up from holes *C*, *D* and *B*. As hole *E* is in the center of the plate, it was bored in the engine lathe in the regular way. The pins *F* and *G* were then located. No particular pains were taken with these, as they were under-cut next to the plate; they were then ground on the surface grinder, the plate being stood on edge to get the proper dimension from hole *B*. Next a drill bushing was inserted in the center hole *E* and a plug in hole *B*.

The piece *B*, Fig. 12, having previously been roughed out of tool steel and the center hole having been bored on the

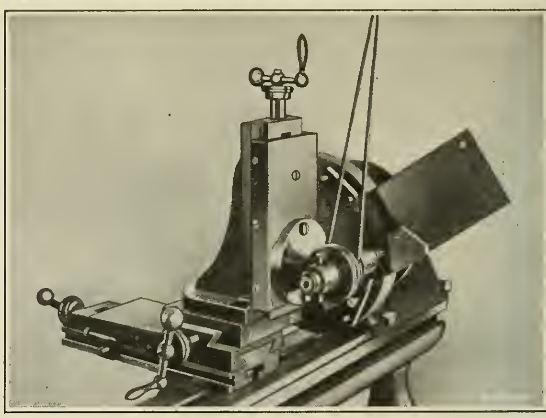


Fig. 14. Milling Edges of Gage and Slots on Master Plate

bench lathe and lapped to a plug fit, was placed over the plug in the hole *B* on the master plate, clamped fast, and the dowel-hole spot-drilled, drilled and reamed through the drill bushing *E*. Next, the four-inch radius was milled, about 0.005 inch being left on a side to be ground off. The milling was done on the bench lathe, as shown by Fig. 14. Plugs were inserted through the work and the holes *E* and *B*, Fig. 15, in the master plate, while another plug was trued up in place in the lathe spindle from which to swing the plate from either of the corner holes *C* or *D*, using the lathe milling attachment as shown. During this operation, the two clearance slots *H* in the master plate were milled so as to allow a grinder wheel to pass over the work on the following operations.

Next the bar *A*, Fig. 12, is milled to receive the piece *B*. This slot is roughed out on the regular milling machine and finished on the bench lathe to within 0.005 inch, using the master plate and the bench lathe milling attachment, as previously described, and locating from the dowel-hole *D*, which has been drilled and reamed, and the two pins *F* and *G*, Fig. 15. Next comes the boring and reaming of the two holes for the pins *C*, Fig. 12. Figs. 16 and 20 show how the part *B*, Fig. 12, is located on an angle-plate over the two pins that

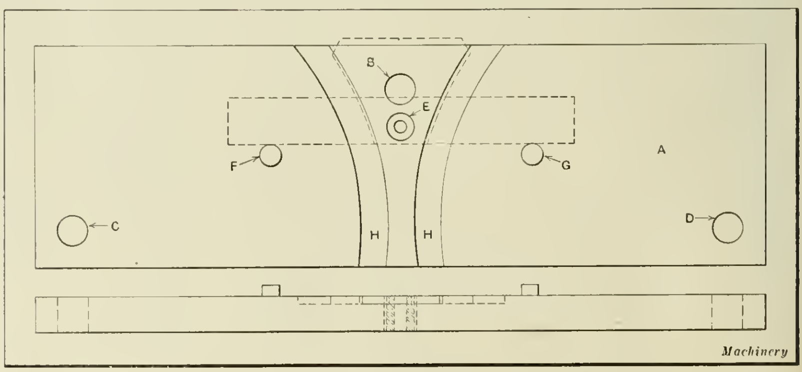


Fig. 15. Master Plate for making Gage shown in Fig. 12

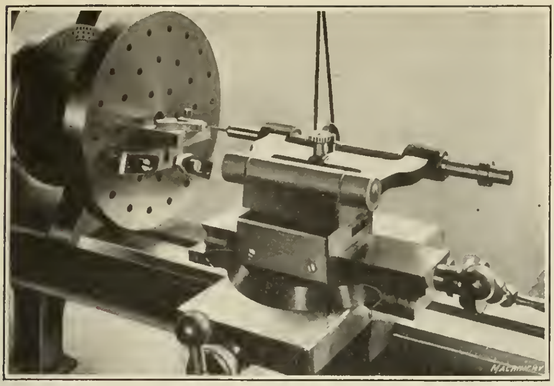


Fig. 16. Lapping Holes in Ends of Gage

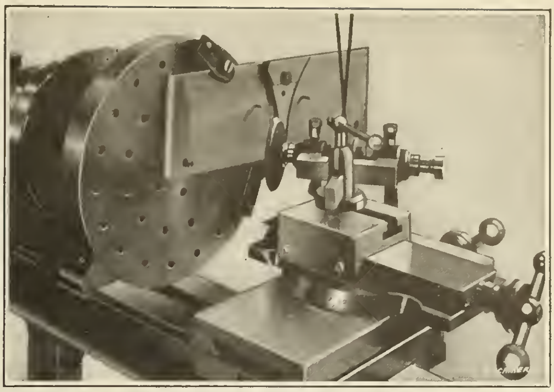


Fig. 17. Grinding Four-inch Radius on Gage

were accurately located for holding the piece in the proper position. After the holes are reamed for the pins, the piece is taken to the milling machine and the end milled where it is to fit on the bar, enough stock being left for grinding after hardening. All the pieces are now ready to harden. After hardening, red-hot tongs are used to draw out those parts that are to be joined together so as to eliminate, as far as possible, any chance of their breaking at this point.

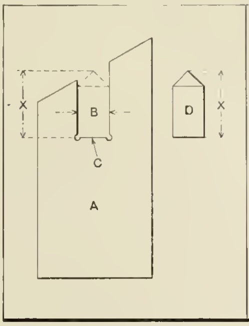


Fig. 18. Master Gage for making Gage shown in Fig. 21

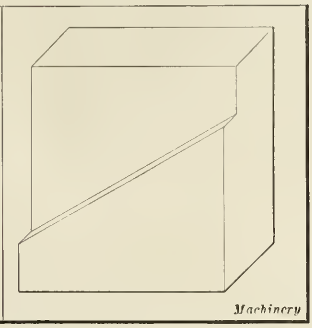


Fig. 19. Master Angle-block for making Master Gage shown in Fig. 18

Next the holes for pins *C* are lapped out and temporary pins driven in place, after which the work is taken to a surface grinder and the sides ground parallel with these pins. Then the center holes and the dowel-holes are lapped out until the pieces can be put back in place. Fig. 16 shows the final finishing of the two pin-holes with a diamond lap, using the bench lathe traverse spindle grinder. Next the four-inch radius is ground on both parts *A* and *B*, Fig. 12. This work is done on the bench lathe, using the master plate swung from the center plug and the tool-post grinder, as is shown in Fig. 17. The lathe is turned back and forth by hand and the measuring is done from the center plug to the side of the radius with a vernier to get the exact radius. Parts *A* and *B* are then fitted together and the dowel-holes lapped true with each other and a tight fitting dowel inserted, but not headed over. Getting the dimensions 0.503 and 0.497 inch is then a matter of calculation and measurement from a plug inserted in the center hole in part *B* to the face of bar *A*, then removing *B* and grinding *A*. After assembling them and inserting and heading the dowel, the gage is finished.

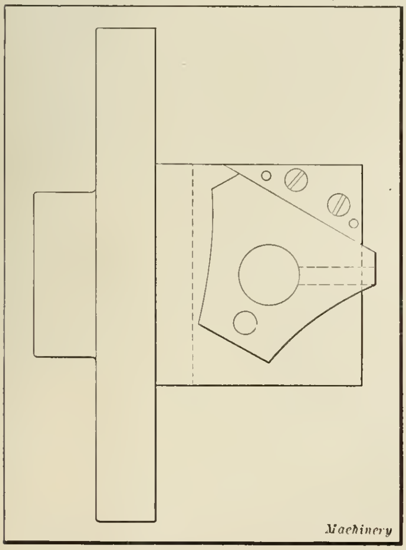


Fig. 20. Holding Gage for boring and lapping Holes in Ends

Flat Gage for Measuring Depth of Slot in Fuse Ring

At *A*, Fig. 21, is shown a gage that puzzles the average toolmaker. It is a simple flat gage used to measure the depth of a milled slot *B* in the fuse ring; a is the angle of the edge of the ring, and *D* and *E* the dimensions given by the part drawing. The dimension X is determined by calculations involving simple shop trigonometry, but measuring this dimension on the piece is another matter. As it cannot be done directly with micrometers, a master gage *A*, Fig. 18, must be made. This, at first, seems to be as hard a proposition as the working gage, but actually is much easier. A piece of Brown & Sharpe ground tool steel is roughed out to approximately the shape shown, leaving enough to grind, and is then hardened. It is then placed on a surface grinder, and after the sides and edges, and the surfaces *B* and *C* are ground, the angle is ground and dimension X made correct.

But before this can be done, a master angle-block must be made. This block, shown in Fig. 19, is made of machine steel and is ground perfectly square and parallel on the ends and sides. The angle is obtained with the aid of a sine bar and an accurate angle-plate. When this block is finished, the master gage is clamped to it while the angle is ground on a surface grinder. To make dimension X correct, a hardened and ground plug *D*, Fig. 18, is made, the outside diameter and the point being ground at one setting, so as to have the point exactly concentric. The point is rounded with a fine Arkansas oilstone to remove any slight burr

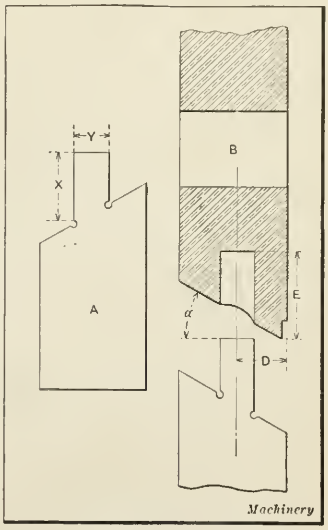


Fig. 21. Flat Gage for measuring Milled Slot in Ring

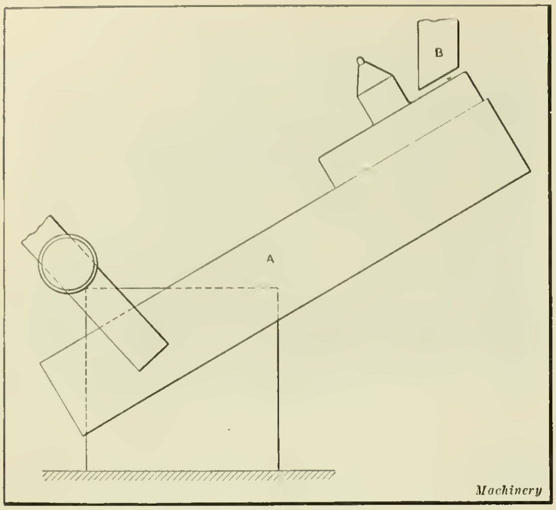


Fig. 22. Using Master Angle-block to get True Angle on Grinding Wheel

or sharpness that can possibly interfere when measuring across it with a micrometer. Care must be taken to remove no more than is necessary. After grinding the outside and the point, the other end is ground, either in the bench lathe or the surface grinder, whichever is most convenient or accurate, until the plug is the proper length. Then the master gage is laid flat on a surface plate and the plug is pressed between sur-

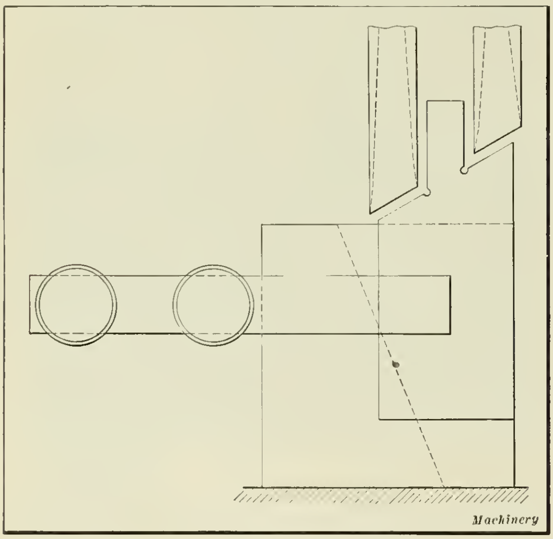


Fig. 23. Method of clamping Gage to Master Angle-block

faces *B* and against surface *C*, as shown by the dotted lines, and secured in that position by a drop of melted wax. This wax is made by melting together one part of beeswax and one part of rosin. When the master gage is secured to it, the master angle-block is taken to the surface grinder and ground on the angle until a straightedge will rest on the angular surface and the point of the plug. Great care must be exercised not to grind off too much, as the point of the plug is so small that a ray of light shining through between it and the straightedge may appear to be several thousandths inch, when in reality it is no more than 0.0001 or 0.0002 inch. After the angle is properly ground, the master gage is ready for use.

The working gages are roughed out of Brown & Sharpe ground stock, no particular pains being taken with them other than to leave enough stock on the working faces to grind, after which they are hardened. They are then ground true and parallel on the sides and edges. In order to grind surfaces *B*, Fig. 18, and the angular faces, the master angle-block is set up on the surface grinder, as in Fig. 22. After a parallel *A* is clamped to it, the diamond emery wheel dresser is slid up and down it past the face of the wheel *B*, thus obtaining the correct angle on the wheel. In Fig. 23, the work is shown clamped to one of the plain surfaces of the master angle-block, in the proper position to grind; the wheel, besides being trued on the face to give the proper angle, is under-cut on the sides with the diamond, as shown by the dotted lines.

In grinding surfaces of this kind, the grinder spindle must have no end play, so it is customary to use a piece of hard wood, sharpened to a blunt point, in the spindle center and keep the spindle in the proper position by lightly pressing against it. If much work of this kind is to be done, a flat spring secured to the wheel guard and pressing against the end of the spindle may be made to answer. After surfaces *B*, Fig. 18, are ground, the angular faces are ground. As these faces must be parallel and perfectly in line, it is difficult to grind them on the surface grinder, so the bench lathe is used.

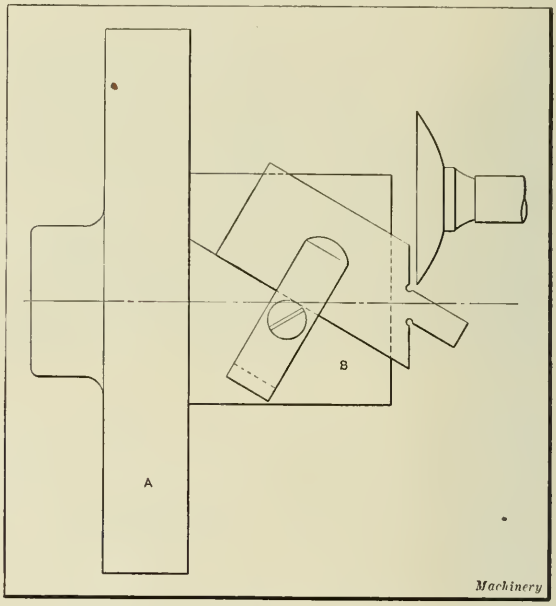


Fig. 24. Grinding Gage in Bench Lathe

In Fig. 24, *A* is the faceplate and *B* is the master angle-block, to which the gage is clamped, which, in turn, is secured to and swung from the faceplate of the lathe. The grinding is done with the bench lathe grinding attachments, either the traverse spindle or toolpost grinder being used. Lastly, the end of the gage has to be ground to make dimension *X*, Fig. 21, correct. This is set up as shown in Fig. 23, only using a straight wheel and trying the work with the master gage.

Gage for Testing Counterbore of Angular Hole in Fuse Body

Fig. 25 shows a gage for testing the depth of counterbore of the angular hole *A* in the fuse body, Fig. 3. This consists of the body into which pins are driven. All the parts are of tool steel and are hardened and ground. The hole through the center provides means for driving out the pins easily. The difficulties

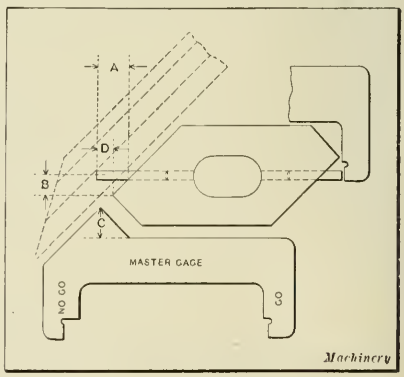


Fig. 25. Gage for Depth of Counterbore of Angular Hole in Fuse Body

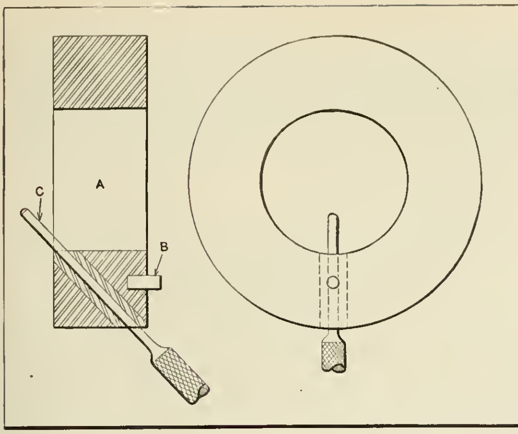


Fig. 26. Gage for locating Angular Hole drilled in Stem of Fuse Body

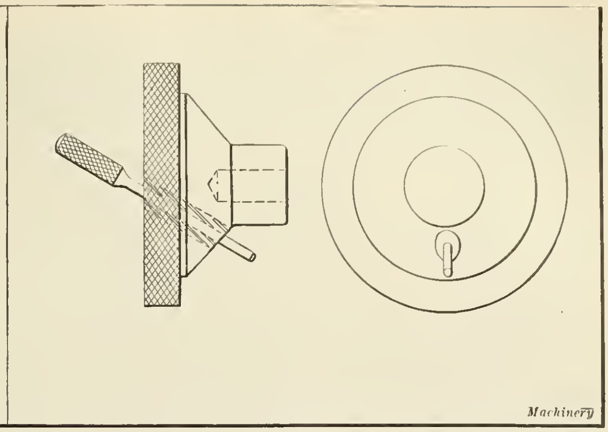


Fig. 27. Gage for locating Angular Hole, Similar to that shown in Fig. 26

met in making a gage of this type are in getting the dimensions *A* and *B* correct, as neither of these may be obtained direct with ordinary measuring tools.

The method of making these gages is as follows: First the body is roughed out, taking care only to see that the two pins are kept in line with each other. Then the body is hardened, the holes lapped out to receive the pins, the pins put in temporarily, and the sides and edges ground parallel with these, care being taken that both the edges are a given distance from the pins. The pins are then removed and the work is clamped to a master angle-block and the longer of the two oblique sides ground.

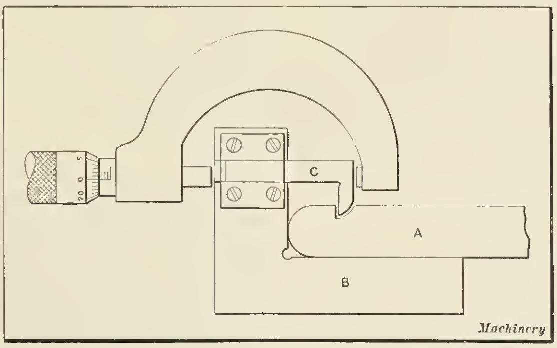


Fig. 28. Testing Slot in Relation to Radius

Before finishing the short sides and getting dimension *B*, it is necessary to make up the master gage, which may be used to test the working gages. The angles on this master gage are generated by a sine bar and an accurate angle-plate, grinding them on a surface grinder. The measurement *C*, which is the difference between *B* and the edge of the working gage, is easily obtained with a micrometer. The "Go" and "Not Go" ends of the master gage, which are used to test the length of the pins, are ground in the usual way, as they can be measured direct with the micrometer.

When the short oblique side of the working gage is to be ground, the gage is clamped fast to a master angle-block, set up on the magnetic chuck of a surface grinder and ground little by little. The master gage and a knife-edge straightedge are then used to test it, as shown, until the two edges are perfectly in line. A variation of 0.0002 inch between the master and the gage will look large when they are held to the light. After finishing the angle, which makes

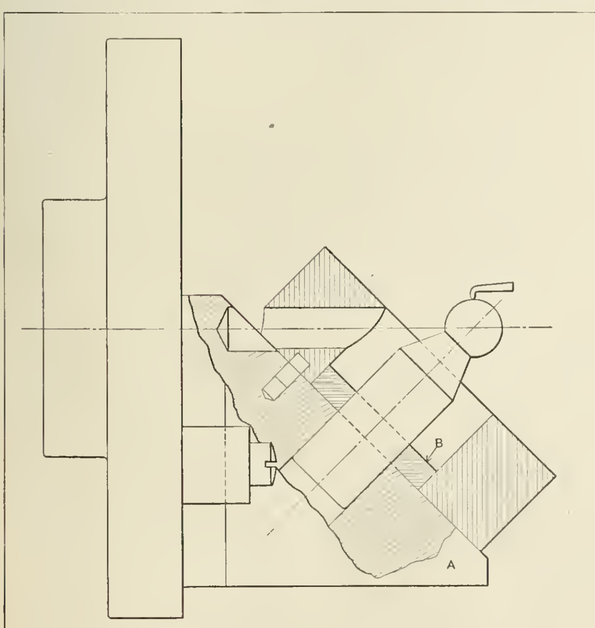


Fig. 29. Method of handling Gage shown in Fig. 26

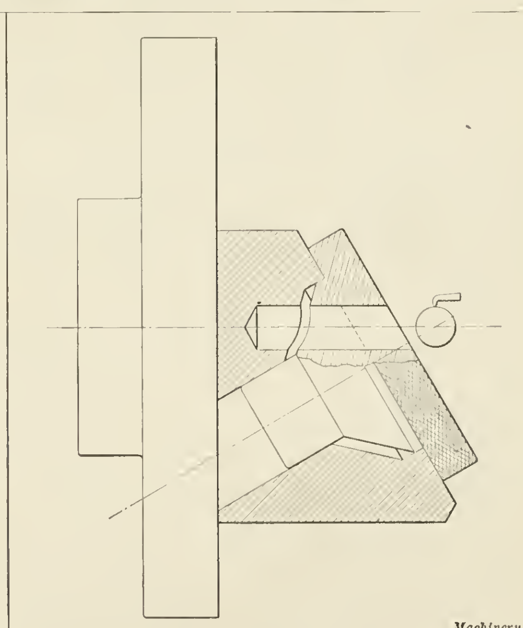


Fig. 30. Method of handling Gage shown in Fig. 27

dimension B correct, the hardened pins are driven in, leaving just enough projecting to grind. Then, squaring up on an angle-plate, the pins are ground off, the master gage being used to get the dimension D, which has been found, by trigonometry, to bring dimension A right and finish the gage.

Testing Slot in Relation to Radius

Fig. 28 shows a method of measuring a slot in relation to a radius that it is desired to make more accurate than can be done with a height gage or other ordinary means. A is the piece to be measured; B, a special square of hardened and ground steel; C, a smaller square made to fit and slide perfectly in a slot in the larger square and held in place by a flat plate screwed on, as shown. All parts of the tool are made as accurately as possible. The manner of using is clearly shown; the width of the square ends are subtracted from the over-all dimension found by the aid of the micrometer.

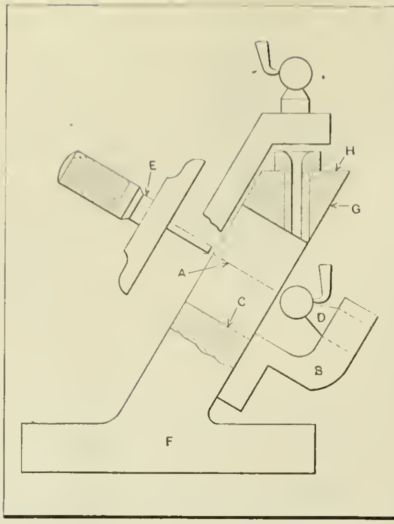


Fig. 31. Jig for drilling Angular Hole in Stem of Fuse Body

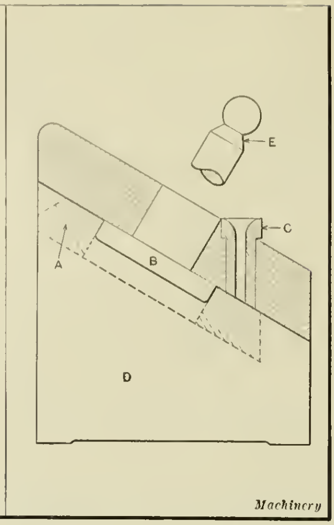


Fig. 32. Jig for drilling Angular Hole in Fuse Ring

Miscellaneous Examples of Gages and Jigs

Figs. 26, 27 and 29 to 32, show other examples of gage and jig work. Fig. 26 shows a ring A that fits over the stem of the fuse body and down onto the platform, where it is located from the pin B that fits into a hole in the platform. The pin C is used to gage the location of an angular hole drilled through the stem. The method of handling this gage is as follows: After roughing out the ring A, allowing for grinding and locating the pin B, it is transferred to a master angle-plate A, Fig. 29, which, in turn, is clamped to a bench lathe faceplate, as illustrated. This angle-plate has been previously ground perfectly true on the surface grinder, using a sine bar to make the angles correct; it also has two holes accurately located in it, one for centering the gage and the other for receiving pin B. When the angle-plate has been properly positioned on the lathe faceplate by means of the ball plug, as shown, the latter is removed and another plug inserted; over this plug is placed a ring B that is used to locate the gage. The remainder of the work is performed as has been previously described.

Fig. 27 shows a somewhat similar gage, while Fig. 30 shows the method of handling it on a master angle-plate, using a ball plug as described for the other gages. In all cases, due allowance must be made for grinding all over after hardening and repeating all operations on surfaces that are to be very accurate.

Fig. 31 illustrates a jig for drilling an angular hole in the stem of the fuse body, this being the hole for which the gage shown in Fig. 26 is used. This jig was made in two pieces, being split on center line A on account of trouble experienced from drill breakage. When solid jigs were used and drills broke, they wedged the body fast in the jig and it was difficult to remove them; but by making the jig in two pieces, the upper part can be removed, and the drill easily extracted without removing the jig proper from the drill-press table.

The method of handling this jig is to fasten an angle-iron B to the back side of the jig, then set it up in a lathe, or milling machine, and finish-bore the hole C. At the same setting, angle-iron B is bored to take the ball plug D, thus having the ball plug exactly central. The ball is easily set to the exact apex of the angle by using the depth micrometer E from the face of the jig. After the ball is set, the jig is swung up on a lathe faceplate from the surface F, the top half of the jig is removed, so that the ball can be reached by an indicator, and the ball indicated until it runs true. The top half of jig G is then put back and bored, reamed, etc., in the regular way.

If the jig had not been made in two pieces, the setting could have been accomplished by locating the ball as already described and then using a second ball fastened to a piece as shown at the top of the view, and transferring the location by means of an indicator, height gage or other means. Another method is to locate a jig button on face H, using the ball for transferring the location.

Fig. 32 shows a drill jig for drilling an angular hole in a time-fuse ring. The ring A is located over the plug B, which, with the drill bushing C, is driven into the jig body D. The manner of using the ball plug E at the apex of the angle is clearly shown.

* * *

RHOTANIUM—A PLATINUM SUBSTITUTE

Rhotanium, a palladium-gold alloy in which the gold content varies from 60 to 90 per cent, is said to form a satisfactory substitute for platinum. It is malleable and ductile and can be welded without the use of a flux or other reagent. Its specific gravity ranges from about 16 to 18.5, according to composition, and its losses by volatilization at temperatures below 1300 degrees C. are less than those of commercial platinum. It can be used, within its temperature limitations, in electric heating units, and is satisfactory for contact terminals in many forms of automatic electric devices. Its behavior when tested on certain magnetos was satisfactory, but experiments performed on a high-grade aeroplane-engine magneto gave negative results. It is not suitable for use with hot concentrated nitric acid nor for electrolytic anodes, but for all other chemical purposes it is entirely satisfactory if the proper composition is chosen and if properly manufactured. Certain of the alloys have given good service in dentistry when used for pins and baked into porcelain teeth and as thin foil and heavy sheet for other types of construction. Rhotanium is said to be superior to pure platinum for use in jewelry; it is harder, stronger and takes a better finish. It does not tarnish, is noncorrodible, has practically the color of platinum, and can be worked as readily. Jewelry made with it passes the common jewelers' and platinum buyers' tests.—*U. S. Commerce Reports.*

* * *

Sir Francis Fox told the Royal Geographical Society, of Great Britain, that one of the difficulties in planning the actual route of the Channel tunnel was to keep the tunnel well within the thickness of the gray chalk. Because of this the tunnel would not be quite a "bee line." The maximum depth of water over the tunnel would be from 160 to 180 feet, and the roof of chalk over the structure had been fixed at a minimum of 100 feet. A dip in the level of the rails would form a water lock, so that a mile of the tunnel could, in case of emergency, be filled with water. The mechanism for doing this would be controlled from Dover Castle, and the entrance and exit of both tunnels would be under the gunfire of the Dover forts. By means of the tunnel, it was stated trains would run direct from London to Paris in less than six hours, and it would be possible to go from London to Constantinople, Petrograd, and by the Serbian express to the Far East.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

DETERMINATION OF BLANK DIAMETER FOR DRAWN METAL SHELL

In some shops, the determination of the diameter of the blank for a shell of given diameter and depth is a matter of guess or "cut and try," although there are tables that give this information. However, all the tables that the writer has seen have been made by calculating the blank diameters for various sized shells by the formula $D = \sqrt{d^2 + 4dh}$, in which D is the diameter of a blank for a shell having a diameter d and a height h. It is obvious that the area of the blank must be equal to the area of a circle having a diameter d and the lateral area of the shell. Then, as the area of the circle with a diameter d is $\frac{\pi d^2}{4}$, the lateral area is πdh, and the blank area is $\frac{\pi D^2}{4}$;

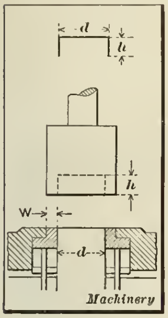


Fig. 1. Shell and Blank-holder

$$\frac{\pi D^2}{4} = \frac{\pi d^2}{4} + \pi dh,\ D^2 = \frac{4}{\pi}\left(\frac{\pi d^2}{4} + \pi dh\right),\ D = \sqrt{d^2 + 4dh.}$$

But this formula does not take into consideration the "draw," or stretch, of the metal that takes place during the stamping operation. This draw is in proportion to the depth of the shell and is different for different metals. To determine the blank diameter for a zinc shell of known depth and diameter, made in one drawing operation, the chart shown in Fig. 2 will be found accurate. This chart is made with each division representing 1/64 inch. The abscissas represent the depth h of the shell, Fig. 1, and the ordinates, the width W of the blank-holder. For example, suppose that it is desired to find the blank diameter of a shell 2 inches in diameter and 13/16 inch deep. Now 13/16 inch is 52/64, so following the vertical line from 52 to the curve and reading the horizontal line that it intersects at that point, the width W of the blank-holder is

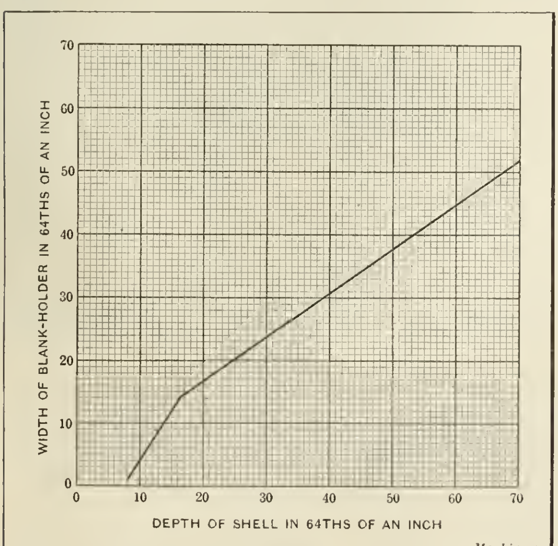


Fig. 2. Chart for determining Blank Diameter of Zinc Shell

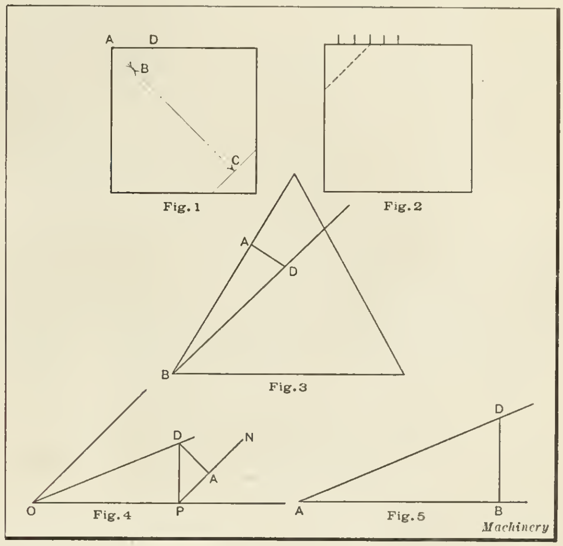
found to be 39/64 inch. $39/64 \times 2 = 1\ 7/32$, which, added to the diameter 2 inches, gives a blank diameter of 3 7/32 inches.

Wheeling, W. Va. H. S. BRADY

MAKING SQUARE STOCK OCTAGONAL

In the machine shop, if a piece of square stock is to be made octagonal, it is necessary to know either the depth of cut AB, Fig. 1, or the thickness BC of the collars between the straddle-mills. To the carpenter, however, the problem presents itself in a different light. He cares for neither of these measurements, but needs AD, so that he can scribe a line to guide his saw and plane.

The methods employed to obtain this dimension are interesting. Some of the men with whom the writer has conversed



Figs. 1 to 5. Diagrams showing Methods used in making Square Stock Octagonal

say that they take AD equal to one-third the side of the square, and "don't cut quite to the line." This is undeniably an easy scheme, but about as accurate as the proverbial "blacksmith's hairbreadth," the actual value of AD being not side $\times$ 1/3, but side $\times$ 0.2929 +. Others adopt the plan, shown in Fig. 2, of dividing half the side of the square into fifths and taking the third division from the corner as the starting point for scribing the line. This is not so inaccurate a method as the first, 0.3 being, probably, near enough to 0.2929 + for wood-working purposes, except in the more exacting branches of work.

Another plan is to lay out an equilateral triangle, as in Fig. 3, then with the miter square subtract 45 degrees from it. The length of the side of the square is then laid off at BA, and the perpendicular AD erected, its length being taken for AD in Fig. 1. This, also, is only an approximation, giving side $\times$ 0.2588 +. Some workmen, however, follow a method that is theoretically exact, as it gives the true value: AD = side $\times$ tan 22 deg., 30 min., $\times$ sin 45 degrees. Laying out an angle of 45 degrees with his miter square, the workman bisects it with dividers and straightedge, as in Fig. 4. Then making OP equal to the side of the square, he erects the perpendicular PD, which equals side $\times$ tan 22 deg., 30 min., and

drawing NP at 45 degrees to PD, he draws the perpendicular AD, which he takes for AD in Fig. 1.

Various other methods of obtaining AD by construction are in use, but none, so far as the writer is aware, is as quick as the approximate schemes here given, nor as accurate as that given in Fig. 4. Obviously, the 22-degree, 30-minute angle can be used in the solution of two problems allied to this; for if, in Fig. 5, AD is made equal to the diameter of a circular piece, BD will be the side of the included regular octagon. Conversely, if BD is made equal to the side of the octagon desired, AD will be the diameter of the circumscribing circle.

New London, N. H. GUY H. GARDNER

BLANKING AND FOLDING PUNCHES AND DIES

The shell shown at A, Fig. 1, is made, in two operations, from 16-gage hot-rolled steel. At B, it is shown seated in position, and as it is surrounded by metal, it will not open if an unequal strain should develop. This shell is utilized as a spring seat and retainer; but it has a wider scope of usefulness by reason of its low cost of production. Under ordinary conditions, a shell of these dimensions drawn from a round blank will take five press operations; or, on a basis of 8000 pieces a day, 40,000 operations are required, against 16,000 operations by the folding method. In addition, five separate dies and punches are required, besides the expense of repairs and extra help. Furthermore, uniform and unstrained walls cannot be guaranteed when dies and punches must often be polished to eliminate the excessive friction caused by the constant rubbing of metal and dies.

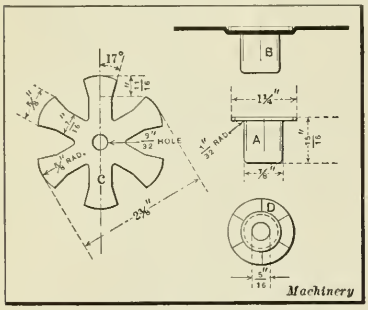


Fig. 1. Blank and Shell formed from it

The shell A, Fig. 1, is made on an inclined press in one blanking and one folding, or drawing, operation. The blanking is done with the compound punch and die shown in Fig. 2. The advantage of operating this die in an inclined press is that the blanks will drop clear of the die, by gravity, and will be transferred to a receptacle by a chute fastened to the stripper at J. The blank C, Fig. 1, which is made of scrap,

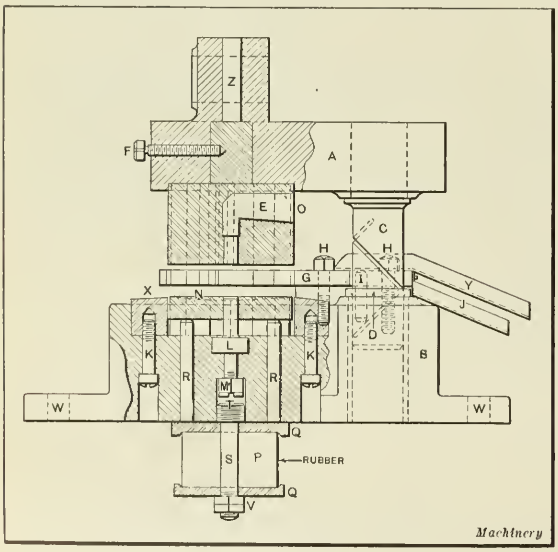


Fig. 2. Blanking Punch and Die

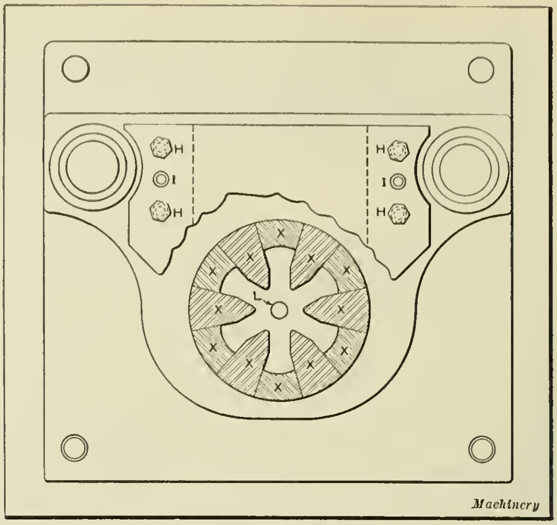


Fig. 3. Top View of Blanking Die

must be carefully developed in size and shape to meet the necessary requirements in dimensions and have all seams tight, as well as to have a uniform and concentric flange, as shown at D, which is a view of the bottom of the shell. This view shows that the hole has opened 1/32 inch in drawing, which is always taken into consideration in developing work of this nature.

Fig. 2 shows the compound blanking and perforating die, which is of the pillar type; this is easily set up, adjusted, and

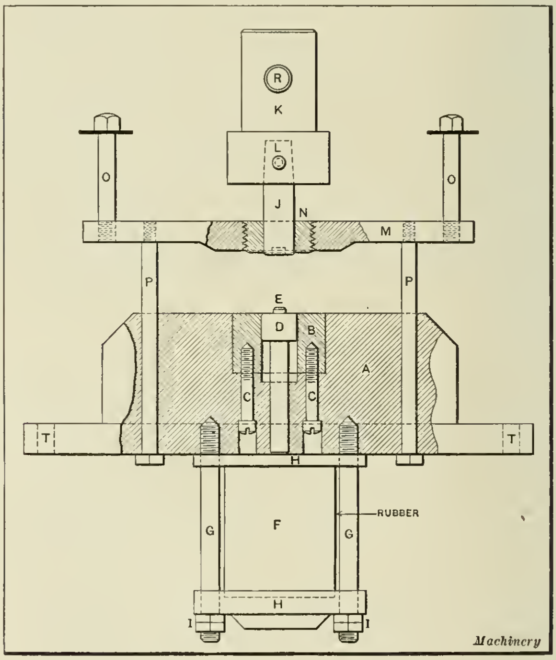


Fig. 4. Folding Punch and Die

put into operation. A is the cast-iron punch-shoe, made to fit the press ram; B is the die-shoe, also made of cast iron. These are held in alignment by guide pins C and bushings D, which are made of tool steel and are hardened and ground. The guide pins C are provided with oil channels to facilitate lubrication; the lubricant used consists of white lead and oil. The punch E is made of hardened tool steel and is held in position by a set-screw F. The hole Z is provided to remove the punch E, when it becomes necessary. Punch E has a clearance hole at O and when operating in an inclined press dis-

charges the slugs over the stripper G, which allows them to slide through a chute Y to the scrap receptacle. The stripper G is held in position by screws H and dowel-pins I.

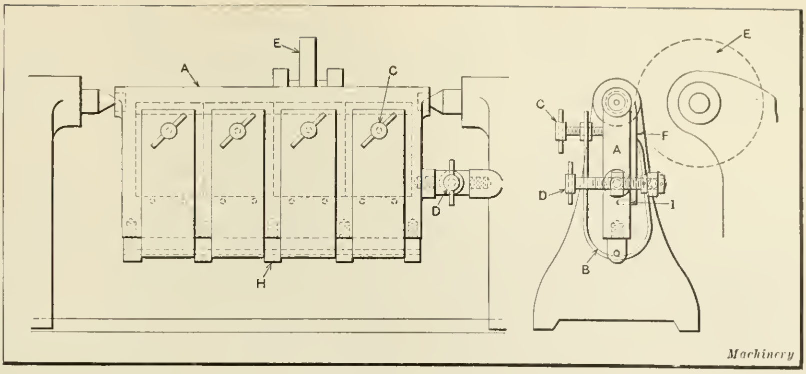
The die X is made, in sections, of tool steel and is hardened. It is securely held in the die-shoe B by reason of the sections being properly fitted and by screws K. Fig. 3 shows a top view of the die, which consists of twelve sections X; it also shows the clearance under the stripper to allow the blank to leave the die and enter the chute J, Fig. 2. The perforating punch L is seated in the bottom of the die and is held in position by nut M. The ejecting pad N receives its motion from a rubber buffer P, the force being transmitted through plates Q and pins R. The rubber buffer is held in position by a bolt S screwed into the die-shoe at T and tension nuts V. Holes W are provided for bolting the die to the press, making it unnecessary to use a bolster plate.

Fig. 4 shows the folding, or drawing, punch and die. The die-shoe A is made of cast iron and has a seating bushing B, held in position by screws C. Bushing B is made unusually long to increase its life; after the face is ground when the edge becomes worn, a washer is placed under the bushing to raise it to the proper height. This bushing is tapered 0.003 inch to allow the shell to be ejected more easily by the knockout pin D. Pin D has a gage pin E on its face to gage and center the blank previous to drawing it. The knockout pin receives the proper tension from a rubber buffer F, which is secured by bolts G, plate H, and adjusting nuts I.

The drawing punch J is made of carbon steel and is counterbored to clear the gage pin E. It is held in a machine-steel punch-holder K and secured by a tapered pin L. The stripper plate M is machine steel and has a hardened bushing N in the center to flatten the flange of the shell when the punch descends. This bushing also releases the shell from the punch when the latter returns to high center. The adjustment of the stripper M is made by bolts O and P. A pin R secures the punch to the ram and prevents it from pulling out under ordinary conditions. Bolt holes T are provided for securing the die to the bed of the press.

Highland Park, Mich. Ernest A. Walters

KNIFE GRINDING FIXTURE



Knife Grinding Fixture

When their edges are to be ground, knives, bayonets or other thin stock may be set up on the centers of a Brown & Sharpe grinding machine or some similar type of grinder. The grinding fixture here shown consists of a cast-iron body A, to which spring-steel plates B are attached by pivots H. These plates are U-shaped and clamp the work F to the cast-iron body A, the tension being adjusted by screws C. The centers are provided with two hardened bushings, which engage the centers of the grinder. The fixture can be set at any desired angle by adjusting screw D. This screw works in pivots, one of which is screwed into the fixture and can rotate to suit the various angles required. The other pivot is screwed into the tailstock in the same way, and is not threaded in the hole. The adjusting screw has two collars, one on each side of the pivot. Stops I support the work while it is being ground by wheel E, which can be adjusted backward and forward. This fixture has proved to be very rapid and efficient.

Mount Vernon, N. Y. S. W. Potts

COATING CASTINGS WITH CHALK

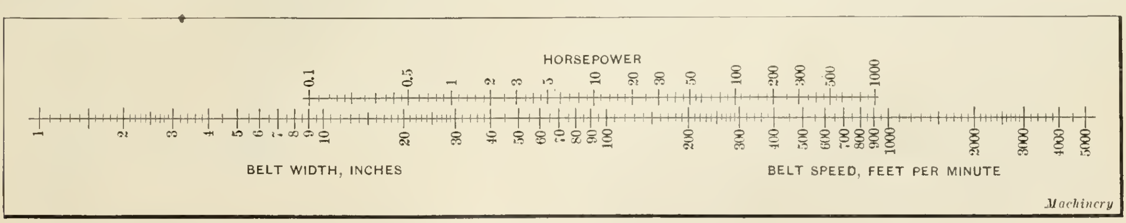
Common white chalk is used extensively as a coating on castings that are to be laid out. Although its application may seem to be extremely simple, some men cannot get the chalk to stay on even if they rub a whole lump into dust and blow it off. The first time over, the chalk sticks fairly well, but the coating is not heavy enough for lines drawn upon it to be easily distinguished; after that the pulverizing begins. Rubbing in this pulverized chalk with the fingers will give a good white face, and one that will stand scribing. When a vigorous rubbing will not make the chalk stay, the old schoolboy trick of wetting it will help. Momentarily, the dampened surface looks too gray or black, but blowing on it drys it to its normal white. If a machined cast-iron surface is to be laid out, chalk should only be used when permission has been obtained, as the chalked section is sure to rust—not badly, but enough for it always to be visible unless a cut is taken over it.

Middletown, N. Y. Donald A. Hampson

CHART FOR POWER TRANSMITTED BY LEATHER BELTS

The accompanying chart may be used to determine the width of a single leather belt necessary to transmit any ordinary amount of power, the horsepower that will be transmitted by a single belt running at a given speed, or the speed at which a belt must run in order to transmit a given power. For example, to determine the power that will be transmitted by a single belt 7 inches wide running at a speed of 5000 feet per minute, locate the points 7 and 5000 in the lower graduated line and then find the point midway between them. This point will be found at 44 horsepower on the upper graduated line. The dividing may be done with a rule, or a pair of dividers, or by folding a piece of paper.

Should it be necessary to transmit 44 horsepower by means of a belt traveling at a speed of 5000 feet per minute, the width of single belt required may be found by measuring the distance between 44 horsepower and 5000 and then measuring an equal distance to the left of the 44-horsepower point. In



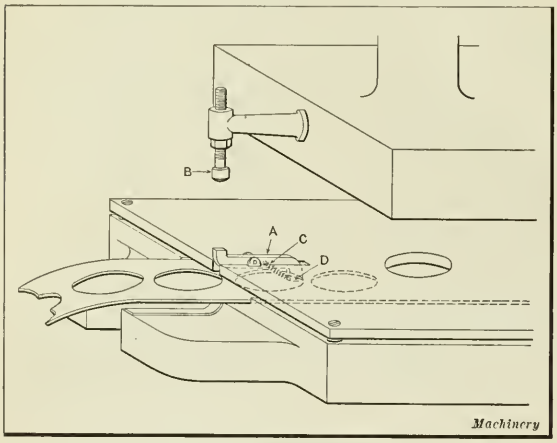
Power transmitted by Leather Belts

this case, it will be found that a 7-inch belt is sufficient. In a similar way, the belt speed can be determined where the belt width and horsepower are known. This chart is based on the well-known rule of thumb: A single leather belt, one inch wide, running at a speed of 800 feet per minute will transmit one horsepower.

N. G. Near

AUTOMATIC STOP FOR BLANKING DIES

Probably one of the most valuable attachments used in connection with blanking, shearing and perforating dies, where stock is fed in by hand, is the automatic stop, and yet it is astonishing how little is known of its application. When the stock is fed in a strip or from a reel, this simple contrivance is more efficient than any kind of automatic feed and is far less expensive. The writer has observed many instances where the automatic stop could have been applied with a great saving of time. In one case the production of mica and hard rubber disks was increased from 11,000 to 100,000 a day by its use, while a shop blanking 8000 sheet-steel gear blanks increased its daily output to 58,000. The stop is an essential feature on dies made by high-class diemakers and is extensively used by firms who specialize in punch-press products, but there is no reason why firms who use the punch press as auxiliary equipment should not adopt its use wherever possible.



Automatic Stop for Blanking Dies

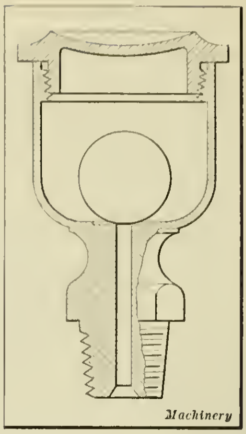
The illustration shows the application of this stop to a simple blanking die. Trigger *A* is shown locating the stock for the next blank, one of the perforations in the stock serving as a shoulder for this trigger at point *D*. When the ram descends, stud *B* trips the trigger *A*, lifting its point *D* until it clears the stock. When the point clears the top of the flat stock, the spring *C* pulls the trigger forward; and when the stock is fed farther, the spring pulls the trigger down into the next perforation, which again forms the shoulder for the point. One end of spring *C* is fastened to trigger *A* and the other to the bottom of the stripper plate. There is a slot in the trigger for the fulcrum pin, which allows the double motion, forward and down. This entire operation is repeated at each stroke, so that the press may be run at full speed and the stock fed through without having to trip the press each time. The trigger is shown mounted on two lugs on top of the stripper plate, but it may be set in the die-block beside the stock, reaching in over the stock. While only a simple case is described here, the application of the automatic stop will not at any time be found complicated.

Cincinnati, Ohio JOSEPH AHLERS, JR.

IMPROVED FORM OF OIL-CUP

On a number of small machines an ordinary brass oil-cup with a top that is screwed on is used. Waste soaked in oil or boiled in vaseline before soaking is then put in it. If the spindle revolves very rapidly a vacuum is formed in the cup, causing a thread of the waste to be drawn into the bearing. On most of the smaller grinders and buffing lathes, the bearings are of babbitt, and so are quickly cut enough to allow dirt to gather and in time to wear the spindle, thus spoiling the efficiency of the entire machine.

This trouble is eliminated in the oil-cup shown in the accompanying illustration. A basin about the diameter of the ball used is milled in the brass cup. Then the steady, positive vibration of a grinding or a buffing machine causes the ball to rock on the oil-hole, thus allowing the oil to drop, as in a sight-feed oiler. The ball also shuts off the supply of oil when the machine is not running. The fact that more oil can be put in at a time means that the machine will run longer without the trouble of oiling and an operator can readily tell if oil is needed by removing the cap. The steel ball used should be six times the diameter of the hole in the oil-cup.



Improved Form of Oil-cup

New Britain, Conn. JOHN J. MCGAULEY

REDUCING GLARE OF ELECTRIC BULB

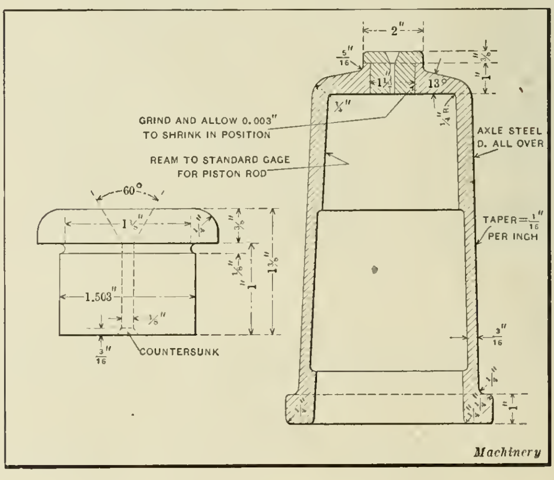
Coating an electric-light bulb with Prussian blue reduces the glare and gives a light that does not tire the eyes. The pigment should be rubbed lengthwise on the bulb, but not on the bottom, of course.

Milwaukee, Wis. FRED FRUHNER

CENTERING SLEEVE FOR PISTON-ROD

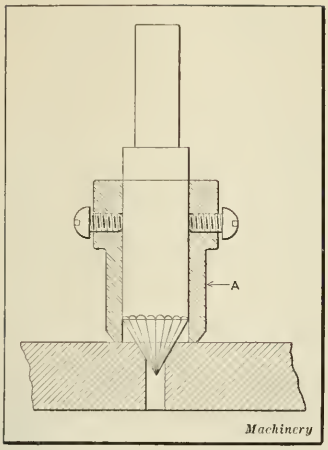
The device shown in the accompanying illustration was designed principally for use on piston-rods that have to be trued up in a lathe or grinding machine, but the centers of which are so battered that they will not run anywhere nearly true. So much material must be cut or ground off a piston-rod in this condition that the rod soon gets down to the limit size, and instead of having a long and useful life it is wasted. For use under these conditions, a sleeve is made to fit the end of the piston-rod. In one end of this a small, hardened, tool-steel plug is shrunk. This plug has a 1/8-inch hole and is countersunk 60 degrees to suit the lathe center. At the other end, the sleeve is made a little larger in section, so that it can be knocked off the piston-rod with a soft hammer, when the rod has been turned or ground, without being injured. This sleeve can be modified, of course, to suit other tapered or straight pieces with poor centers.

M. K.



Sleeve for truing up Piston-rods with Damaged Centers

COUNTERSINK SLEEVE



Countersink with Sleeve attached for obtaining Accurate Depths

The sleeve here shown enables the user to obtain accurate depths in countersinking; where a large quantity of work is to be machined to the same depth, it saves time and produces satisfactory results. The sleeve *A* is made to fit the countersink and may be adjusted to suit the piece being worked on. The tool is fed down until the sleeve touches the surface of the work, so that all the pieces are countersunk to the same depth. It is difficult to countersink all the pieces alike without employing some method of this kind, especially if some of the pieces are thicker than others, but this is successfully accomplished with the tool described.

Ambridge, Pa. AUGUST J. LEJEUNE

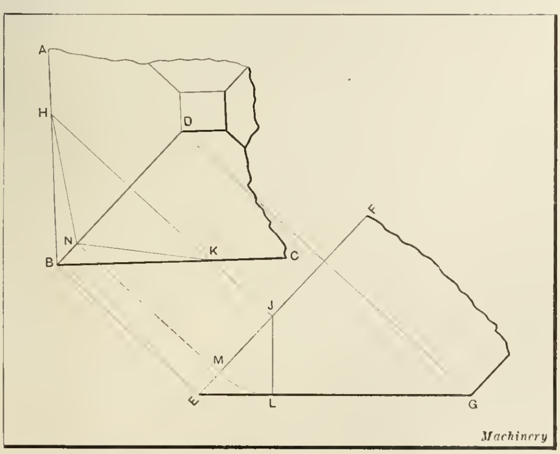
FALSE GRAPHIC REPRESENTATION

I find Babson's "Graphic Representations of Volumes and Weights" to be misleading. For eight times the quantity, he shows a bottle, bag, or barrel eight times as high and wide; whereas it should be only twice the linear dimensions, because $8 = 2\times2\times2$. This method was carried to the height of ridiculousness in the war statistics of the National Security League and American Defense Society, where armies were represented by soldiers of height in proportion to number. Nothing is so simple and convincing as ordinary heavy straight lines to scale.

New York City ROBERT GRIMSHAW

FINDING TRUE ANGLE OF VALLEY PLATES FOR STEEL HOPPERS

The article in the May number of MACHINERY, "Laying Out a Hopper Miter Joint," brings to mind a method the writer has used to find the true angle of valley plates used on steel hoppers. It is a graphic method and may be used for any size or shape of hopper. Let *ABCD* represent the plan of the hopper, while *EFG* is the elevation; *BD* is the intersection line of the sides. Draw *HK* perpendicular to *BD;* line *HK* is the edge of an imaginary plane passed perpendicular to the intersection line and is shown in the elevation by a line *JL* drawn



Graphic Method of finding True Angle of Valley Plates for Steel Hoppers

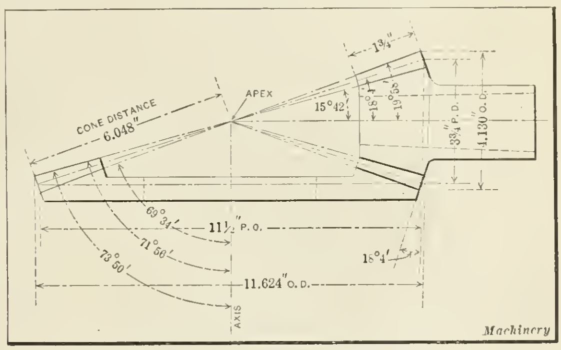
perpendicular to *EG*. Revolve *JL* about the point *J* to the position *JM* and project the point *M* back to the plan to *N*. Then *HNK* is the true angle of intersection of the two sides of the hopper, since it is the trace on a perpendicular plane of the two sides after the plane is revolved into the plane of the drawing.

St. Joseph, Mo. L. M. HAMLET

STUB-TOOTH BEVEL GEARING

Stub-tooth bevel gears are now being used extensively by some automobile manufacturers instead of the standard-tooth bevel gears. By using a 20-degree pressure angle and shortening the height of the gear tooth, a stronger gear is obtained, which requires no under-cutting but which has better rolling contact. This type of tooth is therefore recommended for machinery requiring gearing that will withstand severe stresses. The method of calculating the parts of this gear is best shown by an example.

Let it be required to make a pair of stub-tooth bevel gears of 4/5 diametral pitch, with 46 teeth in the gear, 15 teeth in the pinion, and a 20-degree pressure angle. As the tangent of the pitch angle of the pinion is 15 ÷ 46 = 0.32609, the angle is 18 degrees, 4 minutes. The pitch angle of the gear is then 90 degrees — 18 degrees, 4 minutes = 71 degrees, 56 minutes.



Stub-tooth Bevel Gears of Forty-six and Fifteen Teeth

The pitch diameter of the pinion is 15 ÷ 4 = 3.75 inches, and of the gear, 46 ÷ 4 = 11.5 inches. The addendum of both the gear and the pinion is 0.2 inch. The cone distance is one-half the pitch diameter of the gear divided by the sine of the pitch angle of the gear, or 11.5 ÷ 2 ÷ 0.9507 = 6.048 inches. Then, dividing the addendum, 0.2 inch, by the cone distance, 6.048 inches, gives the tangent of the increment angle for both the gear and the pinion; or, 0.2 ÷ 6.048 = 0.033068. This angle is therefore 1 degree, 54 minutes. The face angle of the gear is 71 degrees, 56 minutes + 1 degree, 54 minutes = 73 degrees, 50 minutes; and the face angle of the pinion is 18 degrees, 4 minutes + 1 degree, 54 minutes = 19 degrees, 58 minutes.

The dedendum for both the gear and the pinion is 0.25 inch. The tangent of the dedendum angle or the angle of decrement for both gears is therefore 0.25 ÷ 6.048 = 0.04133; which is the tangent of 2 degrees, 22 minutes. The cutting angle of the gear is then 71 degrees, 56 minutes — 2 degrees, 22 minutes = 69 degrees, 34 minutes; and of the pinion, 18 degrees, 4 minutes — 2 degrees, 22 minutes = 15 degrees, 42 minutes. The diameter increment of the gear is the product of twice the addendum and the cosine of the pitch angle, or 2 × 0.2 × 0.31012 = 0.124 inch. Adding this to the pitch diameter of the gear gives the outside diameter of the gear, or 11.5 inches + 0.124 inch = 11.624 inches. The diameter increment of the pinion is the product of twice the addendum and the cosine of the pitch angle, or 2 × 0.2 × 0.9507 = 0.38. Adding this to the pitch diameter of the pinion gives the outside diameter, or 3.75 inches + 0.38 inch = 4.13 inches. As the addendum is 0.2 inch and the dedendum is 0.25 inch, the total depth of the gear tooth is 0.45 inch. The thickness of the tooth is 0.3926 inch.

Brooklyn, N. Y. EDWARD J. RANTSCH

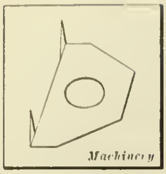


Fig. 1. Piece formed by Die shown in Fig. 2

DIE FOR PRODUCING SMALL STEEL PIECES IN ONE OPERATION

Fig. 1 shows a small piece made from 1/32-inch steel, and Fig. 2 shows the die for producing it in one operation. Similar dies can be used for work of this kind, where great accuracy is not required, where the metal is light, and where the bending point is reduced, so that it is not necessary for the forming punch to bottom the piece against the die to form the bend. As the part is pushed through the die out of the way, the operation is much faster than it would be if the part were left on the die to be slid or knocked off.

Fig. 2 shows the plan of the die without the stripper and the front view of the punch and die. The hole is pierced at *A* and the piece formed, cut off, and dropped through at *B*. *D* and *E* are the cutting edges and *F* the forming edge, which is 3/16 inch higher than the cutting edges. The end of stop *C* is the same size and shape as the cutting-off punch, so that the end of the strip, after being cut, centers against it. The stripper *G* is 1/4 inch thick and extends 3/8 inch above the die, leaving 3/16 inch under it, over the forming edge. The cutting-off and bend is completed before the piece is cut off. The forming edge is under-cut so that the piece is free to drop away from the punch and will not follow it back.

Plymouth, Mich. W. B. Greenleaf

A SIMPLE JIG

The toolmaker in the jobbing shop meets many difficulties; sometimes he is called upon to be a designer, without making elaborate details. The other day it was necessary to make three brass plates containing 280 steel pins, 3/32 inch in diameter, 1/2 inch apart. For one plate the holes for the pins were laid out by the aid of a milling machine, as accuracy was essential. But this method was too slow and not accurate enough. So four rows of holes were laid out on a piece of steel 3/16 by 6 by 3 inches, which was used as a jig.

As the brass plates were milled up square, it was easy to clamp the jig for the first four rows of holes. Then, after these holes were drilled, the jig was unclamped and moved along on the plate, being located by pins that passed through the jig into two of the holes drilled in the brass plate. This method was continued until all the holes were drilled. The plate laid out by the milling machine was not nearly so true as those laid out by means of the jig; this may be due to the fact that when milling machines are used much the screws wear and the graduated collars are not absolutely accurate.

New Haven, Conn. Eric Lee

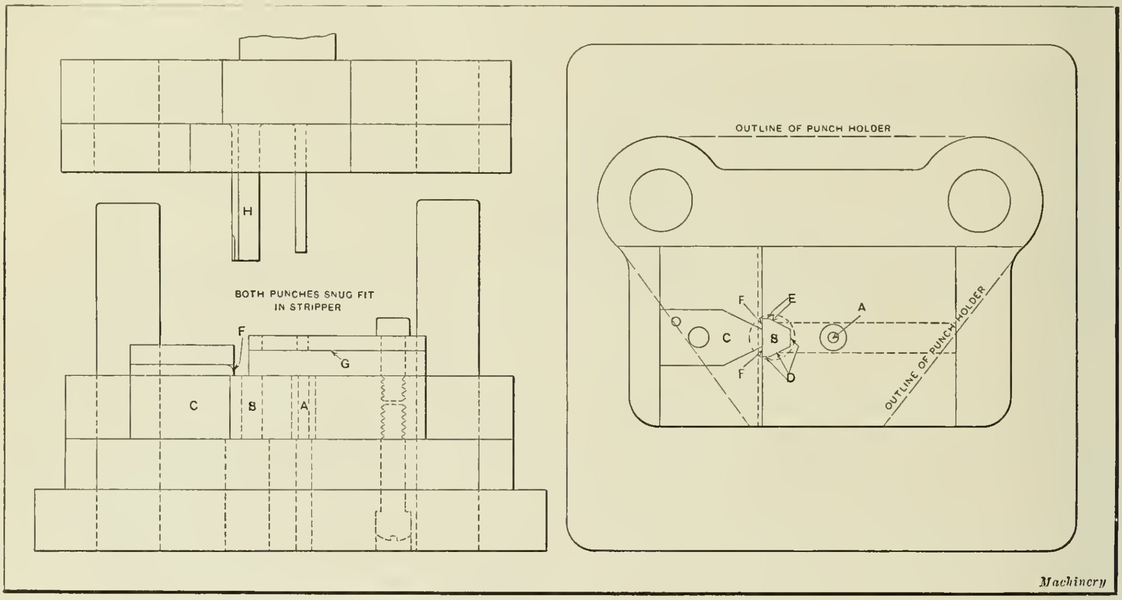


Fig. 2. Die for forming Small Steel Piece shown in Fig. 1

forming punch *H* is made the full size of the hole, except at the two corners where clearance is allowed for the two prongs. This leaves a space between the prongs for it to slide against the forming edge, to back up the cut. The guide pins are of one-inch drill rod; they are not hardened and are left with the original finish. They are a drive fit in the shoe and a nice sliding fit in the punch-holder, and have no bushings. This construction will outlast two or three dies and has been used for the last five years.

In operation, the strip is fed directly against the stop *C*; this gives a blank without prongs or hole. The second blank also lacks the hole, but after this blank a complete piece is produced at each stroke. If this material is bought in coils, the loss of two pieces at the beginning of each coil does not amount to anything. The press may be run continuously to the end of the coil, for the stop is positive and cannot be run over and the part drops through without scrap. As the punches rise after the cut, they carry the strip against the stripper, so that it is pushed forward on that level, with the prongs at the end resting on the forming edge. On the downward stroke, the punch bends the prongs while the blank is still part of the strip, which gives the prongs the necessary support, for the

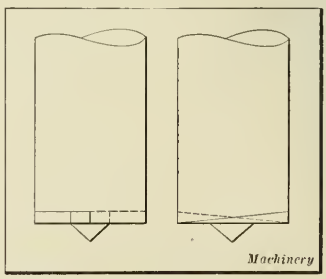
HEAVY-DUTY PUNCH

If a heavy-duty punch is ground off as illustrated, it will take less power to operate, start more easily, and shear a smoother hole than it will if ground as shown in the April number of Machinery.

I have used punches ground as illustrated up to two inches in diameter on material two inches thick, and have found that if the bevel is not greater than 3/32 inch in two inches, the punches stand up to the work and give better service.

C. G. Williams

Miles City, Mont.



Heavy-duty Punch

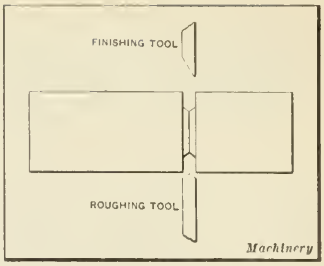
TO PREVENT BREAKING VULCANITE-MOUNTED MAGNIFYING GLASSES

A simple and effective method of preventing the breaking of the ferrule of vulcanite-mounted magnifying glasses consists of placing several rubber bands, about ¼-inch wide, around the ferrule at the glass end, allowing the rubber to project slightly beyond the ferrule. When dropped, the glass end, which is the heavier, will almost always strike the floor first, and if not protected, the vulcanite, being very thin at this end, will chip off and allow the glass to fall out. These bands act as a cushion and protect the vulcanite.

Providence, R. I. R. C. Scholz

CUTTING-OFF TOOLS

The accompanying illustration shows two cutting-off tools mounted on one cross-slide. With a roughing tool shaped as shown, greater speed and better work is insured, and a minimum of power is required. This tool is self-clearing on the sides and guides straight, an important feature when cutting off thin disks of large diameter. When the roughing tool has been fed to a certain point, it is backed off and the finishing tool on the opposite side is brought up to finish the cut. The small amount of work done by the finishing tool makes it possible for this tool to be ground at an extreme angle, thereby making a clean cut.



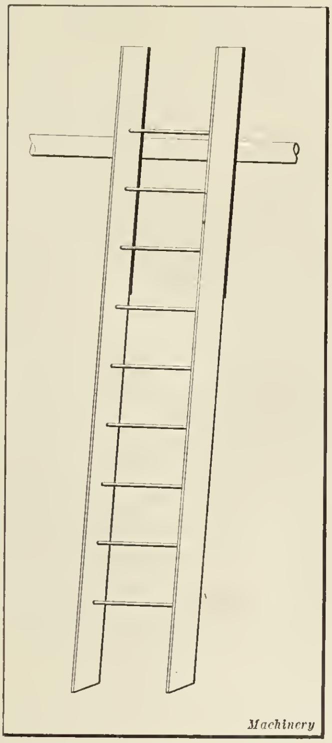
Roughing and Finishing Cutting-off Tools

Oak Park, Ill. P. Bertles

SAFETY ATTACHMENT FOR LADDERS

Several accidents occurred in the plant in which the writer is employed to the men who inspected, repaired, and oiled the lineshafting, before it was noticed that these were due chiefly to the fact that the ladders slipped when the men leaned too far to one side to reach a bearing, etc. Therefore, to prevent the ladder slipping along the shaft on which it was resting, rubber strips were tacked along both sides of the ladder, as indicated by the heavy lines in the accompanying illustration. This device worked out very satisfactorily, and no further accidents have been due to this source. Although not shown, the base of the ladder was also equipped with iron claws to prevent slippage at that point.

Philadelphia, Pa. W. A. Lailer



Ladder with Rubber Strips to prevent Slipping

HARDENING KINK

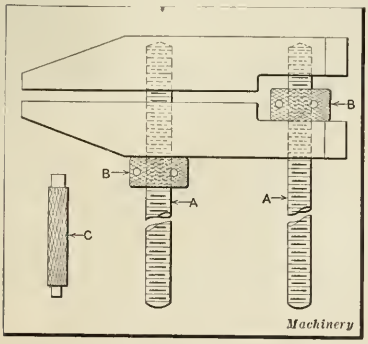
Toolmakers and diemakers often experience difficulty from dies expanding during hardening. If, when a die is put in the furnace, it is placed top face down on a firebrick slab, it will get more heat than if placed bottom face down, which is the usual method. The hole will then contract, instead of expanding, and will allow about 0.002 inch for stoning. When too much metal has been filed from the hole in the die, there is more chance of the templet fitting if the die is hardened this way.

Long Island City, N. Y. E. Kern

TOOLMAKER'S CLAMP

The clamp shown in the accompanying illustration is one of the most useful to be found. As the screws *A* are headless and pass through only one side, it is possible to get to the bottom working surface. The nuts *B* permit the work to be fastened more securely than the screws in the ordinary form of clamp; the nuts are tightened by means of the pin *C*. This clamp is made of cold-rolled steel and is casehardened; the nuts are made of carbon steel and are drawn to a dark brown, and the screws are made of steel (Stubs gage) and tempered in oil.

August J. Lejeune
Ambridge, Pa.



Handy Parallel Clamp for Toolmakers and Diemakers

GRINDING EDGE TOOLS ON EMERY WHEEL

The article entitled "Wheel Dressing" in the June number of Machinery recalls an incident that shows what the average woodworker thinks of the emery wheel for grinding edge tools. The writer was assisting the boss patternmaker to make a large pattern, which was being turned in the lathe, when it became necessary to grind the wood-turning chisel. This was made from a flat file 5/16 by 1 1/2 inch, and considerable stock had to be removed to put the chisel in good working condition. As the shop grindstone was worn down pretty close to the hub, the writer began to grind the chisel on the emery wheel, but was soon stopped by the boss, who called him down for committing such an unmechanical act.

In that particular shop the grinding of an edge tool on an emery wheel might be considered unmechanical, but the writer did it long before he worked there and has done it ever since, and his edge tools are in good condition and in use every day. A great many first-class mechanics in the wood-working lines have an idea that the emery wheel has a bad effect on edge tools. Perhaps experiences have shown this to be true, but if you inquire from these men, "Do you keep the wheel in good cutting condition?" their answer is in a great many instances, "I never bother about that; an emery wheel requires no attention."

Wood-turning tools become dull very quickly; they are made from heavy stock, and grinding, even on a good grindstone, is slow and tedious. In a great many shops, the grindstone is located in a dark corner some distance from the wood-turning lathes, and during the process of turning a great many patterns, several trips to the stone must be made. The writer grinds his turning tools on an emery wheel, which he has mounted on a wooden faceplate that fits on either end of the lathe spindle. When turning between centers or on a faceplate at the front end of the lathe, the emery wheel is mounted at the back end of the spindle, and when turning at the back end of the spindle, the emery wheel is placed at the front. For the small lathe, a small wheel is mounted on a wooden center made like the regular lathe center and fitted to the hole in the spindle. By this plan, the turning tools are easily and quickly ground without leaving the lathe. All inside-ground gouges are ground on the small wheel, as it is but a moment's

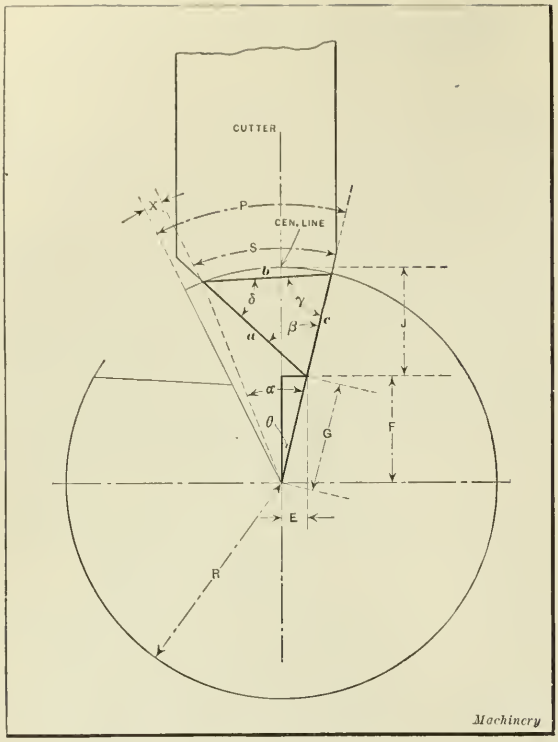


Diagram for finding Set-over, Depth, etc., of Cutter

work, with the aid of the dresser, to form the wheel to the curve of the gouge. The wheels and the dresser are part of the writer's turning-tool kit; they are his own property and he keeps them in good cutting condition. A clean wheel will do good and fast work; a dirty, glazed, neglected wheel will not grind burrs off rough castings, to say nothing of edge tools.

Kenosha, Wis. M. E. Duggan

SETTING AN ANGULAR CUTTER FOR MILLING SPIRALS

The writer recently had a number of spiral end-mills to flute, and not being able to find a suitable formula for obtaining the necessary set-over, full depth, etc., used the solution given herewith. The outside diameter, number of teeth, and width of land are the dimensions furnished. In this solution it is assumed that the vertex of the cutter angles is a point, N = number of teeth; X = land; R = radius. The cutter angles were 53 and 12 degrees. Arc $P = \frac{2R\pi}{N}$; arc $S = P - X$; $a = \frac{360 \text{ degrees}}{\frac{2R\pi}{S}}$; $\gamma = \frac{180 \text{ degrees} - a}{2}$; $\beta = 65$ degrees; $\delta = 180$ degrees $- (\gamma + \beta)$; $b = 2R \times \sin\frac{a}{2}$; $c = \frac{b \times \sin\delta}{\sin\beta}$; $G = R - c$; $\theta = 12$ degrees; $E = G \times \sin\theta$ = set-over; $F = G \times \cos\theta$; $J = R - F$ = full depth.

Denver, Colo. Stanley Edwards

LIGHTING STAIRCASES

Recently, the writer called attention, in a certain factory, to the necessity of having electric lights at the foot of each staircase. Light at the top of the flight casts a shadow on each step and makes the stairs dangerous. He also found a swinging door opening outward at the foot of one of the stairs, tending to block the corner on the turning. Such a door should not be used as a fire exit, unless it can be locked back when open, and it is a poor arrangement in any case.

New York City Robert Grimshaw

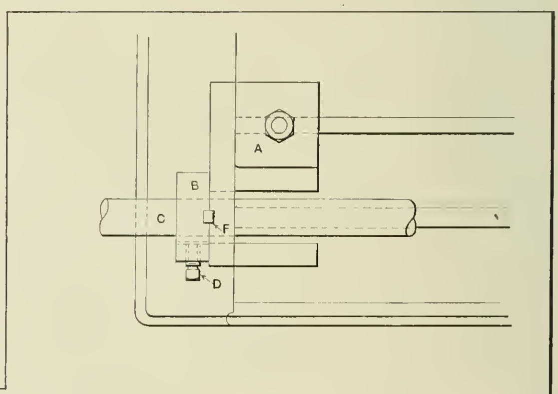
DOUBLE KEYWAY MILLING FIXTURE

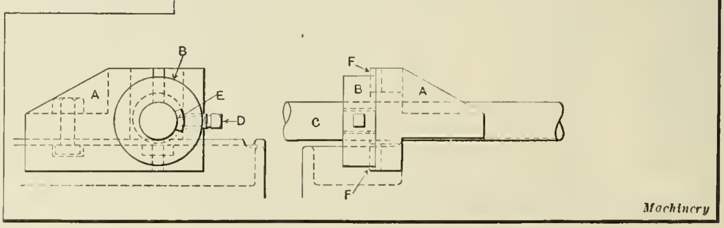
The accompanying illustration shows an indexing fixture that was designed for milling opposite keyways for movable saws in long saw arbors on wood-working machinery. The keyways are cut in opposite sides in order to balance the shafts, as they run at high speed. The fixture consists of a cast-iron bracket *A* and a steel collar *B* which is fastened to the shaft *C* to be milled, by a set-screw *D* that bears on a shoe *E*. The bracket *A* extends down over the end of the platen of the milling machine and is held in place by a bolt in the T-slot next to that in which the work is laid. The collar *B* thus forms a stop, bearing against the bracket and the end of the platen to resist the action of the milling cutter. The collar is slotted to receive two keys *F*, which are fastened in slots in the body *A* of the fixture; the slots in the collar are made central with the hole. No key is used to locate the fixture in relation to the T-slots, as this would entail locating the key an exact distance from the indexing keys, and this would be affected by any variation in the chamfer on the edges of the T-slot where the work is located.

In operation, the work and fixture are put on the milling-machine table, and the holding-down bolt is tightened slightly by hand; the hole for this bolt is 1/16 inch larger than the bolt. Collar *B* is then set up solidly on the shaft in the proper position lengthwise, and the shaft is strapped down over the T-slot with U-straps in the customary manner. The holding-down bolt for the fixture is now tightened, as the work has located it in the correct position. When the slot has been milled, the U-straps are loosened, the shaft is drawn back until collar *B* clears keys *F* (without loosening the collar), the shaft is given a half turn, and the collar is slipped over the keys again. The straps are then tightened and the second slot is milled.

This fixture has done very satisfactory work, indexing the slots perfectly without the necessity of putting the shafts on index centers, which in most cases would be impossible owing to the length of the shafts handled. The accuracy of the fixture is dependent wholly on the accuracy with which the slot in collar *B* is centered; this can easily be done very accurately. The fixture is so proportioned as to handle shafts from 1 7/16 to 2 3/16 inches in diameter, a collar being used for each size of shaft that is milled.

Orange, Mass. W. R. Stults





Indexing Fixture for milling Double Keyways in Shafts

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

HOBS AND MULTI-CUTTERS

A. L. K.—We have had a difference of opinion over the meaning of the term "hob." What is the correct definition?

A.—The term hob, when applied to a tool for cutting threads or gear teeth, means a cutter having teeth in a helical path like a tap. The term hob is sometimes erroneously applied to multi-cutters used in thread milling machines for cutting threads. These cutters do not have the teeth in a helix, but in parallel circumferential rows.

MARKING COUNTERSINK ANGLES ON DRAWINGS

H. G. F.—We have had a lengthy discussion on the proper method of marking the angle of countersinks on a drawing. I made a drawing which indicated three holes for screws with countersink heads, and marked them "25/64 drill, 76 degrees countersink." When the pieces were made and delivered, it was found that the included angle of the countersink was 104 degrees, that is, 180 degrees minus 76 degrees. Will you kindly tell us what is regarded as the proper method of marking countersink angles?

A.—The angle of countersink is always the included angle and there is no practice warranting anyone using the supplement angle instead. The angles of twist drills, countersinks, and similar tools, are always expressed as the included angle or half the included angle.

WHY DIDN'T IT EXPLODE?

W. S. R.—A small can of evaporated milk—not the thickened condensed milk, but the 50 per cent reduction kind—was left in a pot of water boiling furiously for twenty minutes after it came to a boil from 96 degrees F. The can was absolutely tight and there was no apparent escape of steam. Early in the boiling the can ends bulged, indicating internal pressure, but that was all. Why didn't it explode?

A.—The probability is that the ends bulged sufficiently to crack the soldering at some point and make a minute opening through which sufficient steam escaped to prevent explosion. However, there is another side to the matter, and that is the slowness of heat transfer under certain conditions. It may be that even after having been in boiling water for twenty minutes, the whole mass of milk had not yet reached boiling temperature. The question is submitted to the readers.

GRINDING TAPER PLUGS IN BRASS VALVES

F. E. R.—What is an approved method of grinding in the taper plugs of brass plug cocks? I have had trouble in making a tight job, using fine ground glass and flour emery as abrasives.

A.—The grinding in of brass taper plugs in valve bodies is a job requiring considerable care and skill to insure water-tightness. Emery should never be used, as it tends to cut circumferential grooves, and the abrasive action continues after the valve is put in use, due to minute particles of emery that are left embedded in the soft brass. Valve manufacturers use fine burnt foundry sand mixed with machine oil to form a paste abrasive for grinding plug valves. Hard soap is rubbed on the plug at short intervals to furnish the necessary lubrication. The action when grinding in a plug valve should be an oscillating motion, and the plug should be pulled out of the valve body frequently to distribute the abrasive evenly and to prevent cutting. The fine burnt sand and hard soap give good results; when the grinding is finished, the surface may be easily cleaned and no cutting will take place afterward.

CASTING LAMP BASES AND COFFIN HANDLES WITHOUT CORES

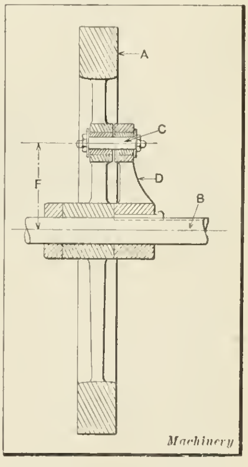
H. T. S.—Will you tell me how fancy lamp bases, coffin handles and other articles requiring a high finish are cast hollow without using cores?

A.—Fancy lamp bases are cast in iron molds by pouring in a comparatively small amount of alloy having a low melting point and turning the mold about while a thin shell of the metal hardens. When the desired thickness has hardened, the workman tilts the mold so that the molten metal runs out, leaving a thin shell of metal in the mold, which is then removed. Essentially the same process is employed in casting coffin handles. The mold is provided with a gooseneck into which the britannia metal is poured. The mold is allowed to stand for a few seconds until the metal hardens and then turned over and the molten metal poured out, leaving the center hollow. The workman can make a thick or thin shell by simply varying the time that the metal is allowed to stand in the mold. Considerable skill is required to make a shell of uniform thickness, especially thin shells. The chief art in this trade is in securing uniform thickness of the shell and using the minimum of metal.

RESISTANCE OF SHEAR PIN

P. G. P.—We have fitted a flywheel with the safety device shown in the illustration. A one-inch square steel pin *C* is held between steel bushings, one bushing being held in the flywheel arm and the other in a spider *D* keyed to the shaft *B*. The flywheel *A* is free to revolve around the shaft, in case an overload should shear pin *C*. We have assumed that it would require 60,000 pounds to shear a steel pin one inch square and also that the pin would be severed when sheared about one-third its thickness. The question is, does the distance *F* affect the resistance of the shear pin? It seems to me that it must remain the same wherever placed.

A.—The position of the shear pin positively affects its effective shearing resistance. If it is located at the hub, its resistance to the action of the flywheel will be much less effective than if it is located in the rim. If the shear pin is located 20 inches from the shaft center, its effective resistance to check the flywheel will be twice that if placed only 10 inches from the center. The principle is exactly the same as found in a pair of shears. If a thick wire is to be sheared, you place it as near the pivot or hinge of the shears as possible in order to get the most effective leverage. The farther the wire is placed from the pivot, the harder it is to force the jaws through it. The wire cuts no harder, however, in one position than in the other, but the effective leverage is lessened as the wire is moved away from the pivot.



Flywheel loosely mounted on Shaft and driven by Shear-pin

MELTING COPPER IN AN IRON CUPOLA

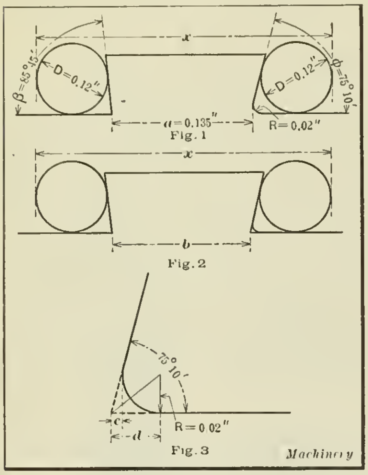
E. P. F. & N. Co.—We have a small brass furnace and an iron cupola in our foundry and have to make three bronze castings weighing one ton each. We understand that the copper can be melted in the iron cupola and the tin, zinc and lead required for making brass or bronze mixtures may be melted in the brass furnace and heated in the cupola as the copper runs from the iron cupola. Will you please advise?

A.—Large quantities of copper for making bronze castings may be melted in an iron cupola by using a reduced tuyere area and a blast pressure of 8 to 10 ounces. The tin and other metals used for making the bronze should be melted in an ordinary crucible brass furnace and poured into a large ladle into which the copper is tapped from the cupola. Care

should be exercised in melting the copper to use a fuel having a low sulphur content. After tapping the cupola, the melted copper should be covered with lump charcoal to prevent oxidation. Heavy brass castings may also be made by melting in an iron cupola. The practice of Dibert, Bancroft & Ross Co., Ltd., of New Orleans, Pa., in melting brass in the cupola, is to charge with 90 per cent heavy red brass and 10 per cent pure copper. A very light blast is used while melting. The losses from oxidation in the foregoing mixture vary according to the quality of brass with which the cupola is charged, but are rarely more than 5 per cent, affecting mostly the zinc and tin. To secure the proportions desired in the casting, zinc and tin, previously melted in a brass furnace, are added to the ladle after tapping from the cupola. The company has not thought it necessary to use deoxidizers in the ladle, although they are regarded as beneficial in some cases.

MEASURING DOVETAIL SLIDES

S. C. B.—Please show me how to calculate the distance over the two wires used in measuring the dovetailed angles shown in Fig. 1, the dimensions of which are as given.



Figs. 1 to 3. Diagrams used for finding Distance x

A.—To calculate the distance x, it is first necessary to know the distance b, Fig. 2, between the sharp corners of the angles; therefore, the distance c, Fig. 3, must be found. This distance may be obtained by first finding the distance d from the formula $d = R \cot \frac{\phi}{2}$; then $c = d - R$. This value of c must be subtracted from the length a to give the distance b. The distance x is then found by the formula $x = D + \left(\frac{1}{2} D \times \cot \frac{\beta}{2}\right) + \left(\frac{1}{2} D \times \cot \frac{\phi}{2}\right) + b$. Applying these formulas to the present case, $d = 0.02 \times \cot \frac{75 \text{ deg., } 10 \text{ min.}}{2} = 0.02598$ inch; so $c = d - R = 0.02598 - 0.02 = 0.00598$ inch, and $b = a - c = 0.135 - 0.00598 = 0.12902$ inch. Then $x = 0.12 + 0.06 \times 1.0774 + 0.06 \times 1.2993 + 0.12902 = 0.3916$ inch.

MEASURING FORCE OF A HAMMER BLOW

C. C. B.—To test the force of a blow in hammers, we take a round lead plug, one inch in diameter and one inch high, and strike it one blow with the hammer; then we take a duplicate plug, put it in a Riehle testing machine, and press this plug to the thickness of the plug that has been struck. Is the pressure indicated by the machine equal to the force of the blow? Some people say it is, while others take the opposite view; which are right?

A.—The fundamental formula for ascertaining the force of a blow is $ft = mv$, in which f = force of blow, t = time required to bring body to rest, m = mass of body, and v = velocity of body at instant of striking. It is seldom possible to measure t and it is usually difficult to ascertain v; consequently it is customary to determine the force of a blow, with more or less accuracy, by employing the principle of work. In the case of a pile driver, this method gives fairly satisfactory results, the formula being, theoretically, $wh = fs$, in which w = weight of falling body, h = height of fall, f = force of blow = resistance offered by pile, and s = distance pile is driven by blow; the weight w and the force f are in pounds and h and s are in feet. In the present case, the hammer is assisted by an additional force, and if this is known or can be found, it must be added to w. Even then, the result will not be exact, because every body, even lead, has a certain amount of elasticity and will not entirely retain the shape it had at the instant of greatest compression. Solving the foregoing formula for f, $f = \frac{wh}{s}$. If it is assumed that the work done in the testing machine is equal to wh, all that is necessary is to multiply and divide the pressure p recorded by the machine by s (measured in feet), and the result ($f = p$) will be a fair approximation to the force of the blow struck by the hammer. But this assumption implies that the pressure is uniform from the instant that the plug begins to be compressed until the required thickness is reached, which is by no means the case. It is also probable that a greater force will be required in the machine than the almost instantaneous force exerted by the hammer; however, it is reasonable to assume that your method is not far wrong. J. J.

CONCERNING THE DIAMETER OF A SHAFT

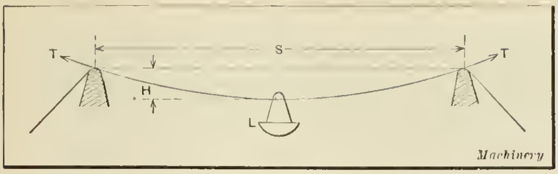
B. C. L.—In an article showing how to calculate the diameter of a steel shaft, I find the statement: "If the diameter is less than 13.6 inches, use Formula (1); but if it is greater than 13.6 inches, use Formula (2)." The formulas are as follows, in which d is the diameter, in inches, H is the horsepower transmitted, and N is number of revolutions per minute: $d = 4.7\sqrt[4]{\frac{H}{N}}$ (1), and $d = 3.3\sqrt[3]{\frac{H}{N}}$ (2). Why are the formulas so different, and how is the number 13.6 obtained?

A.—When a shaft transmits power, it is subjected to a twisting stress, and the resulting deflection is measured by the so-called "angle of twist." It is not desirable to have this angle exceed a certain limit, and when it is taken into account, Formula (1) is derived. But when the angle of twist is neglected and only the strength of the shaft is considered, Formula (2) is obtained. It is evident that there must be one diameter for which both formulas will give the same result; to find it, proceed as follows: Placing the right-hand members of the two equations equal to each other, $4.7\left(\frac{H}{N}\right)^{\frac{1}{4}} = 3.3\left(\frac{H}{N}\right)^{\frac{1}{3}}$, or $4.7\left(\frac{H}{N}\right)^{\frac{3}{12}} = 3.3\left(\frac{H}{N}\right)^{\frac{4}{12}}$. From the last expression, obtain by division $\left(\frac{H}{N}\right)^{\frac{1}{12}} = \frac{4.7}{3.3}$. Raising both members to the 12th power, $\frac{H}{N} = \left(\frac{4.7}{3.3}\right)^{12} = 69.675$, using a five-place table of logarithms. Substituting this value of $\frac{H}{N}$ in either of the two formulas, the value of d is found to be 13.579, say 13.6. In practice, that formula should be used which gives the larger value for d. If the diameter is less than 13.6, Formula (1) will give the larger value; but if the diameter is greater than 13.6, Formula (2) will give the larger value. In the case of engine crankshafts, neither formula will give very good results, because the heavy loads induce bending stresses, which must also be considered, the resulting formula being somewhat complicated. J. J.

STRENGTH OF ROPE FOR A CABLE BRIDGE

W. H. D.—We wish to put a cable bridge across a small stream and would like to know what size steel-wire rope, nineteen wires to the strand, will be necessary. The span is 85 feet, and the sag H must not exceed 5 feet; the greatest weight of the car and contents is 2500 pounds.

A.—As may be supposed, it is not possible to derive a formula that will give exact results; that is, results that will be closer than, at the most, two significant figures. The ten-



Determination of Strength of Rope for a Cable Bridge

sion T in the rope may be found quite accurately by means of the following formula:

$$T = L\left(\frac{S}{4H} + \frac{4HL}{S^2W + 2SL}\right) + \frac{S^2W}{8H} + HW$$

in which S = span, in feet;
H = sag, in feet;
L = maximum weight of car and contents, in pounds;
W = weight of rope, in pounds, per foot of length.

In order to find a value for T, it is necessary first to determine the value of W. When the values of S and L are comparatively large, as in this case, and steel rope is used, W exerts but a small effect on T; hence, making $W = 0$, a value for T is found, by means of which the size of the rope can be determined, approximately. In the present case,

$$T = 2500 \times \left(\frac{85}{4 \times 5} + \frac{4 \times 5 \times 2500}{2 \times 85 \times 2500}\right) = 10{,}900 \text{ pounds, ap-}$$

proximately. It is necessary to allow a reasonable factor of safety, the value of which will depend upon how frequently the cable is used and how often the maximum load is carried; it may be as low as 3 or as high as 6. Assuming that it is 4.5, the rope should have a breaking strength of 10,900 × 4.5 = 49,050 pounds, say 25 tons. A cast-steel wire rope 7/8 inch in diameter has a breaking strength of 25 tons and weighs 1.2 pound per foot. Substituting this value for W in the complete formula for T,

$$T = 2500 \times \left(\frac{85}{4 \times 5} + \frac{4 \times 5 \times 2500}{85^2 \times 1.2 + 2 \times 85 \times 2500}\right) + \frac{85^2 \times 1.2}{8 \times 5}$$

+ 5 × 1.2 = 11,135 pounds. Multiplying by the factor of safety, 11,135 × 4.5 = 50,107 pounds, or 25 tons, very nearly. Hence a 7/8-inch rope will be large enough; but if the cable bridge is to be subjected to heavy usage, it might be well to use a 1-inch rope. J. J.

TRIGONOMETRIC FUNCTIONS FOR ANY ANGLE

J. P. C.—I should appreciate a rule that is easily remembered for finding the trigonometric functions for angles greater than 90 degrees, using an ordinary table.

A.—Let x be any angle less than 90 degrees; then any other angle can be expressed as $n \times 90$ degrees $+ x$, n being an integer. For example, 286 degrees, 42 minutes may be written 3 × 90 degrees + 16 degrees, 42 minutes; 563 degrees, 19 minutes = 6 × 90 degrees + 23 degrees, 19 minutes; and 52 degrees, 24 minutes = 0 × 90 degrees + 52 degrees, 24 minutes. As shown in Fig. 1, angles are assumed to increase by the radius starting from OA and moving counter-clockwise about the circle; hence $AOM = x$, AON = 90 degrees + x, AOP = 2 × 90 degrees + x, and AOQ = 3 × 90 degrees + x. If the angle is greater than 360 degrees (= 4 × 90 degrees), subtract 4 (or some multiple of 4), so that n will be less than 4, but not negative. For example, the functions of 563 degrees = 6 × 90 degrees + 23 degrees are exactly the same as for 2 × 90 degrees + 23 degrees = 203 degrees. Having expressed the angle in the form $n \times 90$ degrees + x, note whether n is even or odd; if it is even (0, 2, 4, etc.), the numerical values of the functions will be the same as those for x; but if n is odd (1, 3, 5, etc.), the numerical value of the functions will be the same as those for the co-functions of x. Thus the numerical value of the sine of 203 degrees = 2 × 90 degrees + 23 degrees is sin 23 degrees; of 296 degrees = 3 × 90 degrees + 26 degrees is cos 26 degrees, cot 163 degrees = 1 × 90 degrees + 73 degrees = tan 73 degrees, etc. The sign of the function is determined by noting the quadrant in which the revolving radius stops. As shown in Fig. 2, all the functions are positive for the first quadrant AB. Note that for the upper semicircle ABC, the sine is positive and for the lower semicircle it is negative. For the right-hand semicircle BAD, the cosine is positive; and for the left-hand semicircle, it is negative. In the diagonally opposite quadrants AB and CD, the tangent and cotangent are positive, and in the other two diagonally opposite quadrants BC and DA, they are negative. From this it follows that cos 685 degrees, 13 minutes, 33 seconds = cos 7 × 90 degrees + 55 degrees, 13 minutes, 33 seconds = cos 3 × 90 degrees + 55 degrees, 13 minutes, 33 seconds = + sin 55 degrees, 13 minutes, 33 seconds. The name of the function changes from the cosine to the sine because n is odd; the sign is plus because the revolving radius stops between D and A in the fourth quadrant, and the cosine of any angle in this quadrant is +. The sign of the secant is the same as that of the cosine of the same angle, since the secant is the reciprocal of the cosine; for the same reason, the sign of the cosecant is the same as that of the sine of the same angle. J. J.

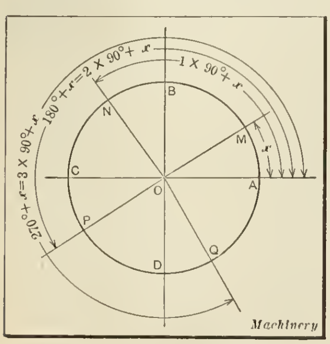


Fig. 1. Angle Diagram

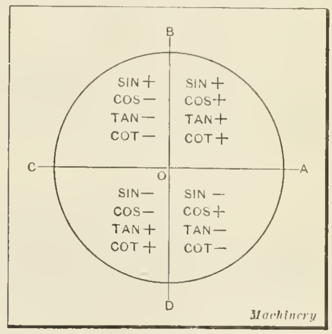


Fig. 2. Signs of Functions in Each Quadrant

GANG AND MULTIPLE-SPINDLE DRILLING MACHINES

E. K. H.—What is the distinction between an upright multiple-spindle drilling machine and a gang drilling machine? It is my impression that a machine is classified as a multiple-spindle drilling machine if there are two or more spindles carried by a single frame, and that it is known as a gang drilling machine if there are two or more spindles carried by individual machine frames.

A.—This question was submitted to the principal makers of multiple-spindle and gang drilling machines, but there seems to be no general agreement. F. K. Hendrickson, of the Reed-Prentice Co., Worcester, Mass., writes: "Originally a gang drill meant not only a machine composed of a series of independent frames or columns carrying one or more spindles, but any type of machine wherein there were several spindles. I note that it is your impression that a multiple-spindle drill is composed of two or more spindles carried by a single machine frame and that a gang drill is composed of two or more spindles carried by individual frames. If your meaning of the word 'frame' applies to the entire column or unit, the distinction would be quite definite, but if your understanding of the word frame merely suggests the member carrying the spindle, the situation becomes a little more complicated. In referring to the old type of gang drills such as were originally used by the railroads, a main housing with cross-rail was a general construction upon which were mounted several heads, each carrying its own spindle or multiple spindles. This type of machine was generally known as a gang drill. It is my opinion that a multiple-spindle drilling machine is any drilling machine having a single housing, with all the spindles either mounted in a single head or in independent heads and supported by the single housing, while a gang drill is a series of practically independent machines driven from one source of power and mounted either on a single base or independently in a group."

G. E. Randles, vice-president of the Foote-Burt Co., Cleveland, Ohio, states that it is their opinion that any drilling machine having more than one spindle is a multiple drill, and from this the different types should be classified, such as: universally adjustable (which would be the Baush type); fixed center independent feed, the type of drilling machine in which the spindle heads are mounted on a common cross-rail and adjustable in a straight line for centers, but provided with an independent feed for each spindle. "The gang type is this same sort of machine, except where the feed is connected up in a gang and the feed on all spindles is engaged and disengaged at one time and from one point. We think this type of machine is more truly the gang drill than the type to which you refer where several individual machines may be set on one base with one common table, such as the Barnes type. We would say that the correct term for a battery of machines of this sort would be fixed by the size of the machine set in a gang, no matter what number may be used. We build practically all types of multiple-spindle drills and class everything of more than one spindle as a multiple drill, but also classify them beyond this as universally adjustable multiple drills, independent-feed multiple drills, gang-type multiple drills, etc."

G. E. Hallenbeck, of Baker Bros., Toledo, Ohio, writes that it is their belief that "multiple-spindle drill" should apply to machines of the Baush, Fox, "Natco" or cluster box type, and that "gang drill" should apply to single-spindle drilling machines connected in a gang.

TOGGLE FRICTION CLUTCH

H. W. L.—The two clutches shown roughly in Fig. 1 act on the toggle principle. What is the theory pertaining to the friction and forces acting on the bearing surfaces of such clutches? I have been unable to find any data of this kind.

Answered by John S. Myers, Philadelphia, Pa.

To illustrate the principle on which such clutches operate, refer to Fig. 2. Here, a block resting upon a smooth surface is acted upon by a force C. This surface reacts against the block with an equal force C_1, neglecting the weight of the block. Now force C may be resolved into a component N acting normal to the surfaces and a component F acting parallel to the surfaces. The resistance offered by friction opposing motion in the direction of the arrow is fN, where f = coefficient of friction. If this resistance is greater than the component F, no sliding of the surfaces will result. As $F = N \tan \alpha$, if we do not desire sliding to occur, $N \tan \alpha$ must be less than fN, or $\tan \alpha$ must be less than the coefficient of friction f.

The same principle applies to the clutch problem, and the forces there acting are indicated by similar letters in Figs. 3, 4 and 5. The function of the spring A, Fig. 1, is simply to keep the friction surfaces in contact, and the forces due to it as well as to centrifugal effect, being small, may be neglected. For example, suppose that it is desired to develop a twisting moment of 6000 inch-pounds with a radius R of 10 inches and a coefficient of friction $f = 0.08$; what are the forces acting? The frictional component must be $F = 6000 \div 10 = 600$ pounds. Taking $\tan \alpha = 0.06$, allowing 0.02 less than f

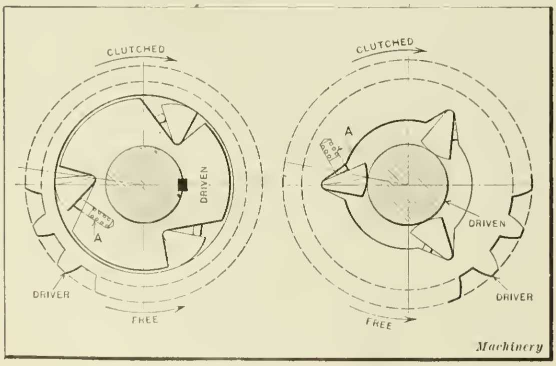
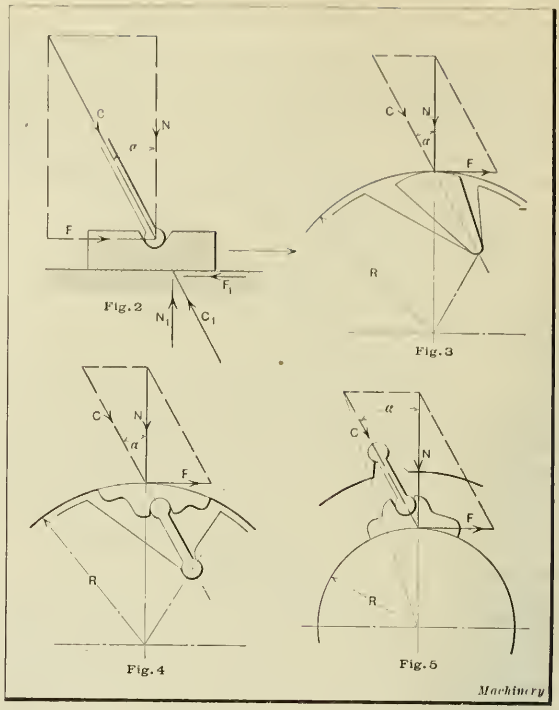


Fig. 1. Toggle Friction Clutches



Figs. 2 to 5. Diagrams showing Principles of Friction Clutches

as security against slipping, the force acting normal to the friction surfaces is $N = \frac{F}{\tan \alpha} = \frac{600}{0.06} = 10{,}000$ pounds, or $10{,}000 \div 3 = 3333$ pounds on each of the three surfaces. The various parts of the clutch would have to be sufficiently strong to withstand these forces. Problems allied to this are discussed in "The Constructor," by Reuleaux, pages 158 to 161. The wearing shoes indicated in Figs. 4 and 5 make no difference in the theory of the device, but increase its useful life by preserving the proper length of the toggle element.

* * *

CONCRETE MIXTURES

In a paper read before the Concrete Institute of Great Britain recently, it was stated that in a 1-2-4 concrete the cement may range from 18 to 24 per cent of the total volume of the mixture. For instance, 130 tons of dry cement is required for a broken-stone aggregate and only 100 tons when gravel is used. But the concrete containing gravel is from 12 to 15 per cent weaker than the one with the broken stone. However, when the quantity of cement per cubic foot of the mixture is the same, gravel concrete is as strong as concrete with a broken-stone aggregate. Washing the aggregate increases the strength of hand-mixed concrete 30 to 40 per cent, and of machine-mixed concrete, from 15 to 20 per cent. As the strength of concrete is governed largely by the percentage of cement that it contains, it has been suggested that specifications, instead of calling for a 1-2-4 mixture, provide that the volume of dry cement used be a specified proportion of the total final volume of the mixture.

* * *

A new type of soldering iron consists essentially of two high-resistance heating points, or electrodes, that become incandescent when the current passes through them. As the circuit is closed as soon as the points come into contact with the metal to be heated, the iron is said to become heated to the required degree the moment it touches the work. Besides, the heat is generated at the point of contact and at the spot where the heat is needed when soldering, brazing, or annealing. The iron operates at from six to sixteen volts and the points are made to carry current according to ratings of 150, 250, and 500 watts.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

LEEDS & NORTHRUP OPTICAL PYROMETER

This is an optical pyrometer for determining temperatures by the comparison of luminous hot bodies with a tungsten lamp filament in the pyrometer, which is adjusted by means of a rheostat until the brightness of the lamp corresponds to the brightness of the heated part as seen through the pyrometer. The reading of a milli-ammeter connected to the pyrometer enables the observer to determine the temperature with considerable accuracy, the readings of different observers for temperatures within the hardening range of steel varying not more than six degrees.

For the measurement of temperatures above, say, 1400 degrees F., only two methods have been found practicable for works service. One of these is based on the thermo-couple and the other on the laws of radiation. The latter includes both the radiation pyrometer and the optical pyrometer, which utilizes only that radiant energy visible to the human eye. For many services the inexpensive base-metal couple may be used for accurate measurements up to 2000 degrees F. with satisfaction; the more fragile and expensive platinum couple may be used up to 2800 degrees F., but the thermo-couple, like thermometers in general, must assume the temperature of the hot object by convection, conduction, radiation, or all combined. This fact militates against its use for measuring the temperature of molten brass, iron and other metals, or for measuring temperatures in gas producers and other locations where the thermo-couple would be subjected to rough mechanical treatment or to contamination by vapors and gases, which would rapidly impair its accuracy. In many industries the temperatures are far above the range of thermo-couples.

Measurements by radiation can be carried out at a distance when the laws concerning the temperature of radiating body and intensity of radiation have once been determined, and the radiation receiving and measuring part need not be heated to the temperature of the radiating body, nor even anywhere nearly to that temperature. Pyrometers utilizing radiation are divided into two classes: those which measure as heat energy the total radiation falling upon the receiving part

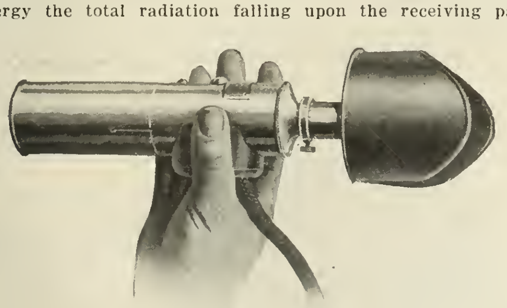


Fig. 1. Leeds & Northrup Optical Pyrometer

of the instrument, and those known as optical pyrometers, which are based upon the fact that the luminous radiation or light varies in a definite manner as the temperature of the hot body changes.

The greatest success has been attained by separating out one wave length of radiation—usually that which excites the sensation of red—and comparing the intensity of this one-color light with the intensity of the light of the same color emitted by a standard source of light. The eye is very sensitive when comparing the brightness of two surfaces when one is superimposed upon the other, and after having arranged to have light from the hot body and light from the standard of comparison viewed in this relation, they can be made equal, either by varying the amount of light received from the incandescent object or by varying the intensity of the standard of comparison. The latter method, that is, variation of the intensity of the standard of comparison, is preferred and used by the U. S. Bureau of Standards, also by the Reichsanstalt, of Berlin, where its practical application has been brought to a high degree of perfection by Messrs. Holborn and Kurlbaum. The Leeds & Northrup Co., of Philadelphia, Pa., working under the

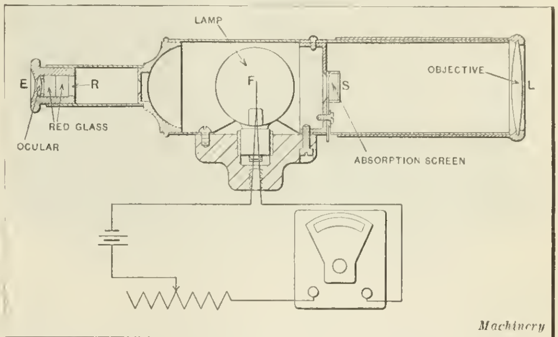


Fig. 2. Optical System and Electrical Circuit of Leeds & Northrup Pyrometer

fundamental Morse patents, has developed this type of optical pyrometer with a view to realizing a high degree of accuracy and reliability in a simple and portable device. The instrument, which is illustrated in Fig. 1, is suitable for measuring from dull red (about 1100 degrees F.) up to the highest known temperature.

The manner in which the luminous radiation from the hot body is balanced against that from a standardized source will be understood by reference to Fig. 2. By means of the lens *L*, rays from the hot body are brought to a focus in the plane *F*, where there is located a tungsten lamp filament. By means of the eye-piece *E*, the observer views the incandescent filament, which appears to lie upon the image, just as the cross-hairs in a surveyor's telescope appear upon the distant object looked at. By means of a rheostat in a case slung about the neck (see Fig. 3), the case also containing a storage battery and a milli-ammeter, the current through the lamp is adjusted until the brightness of the filament is just equal to the brightness of the image produced by the lens; that is, so that the filament blends with the background formed by the hot object. The observer then notes the reading of the milli-ammeter, which may be provided either with a special scale to read in degrees of temperature or the temperature corresponding to the current may be read from a calibration curve supplied with the instrument. The adjustment is made with accuracy, as the eye is keen in distinguishing differences in brightness between superimposed objects.

At high temperatures the light emitted by both the hot body and the filament would become dazzling, and comparison would be difficult. For this reason a red glass is placed in the eye-piece at *R*, which has the further advantage that light of only one color then reaches the eye and no difficulty is introduced by lack of color identity between the light emitted by the hot body and that emitted by the filament. The intensity of light radiation of any one color increases progressively in a definite manner as the temperature of the radiating body rises, and nothing is therefore lost by eliminating all other light from the comparison. As only brightness, not color, of light is matched, inability to distinguish colors and color-blindness do not interfere with the use of the instrument. In fact, in the range of temperatures used for harden-

Fig. 3. Method of using Optical Pyrometer

ing steel, for example, different observers using this instrument agree in their readings within 6 degrees F.

The brightness of the image of the hot body produced by the lens *L* is almost absolutely constant, irrespective of the distance from the hot body, although the size of the image varies with the distance. Since it is the brightness of the image and not the total radiation received through the lens that is measured, it is possible to measure the temperature of a small body or of a body at a distance equally as well as that of a large body or of one near at hand. It is not necessary that the hot body should fill the entire field of view of the instrument, as with "total radiation" pyrometers.

In observing bodies at very high temperatures, as 2500 degrees to 10,000 degrees F., the light received through the lens is too blinding for direct observation, even through the red glass of the eye-piece, and the intensity of the image might also become greater than that at which it is practicable to burn the tungsten filament, so that a balance would become impossible. Some method for reducing the intensity of the light must therefore be provided, such as by placing a screen to intercept some of the light. The screen is placed between the lens and the image so that it reduces the light from the hot body, but not that from the filament. With the reducing screen it is possible to make direct observations of the most brilliant light, as the electric arc or the surface of the sun.

It is not feasible to calibrate the instrument at such high temperatures by direct comparison, since they are above all known melting points and the ranges of contact thermometers, but fortunately a relation has been found to exist between temperature and intensity of radiation of any one color or wave length of light. By making use of this relation, known as Wien's law, and reducing the intensity of the image in a known ratio by means of the screen just referred to, it is possible to extend the scale of the instrument to the highest temperature. The scale thus obtained has been found to agree closely with a scale of temperatures established by known facts about the relation between temperature and total radiation. In other words, this form of optical pyrometer gives the same scale of temperature as do total energy pyrometers used with the precautions necessary to secure accuracy and precision in the measurement of total radiation. The screen used for cutting off part of the radiation from very hot bodies can be thrown into or out of the field of view by means of a milled disk projecting through an opening in the tube of the instrument. With the absorbing screen in use, a different milli-ammeter scale or calibration curve is required, but as the range of the instrument without the absorbing screen overlaps many hundred degrees with the range for the absorbing screen, the accuracy of the two scales can always be checked by observing a hot body, the temperature of which lies within this range.

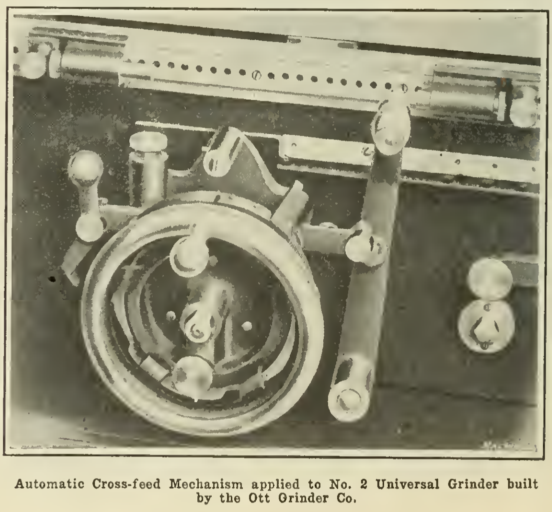
The readings obtained with this instrument are always the same for the same temperature, if the body viewed is surrounded by other objects, such as the walls of a furnace at the same temperature. Also no correction is required in the case of so-called "black bodies," such as incandescent carbon, when viewed in the open. For iron and steel in the solid state, the corrections required for readings taken in the open are also negligible. Objects having a metallic sheen, that is, a surface which reflects light freely, as molten metal or polished platinum, do not give the same readings when viewed in the open as when viewed in the furnace, or as a black body would give with this or any other radiation or optical pyrometer. The readings, however, are always consistent for the same material under the same conditions, and by using suitable reduction factors, can be converted to true temperatures. Furthermore, the readings obtained with this type of instrument when sighted upon a body in the open differ less from those given for the same body at the same temperature enclosed in a furnace, or for a black body at the same temperature, than do the readings of instruments which measure the total radiated energy. In other words, the correction where there is a departure from "black body" conditions is smaller than with the total radiation pyrometer.

The instrument can be calibrated by sighting it upon bodies the temperatures of which are known, either by means of a thermo-couple pyrometer, or by the melting or freezing of various substances. The constancy or reliability depends upon the constancy of the lamp, or its ability always to shine with the same intensity when receiving the same current. This matter has been investigated exhaustively by the U. S. Bureau of Standards and also in the laboratory of the Leeds & Northrup Co., and it has been found that after a tungsten filament is thoroughly aged, that is, burned for some time at a temperature higher than that to which it will be subjected in service, no sensible variation thereafter occurs. The instrument is so designed that one lamp can quickly be replaced by another, and by keeping two lamps, their correctness can always be insured by checking one against the other.

The instrument itself is handy and portable, weighing only a few ounces, and can be sighted as easily as an opera glass. The case, containing the battery, rheostat, and milli-ammeter, is slung about the neck, and weighs about ten pounds.

CROSS-FEED MECHANISM FOR OTT GRINDER

The Ott Grinder Co. of Indianapolis, Ind., has brought out a new design of universal grinding machine. The most notable feature of this machine is the automatic cross-feed mechanism,



Automatic Cross-feed Mechanism applied to No. 2 Universal Grinder built by the Ott Grinder Co.

which is shown by the accompanying detail illustration. In order to obtain simplicity and ease of adjustment, this mechanism has been equipped with a single rocker arm, a spring plunger and a stop-screw. When the table reaches the end of its stroke, the cross-feed rocker arm is swung down to its lowest position by a hardened pin on the reverse lever. As the table reverses its motion, the rocker arm is forced to move upward by a compressed spring. This upward movement continues until it is arrested by an adjustable stop-screw.

The pawl attached to the left-hand end of the rocker arm engages the cross-feed ratchet wheel, thus feeding the wheel slide. The feeding movement may be varied from 0.00025 to 0.003 inch. With this mechanism the grinding wheel is fed inward by the positive action of the reverse lever as it engages the rocker arm, whereas the spring previously referred to is simply relied upon to move the rocker arm and pawl back an amount depending upon the feed adjustment. The feeding movement may be disengaged by swinging over the feed pawl or by screwing down the adjusting stop. The feed may be disengaged automatically, a positive stop being provided for hand feeding.

METALWOOD STRAIGHTENING PRESS

The Metalwood Mfg. Co., Leib and Wight Sts., Detroit, Mich., is now manufacturing a straightening press in 20- and 35-ton sizes, and in three styles, including a motor drive, a belt drive from a lineshaft, and an accumulator drive. The particular press shown is equipped with a motor. The hydraulic pump for operating the press forms an integral part of the design and is of the two-plunger type. This pump is mounted upon the base, which forms a tank for the liquid. The pump body is of bronze, and the plungers are of tool steel, hardened and ground. The pump bearings are of phosphor-bronze. The ram of the press is returned by a heavy spring arranged for differential pull and with an adjustable tension. The ram nose has a sliding chrome-nickel steel resistance block with two steps for crank work, so as to reduce the stroke of the press whenever practicable and increase the operating speed.

The table is made of semi-steel and is provided with renewable steel strips upon which the centers are mounted and which take the thrust of the ram when pressure is applied to the part being straightened. The table is finished on the top and sides so that indicators can be used for testing the work. The centers are of the yielding type and are adjustable for length. The thrust is taken by tapered steel wedges placed under the work on the steel tracks. A single lever and a quick-operating valve serve to control the speed of the press ram, the pressure applied, and the return movement. All parts of the press subjected to heavy stresses are of alloy steel castings or forgings, and all piping under hydraulic pressure is of seamless steel tubing. The press is equipped with a gage reading in pounds per square inch and tons on the ram or applied to the work.

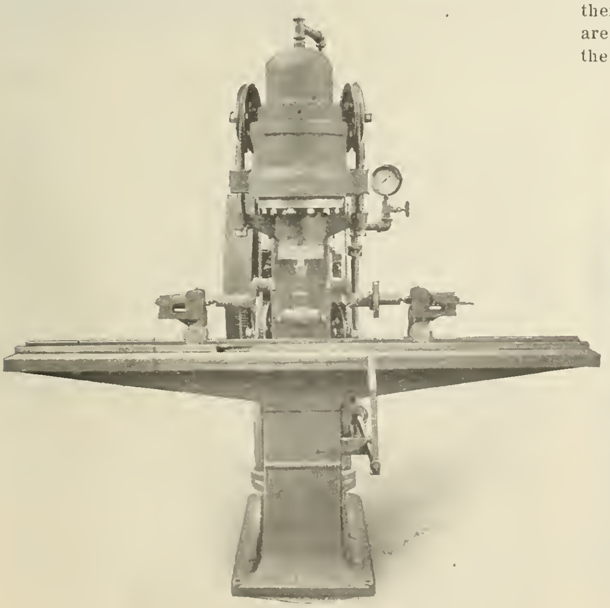


Fig. 1. Front View of Metalwood Straightening Press

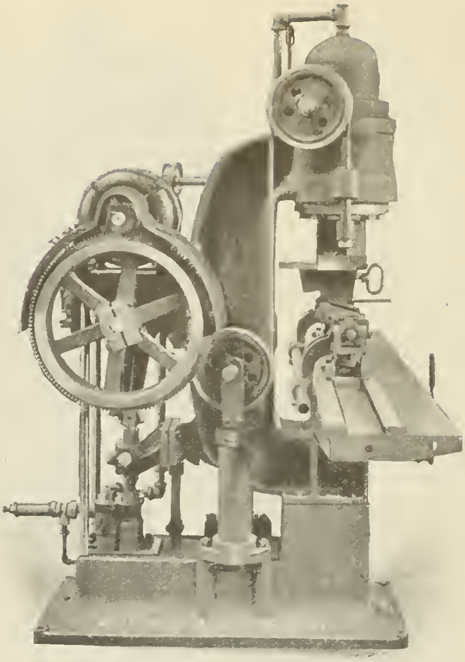
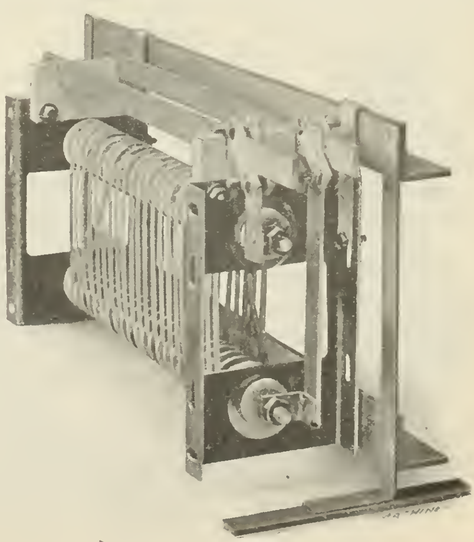


Fig. 2. Side View of Straightening Press

WESTINGHOUSE OVEN HEATER

An electrical oven heater designed especially for use in enameling or japanning ovens is illustrated herewith. This heater may also be applied for a variety of work where ovens are employed for a baking or drying process. The heating element consists of a ribbon wound on a number of fire-clay bushings assembled on two steel tie-rods, between two pressed steel end-plates. The ends of the ribbon are secured to drop-forged steel terminals, clamped to the steel tie-rods, which therefore become the terminals for the heaters. The tie-rods are insulated where they pass through the end frames, and the ends are threaded for bolting onto the connectors. Special



Westinghouse Type C Oven Heater

connectors are furnished to meet requirements. Cold-rolled steel bus bars are recommended, and may be mounted directly above the heater on insulators bolted directly to the end-frames. Connectors are secured to bus bars by steel clamps.

Hooks are used for hanging the heaters from the usual supporting steel work, which may be flat iron, angle iron, channel iron or pipe work. The hooks are bolted to the flanged end-plates of the heaters. Protecting screens may be attached directly to the flanged end-plates without any other means of support. Heaters may be mounted either on the side walls or on the floor, and in any position.

These heaters are normally rated at 2.5 kilowatts at 120 volts. Any number of them may be installed in an oven, and connected to any power circuit, whether single-phase or poly-phase and 110-220 or 440 volts. On 220-volt service, two heaters are connected in series, and on 440-volt service, four heaters are connected in series. Where three-phase power circuits are used, the heaters are connected three-phase, with the phases balanced. This heater (Type C) is made by the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.

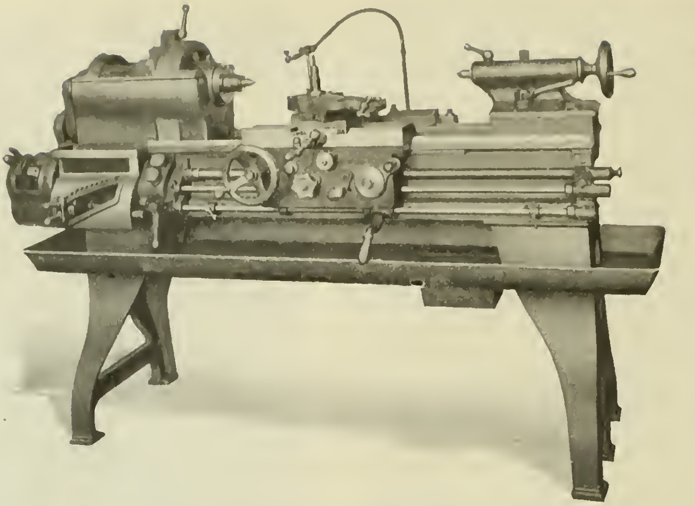


Fig. 1. Davis "Close-coupled" Tool-room Lathe

DAVIS TOOL-ROOM LATHE

The "close-coupled" tool-room lathe now being manufactured by the Davis Machine Tool Co., Inc., Rochester, N. Y., has been designed to meet modern requirements as to accuracy, convenience, power and simplicity of construction. Front and rear views of this machine are shown in Figs. 1 and 2, and a sectional view of the headstock in Fig. 3. One of the important features of this lathe is the method of mounting the "back-gears," which are placed under the headstock at the front end of the spindle. The small cone gear that is usually located at the end of the cone next to the small step is placed next to the large end of the cone. The back-gears are carried in a yoke which swings from a bearing at the back of the headstock. These gears are engaged with the cone gears by a cam operated from the front of the lathe by the small handle seen in Fig. 1 at the right of the gear-box. With this back-gear arrangement, the long eccentric shaft and quill common to cone-driven lathes, and the torsional strains to which this member is subjected, are eliminated.

The headstock is a heavy one-piece casting. Gear guards are integral with the headstock and form a cover for the cone pulley. At the top of the gear guard there is a brake for stopping the rotation of the spindle. This feature is of especial value when frequent inspection or gaging is necessary. The crucible steel spindle is mounted in heavy phosphor-bronze boxes, which are lubricated from large oil pockets by means of rings. The front spindle bearing is tapered to compensate for wear. The carriage has a bearing of 19¼ inches on the ways and a cross-bridge 6 inches wide. The compound rest is provided with four clamping bolts for holding it rigidly in any position.

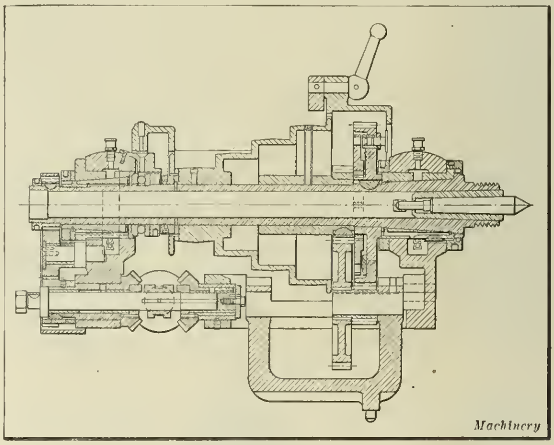


Fig. 3. Headstock of Davis Lathe

The apron is of the double-plate type with two bearing supports for all shafts. A central oil pocket is arranged to lubricate all bearings from one point. The apron has the usual interlocking feature to prevent engaging the feed-nut and half-nut at the same time. The lever seen in Fig. 1 beneath the right-hand end of the apron serves to reverse the movement of the carriage by shifting a sliding clutch interposed between bevel gears located beneath the headstock. The same rod that operates this reverse mechanism carries adjustable collars for stopping the feeding movement of the carriage at any point. This lathe has a screw cutting capacity varying from 1½ to 80 threads per inch, including 11½. The regular equipment provides thirty-six different leads or pitches, and this number can be increased by applying change-gears to the quadrant. The maximum error allowed in the lead-screw is 0.001 inch per foot. Thirty-six different feeds are provided, the feeding movement being transmitted through an independent feed-rod. All gears in the quick-change gear-box are made of steel and generated on a gear shaper.

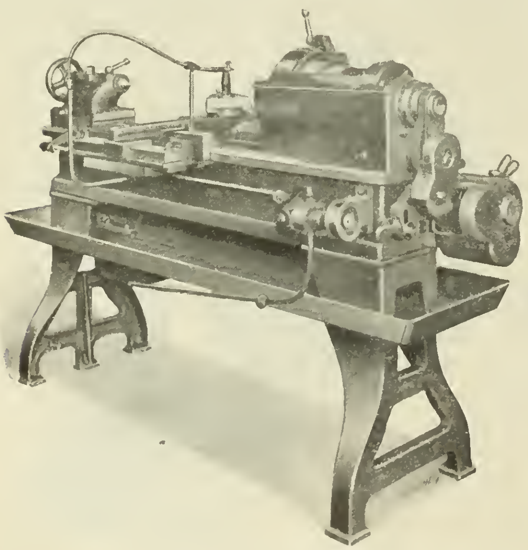
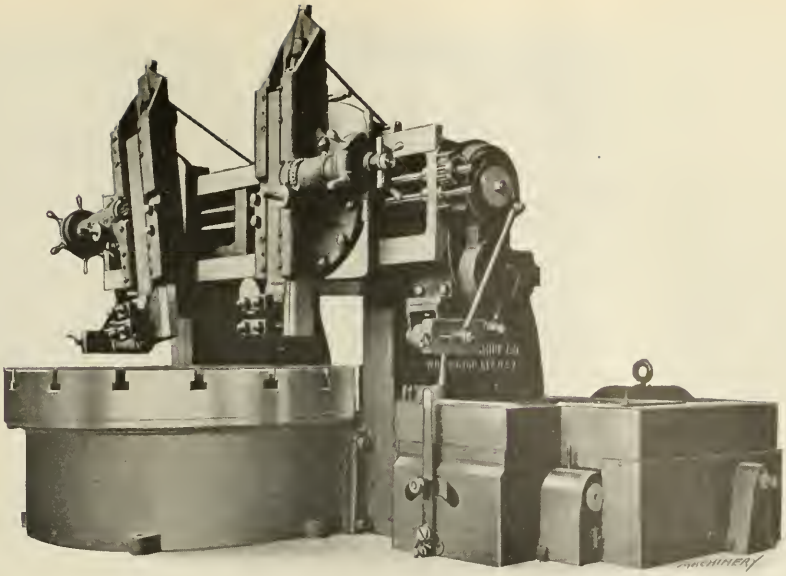
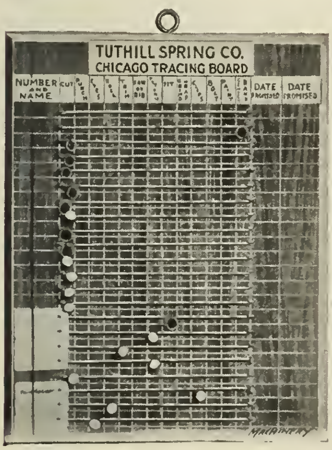


Fig. 2. Rear View of Davis Lathe

To insure correct alignment, an extra foot is placed in the center of the right-hand leg, so that the lathe has a three-point support. The outer ends of the right-hand leg are provided with adjusting bolts which can be screwed down until they just touch the floor, thus overcoming any rocking tendency. The bed of this machine is ribbed transversely with heavy double-wall cross girths. The rear end is low enough to permit sliding off the tailstock without disengaging the clamping bar or removing bolts. The manufacturers will supply this machine with a motor drive if desired. The motor is mounted over the headstock and is geared to the spindle through a train of gears which provide four mechanical changes by sliding clutches. Further speed changes are obtained through the motor, which should have a variation of from 500 to 1500 revolutions per minute. This lathe may be equipped with a taper attachment, draw-in chuck and collets, transposing gears for cutting metric pitches, and a relieving attachment if desired by the purchaser.



Betts Tire Turning Mill



Board for following Progress of Orders through the Plant

TUTHILL SPRING CO.'S TRACING BOARD

The tracing of orders so that delays are noticed, the causes discovered, and deliveries made on schedule time, is a problem common with all manufacturers. Tuthill Spring Co., Kesner Bldg., Chicago, Ill., formerly followed the progress of orders through their plant by a card index system. Every day the exact location of each job was noted on a card, and the superintendent or shipping clerk was kept posted on just what was taking place by referring to the cards.

The tracing board, the upper section of which is shown in the illustration, was devised to facilitate this work. This particular board is used in tracing Chicago orders. Each day the entry clerk, in a much shorter time than it took to make the card records, can bring his tracing board up to date. A glance tells the superintendent, or anyone else interested, the exact status of each job.

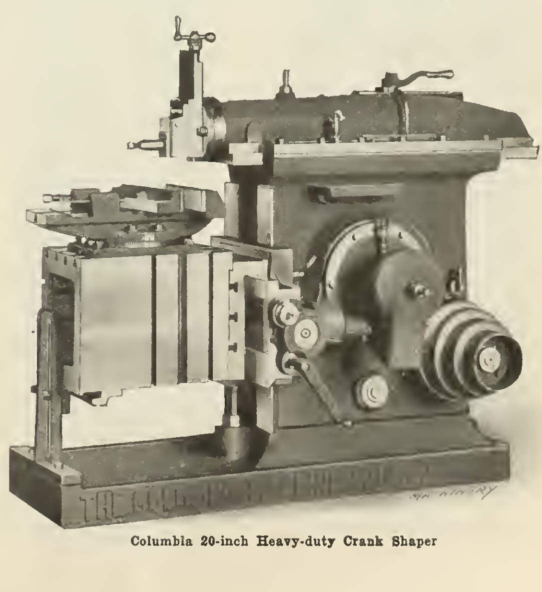
BETTS TIRE TURNING AND BORING MILL

A 66-inch tire turning and boring mill recently built by the Betts Machine Co., Wilmington, Del., is shown in the accompanying illustration. The machine swings diameters up to 72 inches and takes work 16 inches high under the saddles. It is driven by a twenty-five-horsepower electric motor. The general design of this machine is similar to that of a standard boring mill, but owing to the extremely severe duty for which the machine is intended, it has been made exceptionally strong. All driving gears are of steel, thoroughly covered, and provision is made to lubricate them properly; all feed gears, saddles and tool spindles are of steel, and the latter are independently counterbalanced and have rapid hand movement. Separate feed works are provided for each side of the machine, and the feeds can be changed quickly without stopping the machine.

The necessary speed changes are obtained through the field control of the motor in connection with two or three mechanical changes. This style of machine is built in five different sizes, ranging from 66 inches up to 108 inches, and it can be furnished with a movable instead of a fixed cross-rail so that it may be used for general machine shop work as well as for tire work.

COLUMBIA 20-INCH CRANK SHAPER

The heavy-duty crank shaper illustrated herewith is a 20-inch size built by the Columbia Machine Tool Co., Hamilton, Ohio. The column of this machine is made straight in front in order to permit the head to be set at an angle without interfering with its full travel across the table. The feed mechanism of this machine is designed along somewhat different lines from usual; it is carried in a housing which covers and protects the gears, and is an adaptation of the well-known



Columbia 20-inch Heavy-duty Crank Shaper

ratchet type. Feed changes may be made quickly, and a safety stop is provided, as well as means of controlling and indicating the direction of the feed. There are eight feed changes in all.

The position of the ram and the length of the stroke can readily be adjusted from the front of the machine. The ram is held in place by clamping gibs on top of the column, and an angular gib at one side of the ram provides adjustment for wear. The tool-head has a micrometer adjustment and is graduated for angular adjustment. The machine is provided with back-gears, which, in connection with the four-step driving cone pulley, give eight speed changes in geometrical progression. The table is of box form and long enough to accommodate work up to the full rated capacity. In addition to the regular T-slots, a V-groove is formed in one side of the table for holding round stock. The vise regularly furnished is of the double-screw type and has a graduated swiveling base.

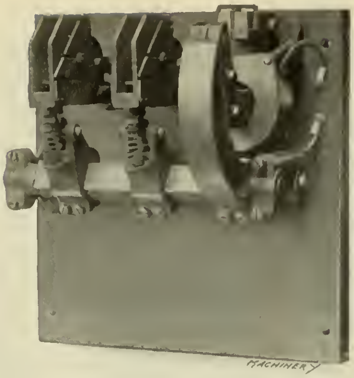


Fig. 3. Magnetic Contactor Panel

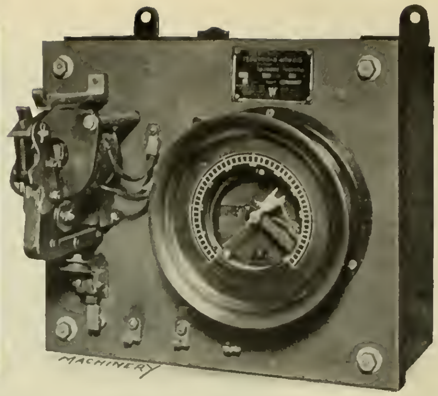


Fig. 4. Gage Type Pressure Regulator

WESTINGHOUSE AUTOMATIC STARTERS FOR INDUCTION MOTORS

Several automatic starters for motor-driven machinery, (manufactured by the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.), are shown in Figs. 1 to 4 inclusive. These automatic starters are for use with single-phase or polyphase squirrel-cage and wound-rotor induction motors, where it is desired to start the motor from a remote point or where automatic acceleration is required to guard against improper starting by unskilled operators. They are simple, reliable, and rugged in construction, consisting of a magnetic contactor panel and a master switch, which may be either a push-button, a float switch, a pressure regulator, or similar device for closing the control circuit, depending upon the service. The vital element is the magnetic contactor. The contactors used on these starters have been employed successfully in steel mill, cement plant, and mine installations, where the requirements are extremely severe. The contactors are opened by strong spring action assisted by gravity. The destructive action of the arc is reduced to a minimum by strong blow-out coils and arcing horns.

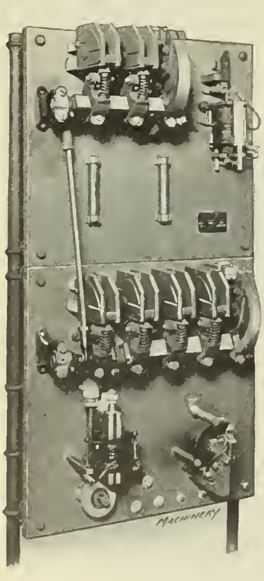


Fig. 1. Automatic Starter of Transformer Type

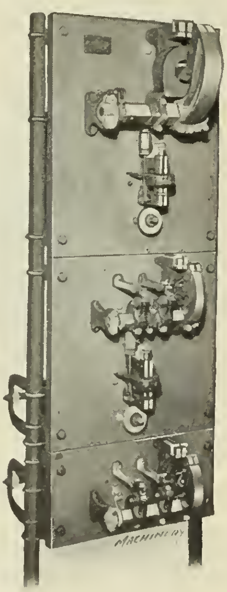


Fig. 2. Westinghouse High-voltage Starter

The operation of the starters is very simple. When starting motors driving lineshafting, woodworking, and machine tools, and similar apparatus, it is only necessary to press a button, and close a small knife or snap switch. The starter then automatically makes the proper connections to limit the starting current to a suitable value and to vary the time required for acceleration according to the load on the motor, thus preventing damage to the machinery by too slow or too rapid acceleration, and saving time by bringing the motor to full speed at the most rapid permissible rate. When used for pump or compressor service in connection with a float switch or pressure gage, the action of the starters is entirely automatic, the motors being started when the pressure or liquid level of the tank control falls to a predetermined point, and stopped when the desired maximum pressure or level is reached, or *vice versa*.

The automatic starters for squirrel-cage motors are most frequently employed for starting motors operating centrifugal pumps, air compressors, fans, blowers, metal-working and wood-working machines, and other apparatus requiring starting torque less than full load torque. This type of starter, however, owing to the wide application of squirrel-cage motors for industrial service, can be applied economically for starting service in nearly every industry.

Squirrel-cage motors of five horsepower and smaller are usually connected direct to the line. Large squirrel-cage motors are first impressed with low voltage from auto transformers or connected to the line through resistance so that in either case the starting current is reduced. When the speed of the motor has reached such a point that the starting current has decreased sufficiently the motor is then automatically connected to the line.

The automatic starters for wound-rotor motors are particularly adaptable for starting motors driving plunger pumps, positive pressure blowers, air compressors, long lineshafts, and loads having heavy inertia. The severe starting conditions encountered in this class of service require from 100 to 200 per cent full load torque in starting, making automatic starting a very desirable feature.

When an automatic starter is used in connection with a wound-rotor motor, the line switch is first closed, with the maximum resistance in the rotor circuit. When the speed falls to a predetermined value, a relay closes a magnetic contactor which cuts out a part of the resistance in the rotor circuit. Each contactor operates in a similar manner, cutting out its portion of the resistance at the proper time until all the resistance is short-circuited by the last contactor.

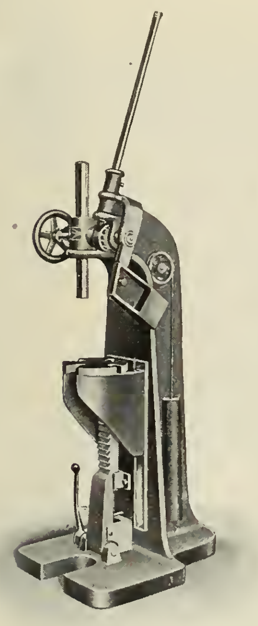
The power on any circuit may fail suddenly, and it is important that some protection be afforded both operator and motor against an unforeseen return of power. This protection may be provided for motors operating pumps, compressors, etc., by a low-voltage release to disconnect the motor from the line when the voltage is low or the power fails entirely. Then as soon as the power returns, the motor will automatically start up again. In many applications, however, such as for motors operating machine tools or wood-

working machines, low-voltage protection is required. Motors so protected are disconnected from the line when the power fails and will not start when the power comes on again until the operator presses a button or manipulates a similar device; hence, there is no danger from the unexpected starting of a machine.

The advantages resulting from the use of automatic starters for induction motors comprise absolute protection to both operator and machinery, proper starting at the most rapid permissible rate, economy in operation and maintenance, convenience of remote control, and automatic operation.

FOX ARBOR PRESS

The Sunderland Machinery & Supply Co., 1006-1010 Douglas St., Omaha, Neb., has placed on the market an arbor press known as the Fox "high-speed" No. 4, that is designed for rapid operation and adjustment. The press is equipped with a special type of mechanism for elevating and lowering the table easily and rapidly. The table is counterbalanced by a weight at the rear of the press so that it can easily be raised or lowered. It is elevated by grasping the handle at the left-hand side and simply lifting it, and is held in position by the rack and pawl shown beneath it. In order to lower the table the pawl is first disengaged from the rack by a lever provided for that purpose, and the table is then pushed down to the required position. The press ram is operated by a counterweighted ratchet lever, as the illustration shows. The frame and table are of cast iron, and the rack, pinion, pawl and ratchet are made of a special alloy steel properly heat-treated. This press will take diameters up to 19 inches, and the capacity over the table is 30 inches. The ram has a movement of 17 1/7 inches and the leverage is 60 to 1. The weight of the press is 1100 pounds.



Fox No. 4 Arbor Press

SKELTON TAPER REAMER

The taper reamer shown in Fig. 1 is designed for reaming taper holes and has a flat, high-speed steel blade and a low-carbon steel holder. The edge *A*, Fig. 2, is ground to a circular form, and between this edge and the heel *B* there is a flat surface. The heel is backed off or relieved sufficiently to allow for the maximum cut and still prevent "hogging in," the depth of cut being positively controlled by the clearance or amount ground away at *B*. The curved flutes *C*, adjacent to each cutting edge, provide rake so that the reamer cuts the metal instead of scraping it. The method of holding the blade allows

Fig. 1. Skelton Taper Reamer

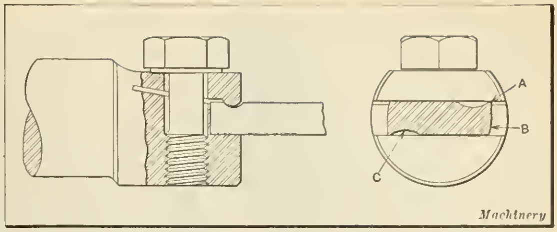
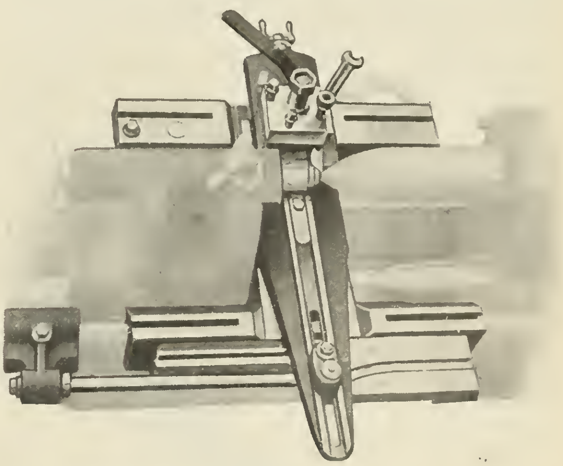


Fig. 2. Connection between Blade and Holder of Skelton Reamer

for lining up the reamer with the spindle in case the turret hole is out of alignment. As Fig. 2 shows, the end of the holder is split and it has a circular tongue which engages a circular groove extending across the end of the reamer blade. The tongue is offset slightly with reference to the groove in the blade so that the blade is forced back into the bottom of the slot, thus aligning it with the holder. The clamping screw is of nickel steel, heat-treated and so arranged that the pressure comes in front of the holder. This reamer has been placed on the market by Charles E. Skelton, 107 N. Franklin St., Syracuse, N. Y.

SHELL FORMING ATTACHMENT FOR CINCINNATI LATHES

An attachment for use when turning shells is shown in the accompanying detailed view as applied to one of a number of 18-inch lathes built by the Cincinnati Lathe & Tool Co., 3207-3211 North St., Oakley, Cincinnati, Ohio. A shell made of 50-point carbon steel, having a 12-inch radius, was finished to the required size and form with an attachment of this type in 16 minutes, 48 seconds. The actual cutting speeds varied from 69 to 204 feet per minute, owing to the curvature of the shell, and a feed of 1/32 inch was used. The attachment illustrated is equipped with a cam for forming 6-inch shells.



Shell Forming Attachment applied to Cincinnati Lathe

ARMSTRONG-BLUM METAL-CUTTING BAND SAW

A universal metal-cutting band saw, which is the product of the Armstrong-Blum Mfg. Co., 343 N. Francisco Ave., Chicago, Ill., is shown in a vertical position in Fig. 1, and in Fig. 2 with the saw blade tilted to an angle of 45 degrees for cutting an 18-inch beam. The saw may be inclined to a 45-degree angle, either to the right or left, and its position is indicated by suitable graduations. The saw blade is mounted on two flanged wheels supported by a rigid frame, which is pivoted to a frame or cage under the table. This cage is equipped with four hardened roller bearings that travel in planed dirt-proof races. The automatic feeding movement may be engaged or disengaged by means of a small lever at the front of the machine.

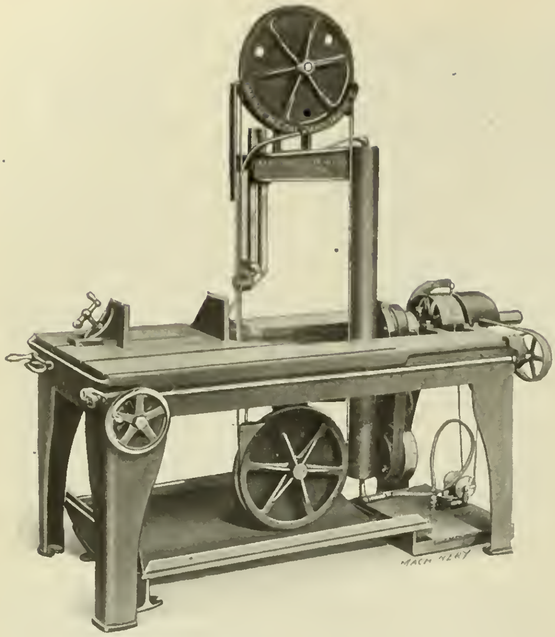


Fig. 1. Armstrong-Blum No. 8 Metal-cutting Band Saw

The required pressure is imparted to the saw blade by a bronze worm-gear having cork inserts, two friction disks, a spring and an adjusting nut. Lubrication is supplied to the saw blade at the cutting point by a submerged centrifugal pump, the lubricant passing directly through the teeth at the point of delivery. The saw blade guide rollers have double ball bearings and felt dirt-proof rings. The machine may be stopped at any required depth of cut by a knock-off dog or trip. The saw table is 32 inches wide, 5 feet long, and has four T-slots. The two inner slots are machined and notched to receive the vise jaws, which may be placed wherever needed or be removed entirely. The drip-pan is telescopic and designed to catch the lubricant when the saw blade is inclined 45 degrees either way from the vertical. The speed of the saw

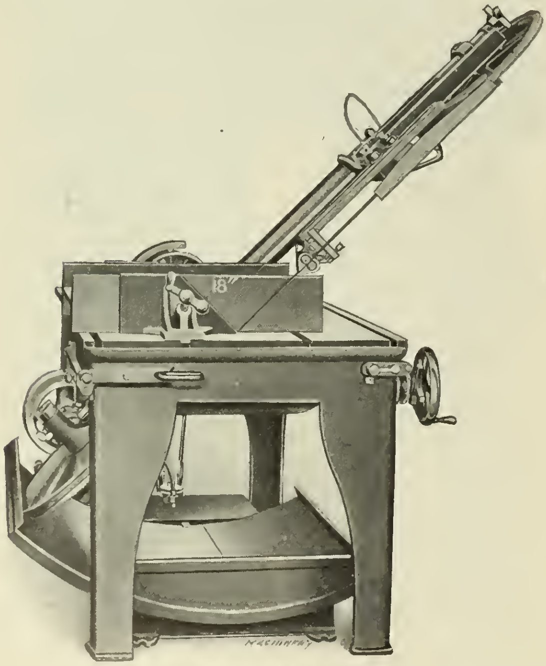


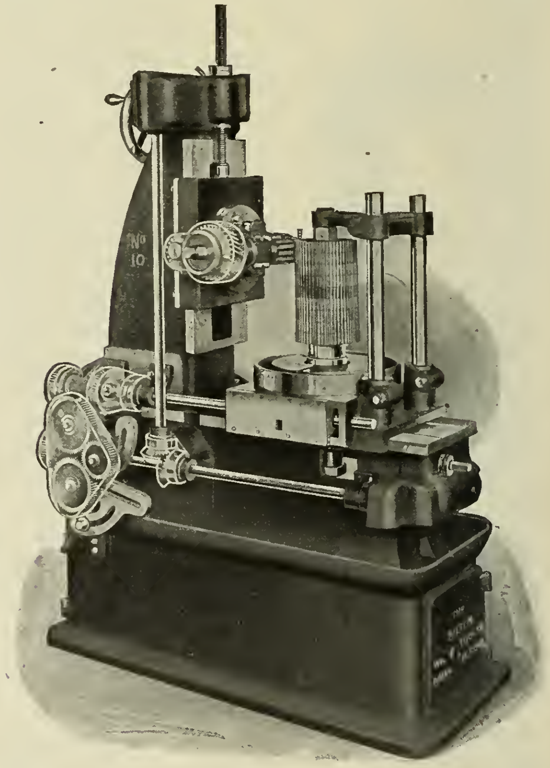
Fig. 2. Metal-cutting Band Saw set at Angle of 45 Degrees for cutting 18-inch Beam

may be increased about 90 per cent by means of double cone pulleys. This machine has a throat capacity of 18 by 20 inches. The saw blade is 14 feet, 8 inches long, ⅝ inch wide, and 0.032 inch thick. Guards are provided wherever necessary.

BILTON UNIVERSAL GEAR-HOBBING MACHINE

A universal gear-hobbing machine recently added to the gear-cutting equipment of the Bilton Machine Tool Co., Bridgeport, Conn., has a rated capacity for gears of 10 inches outside diameter, 10 diametral pitch and 10 inches width of face. The work-table of this machine (see accompanying illustration) is driven through a steel worm and a bronze worm-wheel 11½ inches in diameter. The worm is automatically lubricated and is fitted with a ball thrust bearing. Automatic stops are provided for the vertical and horizontal feeding movements, and the horizontal feed shaft has a micrometer dial. The differential gears and the feeding and indexing gears, which are on the rear end of the machine, all have teeth of 14 diametral pitch, so that they are interchangeable, and the total number is reduced to a minimum.

The vertical slide is made extra long and has flat ways with large bearing surfaces. The hob spindle head carried by this slide may be set at any desired angle for cutting right- or left-



Bilton No. 10 Universal Gear-hobbing Machine

hand spirals. The hob spindle is driven through helical gears, and it may be adjusted lengthwise to relocate the hob if it should become dull in one place, without disturbing the adjustment of the spindle bearings. The work-table has a central hole 1⅜ inch in diameter, so that teeth can be hobbed on the ends of shafts up to 1⅜ inch diameter and 24 inches long. The table has deep oil-grooves with a drain running to the base of the machine where the oil reservoir is located. This reservoir is removable so that it can be cleaned. The hob speeds vary from 50 to 250 revolutions per minute and the range of hob feeds per revolution of the work is from 0.010 to 0.125 inch. The machine is driven through a three-step cone pulley designed for a 2½-inch belt. The net weight of the machine is 1100 pounds.

UNITED STATES ELECTRICAL GRINDER

The United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, Ohio, is now building a combination wet and dry grinding machine that is electrically driven. This grinder is built in two sizes, with motors of three and five horsepower capacity. The machine equipped with a three-horsepower motor is arranged to carry two grinding wheels 12 inches in diameter by 2 inches face width, and the five-horsepower machine carries two grinding wheels 18 inches in diameter by 3 inches face width. These grinders are equipped with either direct-current motors for 110-, 220- or 550-volt circuits or alternating-current motors for 220-, 440- or 550-volt circuits of 25 or 60 cycle and two or three phase.

The bearings used in these machines are of the self-aligning ball bearing type, and the motors are built by the Westinghouse Electric & Mfg. Co. The grinding machine equipped with a three-horsepower motor weighs 575 pounds, and the

United States Electrical Grinder

machine equipped with a five-horsepower motor weighs 700 pounds. The speed of the grinding machine driven by a three-horsepower motor is 1800 revolutions per minute, and the machine driven by a five-horsepower motor runs at 1120 revolutions per minute.

NEW MACHINERY AND TOOLS NOTES

Plug Gages: Simplex Tool Co., Woonsocket, R. I. A standard line of hardened tool steel plug gages varying by 1/32 inch from 1/8 to 1 inch in diameter.

Cutter Grinder: Elmer Sacrey, 1001 Diamond St., Philadelphia, Pa. A grinder for sharpening milling cutters up to 9 inches in diameter. The machine is equipped with a diamond wheel-truing device.

Pneumatic Hammer: H. Edsil Barr, Erie, Pa. This hammer strikes a maximum of 200 blows a minute and has a capacity for stock up to 2 inches square. The hammer is arranged to permit continuous striking.

Engine Lathe: Richard H. Kiddle, Kinsman, Ohio. Fourteen-inch engine lathe of cone pulley type, with beds varying from 4 to 10 feet in length. The swing over the carriage is 8¾ inches, and the weight, 1200 pounds.

Grinding and Polishing Stand: Lamb Knitting Machine Co., Chicopee Falls, Mass. A ball bearing grinding, polishing, and buffing machine. The head is separate from the base so that the machine may be used either as a bench or pedestal type.

Grinding and Buffing Stand: U. S. Electrical Mfg. Co., Los Angeles, Cal. This is a self-contained, motor-driven tool equipped with ball bearings that are sealed against dirt and grit. The machine may be supplied for bench mounting or with a pedestal.

Hydro-pneumatic Press: Metalwood Mfg. Co., Leib and Wight Sts., Detroit, Mich. A press for subjecting high-explosive and shrapnel shells to internal pressure. Presses of this type are built in various sizes with pressures ranging from 2000 to 21,000 pounds per square inch.

Bender for Ship Frames: Watson-Stillman Co., 192 Fulton St., New York City. Hydraulically-operated bender designed for bending heavy steel ship frames, deck beams, etc. The machine is mounted upon broad rollers so that it can be moved along the work when bending long parts to the shape of a templet.

Polishing Machine: Harvard Machine Co., Harvard Square, Cambridge, Mass. Polishing and lapping machine provided either with a No. 2 Morse taper spindle or with spring chucks for accommodating work up to ½ inch in diameter. These machines are intended especially for tool-room use in lapping bushings, plug gages, etc.

Pyromagnetic Indicator: Pyromagnetic Instrument Co., 175 N. Jefferson St., Chicago, Ill. An instrument of the magnetic type for determining the critical point when heating steel parts for hardening. One end of the instrument is energized and is placed in contact with the steel, which is heated until it becomes non-magnetic.

Universal Curveograph: W. G. Classon, Leominster, Mass. An instrument for the use of engineers and draftsmen, adapted for drawing simple, compound, reverse, and irregular curves. The spline or part for guiding the pen or pencil is held by adjustable fingers provided with graduations indicating the radius of curvature.

Automatic Threading Lathes: Automatic Machine Co., Bridgeport, Conn. These lathes operate on the same general principle as those formerly manufactured, but differ in some of the details. They are adapted for single or multiple thread cutting on either right- or left-hand screw threads. Forged tools or circular form cutters may be used.

Two-spindle Milling Machine: Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa. A machine of the type having a horizontal planer type table equipped with two spindles, one being vertical and the other horizontal. The maximum height under the vertical spindle is 36 inches, and the width between the uprights, 42 inches.

Vertical Bending Rolls: Southwark Foundry & Machine Co., Philadelphia, Pa. A large bending roll for boiler plates having rolls which are vertical instead of horizontal. Two of the three rolls in the set are 22 inches in diameter, and the third roll is 30 inches in diameter. The driving motor and mechanism is located in a pit beneath the floor.

Cold Saw: Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa. A cold metal-cutting saw for handling heavy structural steel sections. The machine is equipped with a 56-inch saw blade, but this may be increased to 62 inches in diameter if necessary. With the smaller blade the machine will handle rounds up to 16¾ inches, squares up to 15½ inches, and oblong sections up to 17 by 58 inches.

Power Shear: Buffalo Forge Co., Buffalo, N. Y. A line of power cut-off shearing machines. These shears are mounted on wheels to make them portable, and individual electric motor drive makes the entire machine self-contained. Four sizes of shears are built, the largest of which has a capacity for cutting flat bars up to 1⅛ by 5 inches, round stock up to 1¾ inch in diameter, square stock up to 1½ inch, and angles up to 5 by 5 by 9/16 inch.

Spline Milling Attachment: Standard Engineering Works, Pawtucket, R. I. An attachment of the vertical type for use on hand and weight-fed milling machines. It is adapted for milling tang slots, feather keyways, etc. A cam operated by a ratchet gear controls the vertical movement of the cutter, and the spindle returns to an upright position automatically after reaching the proper depth. The horizontal travel is controlled by an automatic trip.

Sandblast Room: American Foundry Equipment Co., 52 Vanderbilt Ave., New York City. A compartment for the protection of the operator when sandblasting. The compartment or room has a circular table which extends beyond the enclosed part at the rear, so that it can be loaded while the work inside the compartment is being operated upon. The sandblast nozzle is inserted through a slit covered with rubber flaps, and the work may be seen through a fine brass screen.

Power Press Guard: G. H. Scott Machine Co., Cleveland, Ohio. This guard is entirely independent of the press treadle. Accidents due to repetition of the press are claimed to be impossible, and it is also stated that interference with the production of the machine is avoided, as well as accidents to the dies and the press. The guard is actuated by a cam and roller, and descends ahead of the ram, but the work is visible at all times and the operator has free use of his hands.

Dynamic Balancing Fixture: N. K. Akimoff, 1013 Harrison Bldg., Philadelphia, Pa. A fixture applied to an engine lathe for testing the dynamic balance of revolving machine parts. One end of the part to be tested is held in the chuck while the other rests on rollers having a yielding support. The position of an adjustable member is changed until an indicator dial shows that the part is in balance. The amount and location of excess metal to be removed by drilling is determined by reference to special tables.

Wire Nail Machines: Sleeper & Hartley, Inc., Worcester, Mass. Distinctive features of these machines consist of the employment of toggle joints actuated from a single crankshaft to provide the working motions, separation of the pointing and heading operations, and reduction in the size and weight of the machines and the floor space which they occupy. In operation, wire is taken from a coil and run through straightening rolls. During a single revolution the wire is fed forward to form the nail blank, the blank is cut off and the incoming end pointed. In the meantime the previously cut-off blank is headed.

* * *

MR. SHIPLEY RETIRES FROM THE LODGE & SHIPLEY MACHINE TOOL CO.

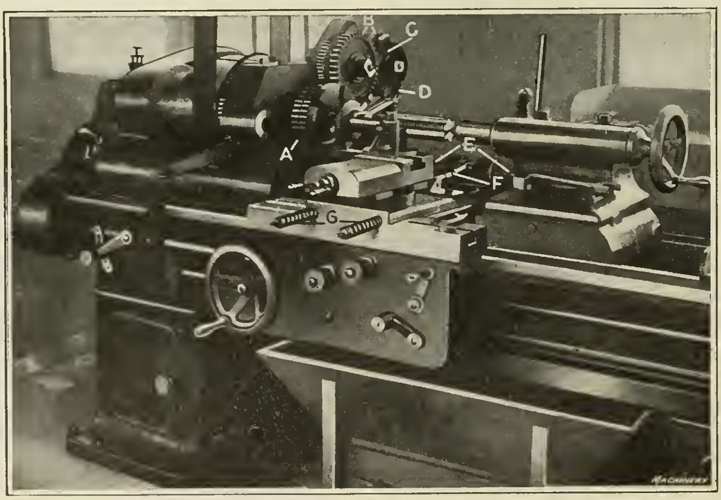
Mr. Murray Shipley has sold his holdings in the Lodge & Shipley Machine Tool Co. of Cincinnati to Mrs. Lodge and her daughters, and given up all connection with that business. Mr. Shipley states that his retirement from the company does not necessarily indicate a permanent retirement from business, but rather a relief from the close attention which he has had to give to details for twenty-five years. Mr. Shipley has been identified with the concern since its establishment by Mr. Lodge and himself in August, 1892, and his activity in the machine tool business has covered a period of great progress and expansion in the industry, of which the Lodge & Shipley Machine Tool Co. has had its full share, starting from a small shop on Culvert St., from which it was moved to its present location, where the plant and business has steadily increased until it is now one of the largest and best known in the world. The new officers of the company are Mrs. M. G. Lodge, president; J. W. Carrel, vice-president and general manager; and L. A. Hall, secretary and treasurer. It is stated that the policy and organization of the company will continue on the same progressive lines as before. J. W. Carrel, the vice-president and general manager, has had many years of training and experience in the manufacture and sale of machine tools, having been connected with several well-known concerns before he became sales manager for the Lodge & Shipley Machine Tool Co. Mr. Carrel is widely known and highly regarded in the industry, and under his management the business will undoubtedly continue moving onward and upward.

* * *

RELIEVING ATTACHMENT FOR LATHE

The Phoenix Mfg. Co. of Eau Claire, Wis., has equipped one of its engine lathes with a simple attachment for relieving hobs, taps and various forms of milling cutters. It will be seen that this consists of a gear *A* mounted on the lathe spindle nose, from which power is transmitted to compound gears *B*, carried on a bracket at the back of the lathe. These compound gears may be changed to suit the cutter that is being relieved. Secured to the last gear of the compound train there is a cam *C* which has the same number of lobes as there are flutes in the cutter. A roller mounted at the end of crank *D* runs in contact with cam *C*, and is secured to an eccentric shaft *E* mounted in bearings at the back of the lathe bed.

By disengaging the cross-feed screw in the lathe carriage, the cross-slide is left free and connection is made between it and the eccentric on shaft *E* by means of a connecting-rod *F*. It will be apparent that cam *C* and crank *D* impart an oscillating movement to eccentric shaft *E*, from which a corresponding reciprocating movement is imparted to the cross-slide on the carriage. In this way the necessary motion is obtained to give the cutter teeth the required relief. Different cams *C* and combinations of compound gears *B* are employed according to the type of cutter that is to be relieved. Cam *C* must, of course, have the same number of lobes as there are flutes in the cutter. Springs *G* hold the cross-slide so that all lost motion in the mechanism is taken up and accurate results are secured. E. K. H.



Lathe Attachment for relieving Milling Cutters, Taps and Hobs

* * *

"COLLEGE OF THE MIDNIGHT LAMP"

BY GUY H. GARDNER [1]

Though not wholly unfamiliar with other institutions of learning, I hold high opinions of the "College of the Midnight Lamp." Just now I have a small yarn to spin in regard to it. Last November a young apprentice wrote asking me to tell him how to find by a lay-out, as he knew no mathematics beyond long division, how far apart to place the tacks to draw an ellipse 8 by 12 inches. I learned subsequently that he wished to make a hole for an 8-inch stovepipe. In the last week of November he began the "midnight" study of plane geometry. In January of this year he began trigonometry. March 24, in response to his request for "something a little harder," I sent him a trigonometric problem which I have put before successive generations of high school and academy boys without finding one who could solve it. It is simple, but depends on the formula for the sine of twice an angle. My apprentice friend sent me the solution by return mail. Rah for the "College of the Midnight Lamp!" He is now working on the mathematics of gearing, and asks me to help him later with navigational astronomy, as he thinks "a man ought to have a hobby unconnected with his daily work."

His father writes that he has never seen so marvelous a transformation of character. No more loafing, no more "movies," just hard work, which is not hard because he loves it. That boy will amount to something. I could tell a dozen tales of men who have subscribed to MACHINERY to get rid of an importunate solicitor, and have undergone, in consequence, as complete a change of character as this youngster. Billy Sunday "has nothing on" MACHINERY as an agent of reformation.

* * *

GRINDING WHEEL BALANCE

Howard W. Dunbar calls attention to the need of perfect grinding wheel balance in *Grits and Grinds*, asserting that probably nine-tenths of all trouble with cylindrical grinding machines is caused by the efforts of the operator to obtain good work by tightening the boxes so as to prevent an out-of-balance wheel causing marks on the work. Out-of-balance wheels set up vibrations throughout the whole machine, which cause chatter marks in the work; they are more likely to break than wheels in balance; they wear out the spindle boxes rapidly; and are more destructive to diamond truing tools, requiring more frequent dressing. Out-of-balance wheels, therefore, are more expensive than wheels in balance because of more rapid wear and their deteriorating effect on grinding machinery.

[1] Address: New London, N. H.

SPOT-FACING TOOLS

BY F. B. JACOBS[1]

Spot-facing tools and counterbores are often spoken of as the same thing, but there is a slight difference between them. As a general thing, a spot-facing tool is used to finish off a surface, although it is sometimes used to counterbore a hole slightly. On the other hand, a counterbore is generally used for counterboring comparatively deep work and sometimes for enlarging a hole that has been drilled, particularly when several holes are so near together that they break into each other. There are many varieties of spot-facing tools, but this article will be confined to some of the more simple forms that have been found efficient in everyday work, especially in the automobile industry.

The simplest form of spot-facing tool is shown in Fig. 4. This consists of a bar of the requisite length having a hole drilled and reamed near the bottom to accommodate the cutter, which is held in place by a set-screw. Owing to the ease with which it is made, this tool is a favorite with those employed on experimental work, who often have occasion to face off several bosses of different sizes. If the tool is of medium size, say with a one-inch shank, it can be made by a machinist in about one hour. The only feature calling for any degree of accuracy is the angle made by the shank and the bar, which should be 90 degrees. This tool is comparatively short-lived, as it has only one cutting edge, but when only a few holes are to be spot-faced it serves the purpose as well as some of the more elaborate and costly forms.

A more substantial form of spot-facing tool is illustrated in Fig. 5. This consists of a shank to which the cutter, which closely resembles a hollow-mill, is fastened by means of a cone-point set-screw. The teeth terminate in a liberal fillet and the angle is comparatively slight. This is essential on rapid production work, where tools are worked to the limit to avoid undue breakage. The pilot can be protected from undue wear by casehardening, if machine steel is used. Boiling in cyanide for fifteen minutes will produce a case deep enough to withstand several weeks of constant use. The cutter should be made of high-speed steel if the material to be machined is cast iron or steel; for brass and aluminum, however ordinary tool steel may be used, especially since the war has forced the price of high-speed steel to an almost prohibitive mark. If an accurate face is desired, the hole in the cutter should be finished after hardening by grinding or lapping, and the teeth should be backed off by locating the piece from the hole. If only a fair degree of accuracy is called for, however, the teeth can be backed off with a file before hardening, and in this case no grinding is necessary until the teeth become dull through use.

Occasionally, it is convenient to have spot-facing tools that are interchangeable, as shown in Fig. 1. Here the shank is drilled and reamed to accommodate the pilot, which is held in place by a set-screw, while the cutter is fastened to the shank by another set-screw. By providing several pilots and cutters, quite a variety of work can be taken care of without making complete tools for each hole. The shank can be left soft, but the cutters and pilots should be finished by grinding after hardening. It is not necessary to make the pilots of tool steel, as ordinary machine steel, casehardened by packing in bone dust, gives equally good results. The tool shown in Fig. 2 has a removable pilot, but inasmuch as the shank and cutter are made integral it is an expensive form of construction. For small sizes, however, say one inch in diameter and smaller, this form is often used. In sharpening, the pilot is removed and the tool is located by the shank.

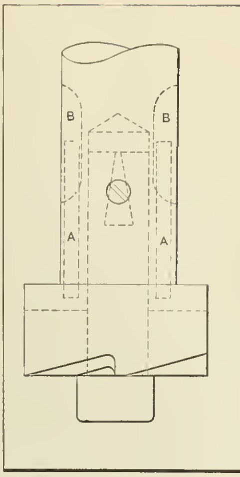


Fig. 6. Form of Spot-facing Tool that is easily repaired

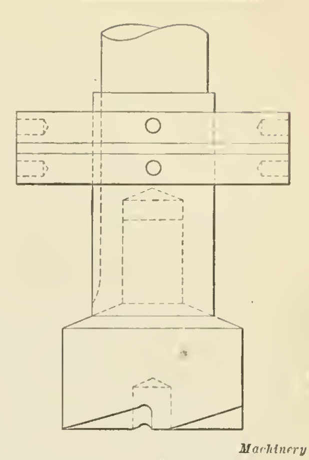


Fig. 7. Tool for spot-facing Surfaces drilled and reamed in a Jig

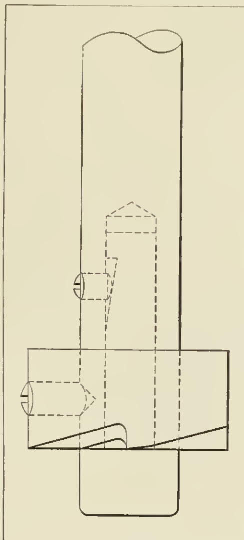


Fig. 1. Spot-facing Tool with Interchangeable Cutter

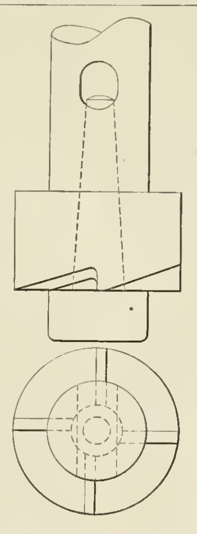


Fig. 2. Convenient Form of Spot-facing Tool for Small Sizes

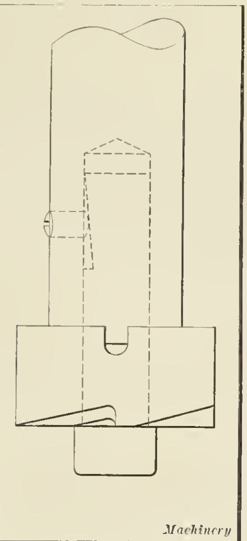


Fig. 3. Spot-facing Tool in which Cutter is driven by Projections on Shank

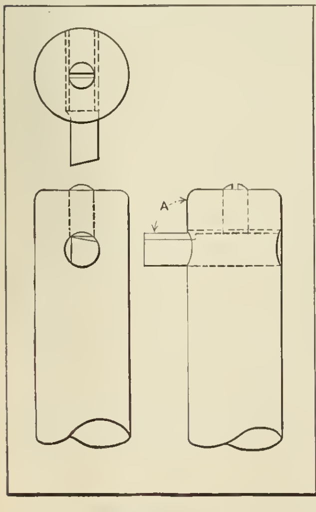


Fig. 4. Simplest Form of Spot-facing Tool

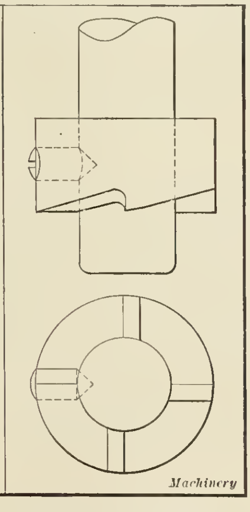


Fig. 5. Rapid-production Spot-facing Tool

[1]Address: 435 Harvard Place, Indianapolis, Ind.

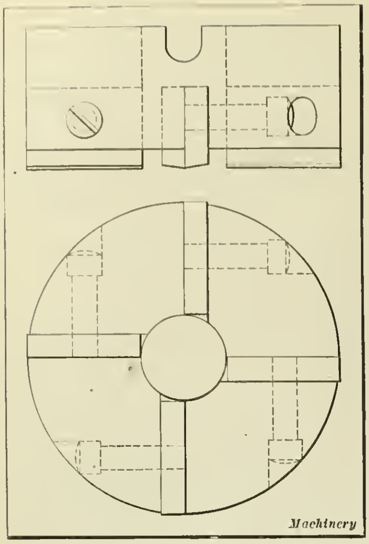


Fig. 8. Spot-facing Tool with Inserted Teeth

A good design is illustrated in Fig. 3. The pilot locates the cutter, being fastened by a set-screw, while the strain of driving is taken by two projections, milled on the end of the shank, which fit a slot in the top of the cutter. This is a practical form of tool if properly made. As the illustration shows, the slot in the top of the cutter terminates in a half-round section; this form is essential, for a sharp corner at this point would be very likely to result in a fracture.

A unique form of spot-facing tool is shown in Fig. 6. The cutter is driven by two pins *A* that are a driving fit in the shank. Slots *B* are milled with a Woodruff key cutter for the purpose of driving out the pins when necessary. When the pins shear off, which sometimes happens, all that is necessary is to remove the pieces that have been cut off and drive the pins down slightly; the cutter is then ready for use. With the form shown in Fig. 3, it would be necessary to remill the end of the shank, which would take at least an hour's time, whereas with the pin design the operator can repair the damage in a few minutes. For this reason the pin form of tool is extensively used.

Comparatively large spot-facing tools, from two inches in diameter upward, are often made with inserted teeth as shown in Fig. 8. The cutter-head can be made of machine steel while the cutters can be of either tool or high-speed steel according to the nature of the work. The cutters are held in place by fillister-head screws. As the cutters seat firmly on the bottoms of the slots provided for them, one screw suffices to hold each cutter in place. The wear on the cutter-head is slight, and it should last indefinitely; when the cutters have been ground until they have become useless, they can be replaced at slight cost.

It is often advisable to spot-face surfaces on work that is drilled and reamed in a jig, in which case it is a good plan to dispense with the pilot, guiding the tool by means of a supplementary bushing inserted in the jacket bushing. As shown in Fig. 7, the cutter is held to the shank by means of a coarse-threaded screw machined to fit rather loosely, as the tool is centered by the bevel. The two collars are threaded to the shank and are for the purpose of adjusting the depth of cut as occasion requires; as they bear on the top of the bushing they should be hardened and ground true. A cutter of this kind could, of course, be guided by a pilot, but as spot-facing tools are generally broken by the pilot galling up it is a good plan to eliminate this feature when possible. In order to save the expense of an extra bushing, these tools are sometimes run directly in the jacket bushing, but this is poor economy, as the bushing is soon worn oversize, and the accuracy of the jig is impaired. The tools described are among the simple things that are often lacking, even in many well organized shops, but a little attention to simple tools often leads to efficient results, thus aiding materially in cutting down the cost of production.

* * *

In order to prevent the misappropriation of foreign trademarks, the president of Costa Rica has ordered that no trademark that is well known in the country, because of the advertising or the sale of the trademarked articles, shall be registered unless authority to apply for such registration is proved.

THE GRINDING WHEEL[1]

The electrochemist speaks of the abrasive wheel and the automobile manufacturer of the emery wheel, but the manufacturer thinks that neither of these words adequately describes his product, and so has adopted the term "grinding wheel." This term is here restricted to those wheels that are composed of two main constituents: the abrasive and the bond, or the substance that holds the particles of abrasive together. The commercial method of classifying grinding wheels is by the kind of bonding material used.

The most important type is the vitrified wheel. The bonding material in this type is composed of various kinds of clay mixed according to definite, secret formulas. Weighed amounts of the abrasive and the bond and a measured amount of water are stirred together in a mixing kettle for a certain length of time and then the mixture is drawn off from the bottom of the kettles into molds and allowed to dry. When dried, the wheels are taken to the shaving department, where they are turned to the approximate dimensions and shape called for by the order.

A kind of vitrified wheel, known as pressed wheel, is made by the pressed process. In this case, only enough water is added to the bonding clays to make the particles stick together to a slight degree. The abrasive and bond are mixed in kneading machines and are then placed in an iron mold and subjected to pressure by powerful hydraulic presses. The pressure applied depends on the grade of hardness desired. These wheels do not need shaving. The next operation is the heat-treatment, in which the wheels are subjected to a heat that will properly vitrify and mature the bond; the highest temperature reached is about the melting point of steel. The length of time required for heating, the length of time during which the wheel is subject to high heat, and the cooling period must be carefully controlled.

In silicate wheels, the bonding material is a commercial grade of silicate of soda, commonly known as water-glass, to which certain chemicals are added to make the bond waterproof. A weighed amount of the grain and a measured amount of the bonding material are placed in long cylinders, which are slowly revolved, end for end, until a uniform mixture is obtained. The mixed mass is placed in an iron mold of the approximate dimensions called for by the order and rammed into place by hand or air hammers. The wheel is then baked.

The name elastic wheel is derived from the fact that the bonding material has quite a degree of elasticity. The bond is of organic nature, the most satisfactory material being shellac, to which certain chemicals are added to facilitate hardening in the baking and also to make the wheel waterproof. Weighed amounts of the grain and the bond are thoroughly mixed and then dumped into large shallow pans and allowed to cool, thus becoming brittle. This brittle cake of abrasive and bond is broken into small pieces and then put through rolls that break the mass into the individual grain. The rolls do not fit close enough, however, to reduce the size of the grain, the idea simply being to produce a mass composed of loose grains, each of which has a coating of shellac. The material is then placed in an iron mold the approximate shape of the wheel, heated and then subjected to pressure. The amount of pressure depends on the degree of hardness desired. The mold and mass are again placed in a steam box and heated until the bond becomes permanently hard.

In vulcanized wheels, the bonding material is rubber, and their manufacture is practically like that of any other hard-rubber product. A weighed amount of the very best grade of crude rubber, the right proportion of sulphur, and a weighed amount of grain are thoroughly mixed by numerous passes in a vertical direction. After a uniform mixture is obtained, the mass is passed through a set of rolls that passes the material in a horizontal direction. It is then rolled down to the required thickness, cut to the required diameter, and a hole of the required diameter is cut in the center. The next operation is vulcanizing, which does not differ from the vulcanizing of any other rubber product.

[1]Abstract of a paper by R. G. Williams read before the American Electrochemical Society, in Detroit, May, 1917.

The next operation in the making of the wheels is that of truing, or bringing the wheels to the dimensions called for on the order. The wheels are mounted in a three-jaw chuck, revolved, and special tools resembling an emery-wheel dresser are brought up against the side of the wheel. In order to bring the wheels to the desired diameter, they are firmly held on a revolving arbor and the dressing tool passed back and forth across the face, gradually reducing the wheel to the desired size. For fine wheels that must be carefully shaped on the face, a diamond is securely mounted in a fixture and slowly passed across the face of the wheel. Light cuts only are taken so as not to crack and destroy the diamond.

The bushing, as it is termed, consists of lead or a babbitt. The wheel is allowed to rest on its side in a three-jaw chuck and is carefully centered; then a steel arbor from 0.002 to 0.005 inch larger than the desired hole in the wheel is placed in the center hole in the chuck and the lead poured around the arbor. When the lead has solidified, the wheel is removed from the chuck and the arbor is carefully driven out with a soft hammer. The bushing is then trimmed, so that it is not quite flush with the sides of the wheel; this is to provide clearance so that when the wheel is mounted on the machine there will be no possibility of stress being concentrated at the hole of the wheel.

In the next operation, the speed test, the wheel is revolved at a speed higher than that recommended for its operation, in order that the manufacturer may know that his product goes out with a sufficient factor of safety. The testing speed for wheels is 9000 surface feet per minute, except for those of organic bonds, when the test speed is higher. Since wheels are recommended to operate at about 5000 surface feet per minute, this gives a factor of safety, based on the squares of these speeds, of between 3 and 4. A careful record of every test is kept; and before these records are filed, the men that keep them are required to appear before a justice of the peace and swear that their statements are true.

Grinding Characteristics of Various Abrasives

Probably the most important physical property of an abrasive is hardness. Other properties, such as toughness and ability to resist shock, are also important, but knowledge of the art of grinding has not advanced sufficiently for us to state definitely the relative importance of the different physical characteristics; that is, we cannot state on which of the properties the grinding action of the abrasive most depends. It is known that the artificial abrasives are harder than corundum but not so hard as diamond. It is hard to determine differences in the hardness of artificial abrasives, although it is known that carbide-of-silicon abrasives are harder than aluminous abrasives.

When a grinding wheel containing a certain abrasive satisfactorily grinds very tough material, it is said to possess considerable toughness. Actual experience has shown that when materials of low tensile strength, such as cast iron, brass, bronze, etc., are ground, carbide of silicon, which is hard but relatively weak, is more efficient than aluminous abrasives. On the other hand, when grinding materials of high tensile strength, ranging all the way from medium carbon to the high-speed steels, aluminous abrasives give better satisfaction.

Precision Grinding Machines

The word "precision" is used to designate a type of grinding machine, because these machines must be capable of producing work of great accuracy. The art of precision grinding has advanced rapidly during the past few years and the demand of the automobile manufacturer should receive credit for producing most of the advance. Only a few years ago anyone advocating the accurate grinding of shafts five or six inches long without table or wheel traverse would have been condemned as too visionary; this step in the art has long since been passed. It is now possible to grind more than one diameter at one time with one wheel; this is an outgrowth of the use of very wide wheels taking extreme cuts without any traverse of the table or the wheel.

A machine using a very wide wheel, say ten or twelve inches, must be very rigid as well as capable of producing refined work. Imagine the forces present when a wheel weighing 150 or 200 pounds revolves on a spindle, in plain bearings, at 1000 to 1200 revolutions per minute. This spindle must be kept in perfect alignment so that the face of the grinding wheel will produce an absolutely straight cylinder, and there must be ample weight in the base of the machine and in the wheel-slide to absorb all vibration caused by the revolving mass. Another factor that must be borne in mind is the resistance offered when the wheel is brought in contact with the work, as small particles of a very hard material are removed at an extremely rapid rate. The spindle bearings must be so adjusted that the boxes will be quite hot when the machine is in operation; in fact, a temperature of about 140 degrees F. is desirable.

Limits of 0.0005 inch on the work being ground are very common; those of 0.00025 inch are quite common; and in some cases less than 0.00025 inch is demanded. When the work is reduced 0.00025 inch, the massive slide carrying the wheel-spindle and the grinding wheel moves forward only one-half this distance, or 0.000125 inch. If it were possible to split a piece of tissue paper into twelve thicknesses, the thickness of one piece would represent the motion of the wheel-slide when the grinding wheel removes 0.00025 inch from the work, and this accuracy must be maintained not only where very small cuts are taken, but also when the object is to grind off as many cubic inches per minute as possible.

* * *

CONFERENCE WITH GOV. WHITMAN

A conference between Governor Whitman of New York State and trade press editors and publishers was held in Albany, July 25, at the Executive Mansion. The conference is likely to have bearing on some of the relations of the state executive to the various industries represented. Questions of transportation, food control, marketing, conservation of coal and lumber, relations of manufacturers and labor, the importance of exempting machinists and toolmakers and others vitally necessary to the prosecution of this war with machinery, were discussed at some length. A committee of five editors has been appointed to give Governor Whitman the expert advice they are able to furnish because of personal knowledge and connections that enable them to draw from sources of information which may be of service in the prosecution of war.

* * *

The new color scheme of signal indications, by which white lights will be eliminated altogether, was placed in effect on all lines of the Pennsylvania Railroad east of Pittsburg, June 28. Nearly a year of preparatory work was required to make the change possible. Great difficulty was experienced in obtaining deliveries of materials, owing to the war conditions. The decision to eliminate white from the signal color scheme was reached on account of the increasing use of white lights in buildings, driveways, roads and streets close or adjacent to the railroad's right-of-way. Under the new plan, green will replace white for "clear" or "proceed." "Caution" will be indicated by yellow. Red will mean "stop," as heretofore. The glasses in all the semaphore signals and the following devices have been altered to conform to the new plan of color indication: marker lights on the rear of passenger and freight trains; switch lamps and targets; markers for track tanks; "slow" signs; "resume speed" signs; and hand lamps at interlocking and block signal stations.

* * *

An elaborate electrical sign has recently been erected by the Rice Leaders of the World Association in a prominent position overlooking upper Broadway in New York City. The firms in the machinery and tool field whose products are advertised by flashes on this sign are the Billings & Spencer Co., Hartford, Conn.; the Nicholson File Co., Providence, R. I.; and the L. S. Starrett Co., Athol, Mass. The names and products of the various firms that are members of the Rice Leaders of the World Association are flashed upon the sign in rapid succession. The upper part of the sign is composed of the elaborate coat-of-arms or emblem of the Association in colors.

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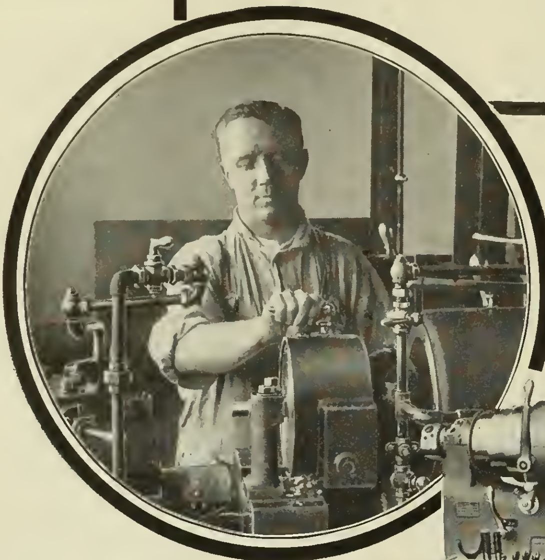

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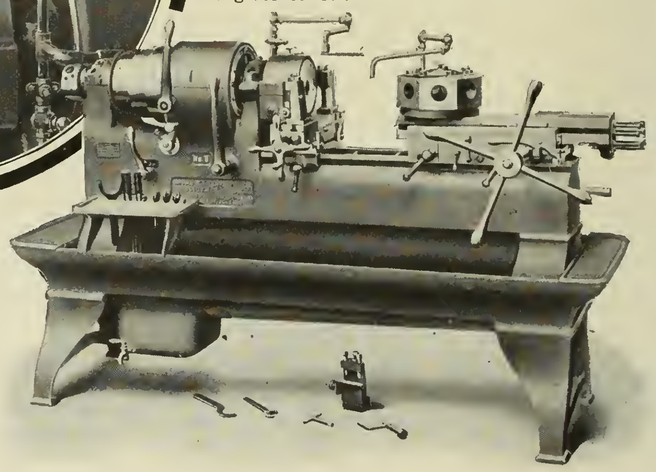

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LESSONS FROM BRITISH EXPERIENCE

In 1915, the British Minister of Munitions appointed a committee to consider and advise on questions of industrial fatigue, hours of labor, and other matters affecting the personal health and physical efficiency of workers in munition factories and workshops. This committee, after making a careful investigation, has made the following suggestions and recommendations with the purpose of securing maximum output over a period of months, or even years, and at the same time safeguarding the physical efficiency of the workers:

If the maximum output is to be secured and maintained for any length of time, a weekly rest period must be allowed. Except for short periods, continuous work is a mistake and does not increase the output. On economic and social grounds, this weekly rest period is best provided on Sunday. The foremen and the higher management even more certainly require definite periods of rest. They have never spared themselves; they carry a heavy burden of responsibility and cannot be replaced. It is of primary importance, in the interests of the nation, that they should be allowed that rest which is essential to the maintenance of their health.

The objections to overtime, briefly stated, are: It is likely to impose too severe a strain upon the workers, which adversely affects the rate of production and quality of output during the whole period of work as well as during the hours of overtime. It frequently results in a large amount of lost time, which is attributed to the workers becoming exhausted and taking a rest, and also to sickness. It imposes a serious strain upon the management, the executive staff, and foremen, since these persons cannot take days off like the ordinary worker. It is likely to curtail unduly the period of rest and sleep available for those who have to travel long distances to and from work, a matter of special importance in the case of young persons. The fatigue entailed increases the temptation to indulge in the consumption of alcohol.

Admitting that overtime must continue, for adult male workers the average weekly hours (exclusive of meals) should not exceed 65 to 67, including overtime. It may be desirable to differentiate to some extent between different kinds of work and to fix a rather low limit of hours for work requiring close individual attention. Where practicable, the overtime should be concentrated within three or four days in the week, which should preferably not be consecutive. Where overtime is necessary, it is specially important that there should be no Sunday work. The committee feels that the need for overtime among women and girls is much less pressing than it is for men, and should be abandoned in favor of shifts.

Although work on shifts involves night work, night work is not a good thing in itself because it is uneconomical. Though wages are paid at a higher rate, the rate of output, more particularly during the last two or three hours of a twelve-hour shift, is generally lower. Supervision is frequently unsatisfactory. Conditions of lighting are seldom as good as in the daytime and make fine work more difficult. Workers experience great difficulty in sleeping by day. The unfamiliar meal hour makes it difficult for the workers to consume substantial food, and digestion is likely to be upset.

As a method of speeding up production, the committee recommends the careful regulation of rest periods. It has been found that the operatives, if left to themselves, take rests at irregular and often unsuitable times; hence it is much better for the rest periods to be chosen for them. For instance, a ten-minute period in the middle of the morning and the afternoon, during which the operatives remain at their machines, but have tea or other nutriment brought them by boys or by traveling canteens, has been found a valuable aid to output. Some kinds of work need longer and more frequent rest periods than others; this is determined only by experience.

The committee found that the munition workers, in general, have been allowed to reach a state of reduced efficiency and lowered health, which might have been avoided without reduction of output by attention to the details of daily and weekly rests. The signs of fatigue are even more noticeable in the case of managers and foremen.

The committee calls attention to the fact that bad lighting affects output unfavorably by making good and rapid work difficult, and also by causing headaches and other effects of eyestrain. The difficulties of supervision are further increased. The essentials of good lighting are: adequacy; a reasonable degree of constancy and uniformity of illumination over the necessary area of work; the placing or shading of lamps so that light does not fall directly on the eye of the operator when engaged at his work or when looking horizontally across the work-room; the placing of lights so as to avoid the casting of extraneous shadows on the work. The committee also calls attention to the need of special measures to prevent undue strain upon the eyesight or to reduce the liability to accidents to a minimum. It suggests that the eyesight of operatives employed on close work be tested and the persons supplied with glasses when necessary; it also suggests guarding the eyes by the use of goggles.

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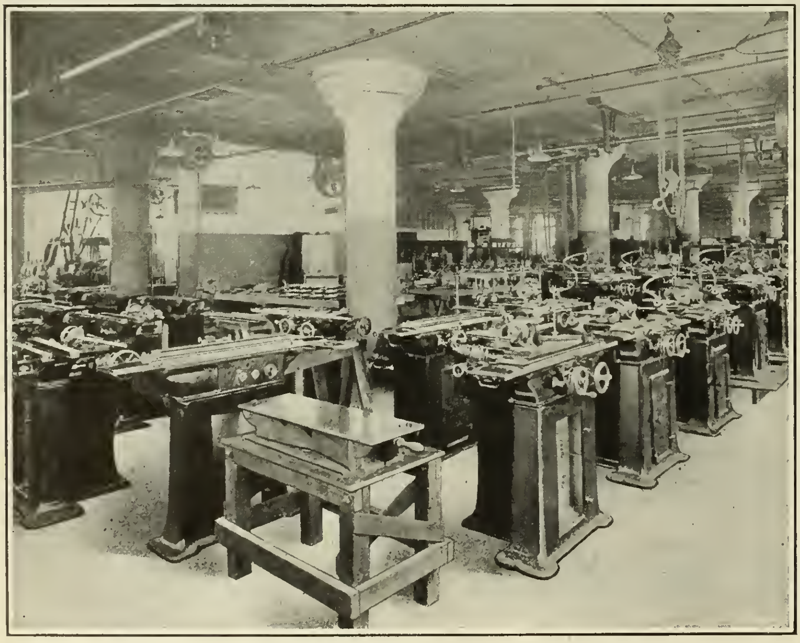

Assembling, erecting and testing Ott No. 1 Universal Grinding Machines

The illustration shows the floor of the Ott Grinder Co. in the Industrial Building, Indianapolis, Ind. The view is of interest, as it gives an idea of the rapid development of one comparatively small manufacturer who started a few months ago to build the line of cylindrical grinding machines acquired by purchase from the Modern Tool Co. of Erie, Pa. The growth of the business reflects the fact that the cylindrical grinding machine is no longer regarded as a refinement for the use of toolmakers only, but is rapidly becoming an indispensable machine tool to many concerns that found no use for it in their machine shops a few years ago. The view shows thirty No. 1 universal grinding machines in the various stages of assembling, erecting and final testing under belt. These are part of fifty machines put through in one lot. The first machine in the front row is being tested for accuracy, a Brown & Sharpe indicator being used for testing the alignment of both wheel-spindle and headstock.

PERSONALS

B. H. Blood has been appointed general manager of the Pratt & Whitney Co., Hartford, Conn., following the resignation of B. M. W. Hanson.

L. A. Larsen was appointed comptroller, effective July 1, at a recent meeting of the board of directors of the American Locomotive Co., New York City.

B. Orum Andresen has joined the engineering staff of Aall & Co., of Tokyo, Japan, the Japanese agents for the American Steel Export Co., Woolworth Bldg., New York City.

Charles H. Purdy, superintendent of the Dalton Machine Co., of New York City, has resigned to engage in the designing and building of special machinery, with offices at 103 E. 125th St., New York City.

H. L. Paulus, R. G. Ferguson, and F. L. Graf, for many years connected with the Baird Machinery Co., of Pittsburg, Pa., have resigned and joined forces with the J. S. Miller Machinery Co., of Pittsburg.

B. M. W. Hanson, general manager of the Pratt & Whitney Co., Hartford, Conn., has resigned, and has been made vice-president and general manager of Colt's Patent Fire Arms Mfg. Co. of Hartford.

Albert P. Weigel, superintendent and general manager of the Superior Machine Tool Co., Kokomo, Ind., has resigned and organized the Weigel Machine Tool Co., Peru, Ind., to manufacture machine tools.

Edgar N. Dollin, organizer and president of the Acme Die-Casting Corporation, Brooklyn, N. Y., has sold his holdings in the company and retired from active management. Mr. Dollin was formerly secretary of the Doehler Die-Casting Co., and president of the Kalak Water Co. He has had a wide business experience as a lawyer and as a manufacturer. His new activities have not been announced.

R. M. Klein has been appointed sales manager of the International Oxygen Co., with headquarters at the company's main office at 115 Broadway, New York City. Mr. Klein brings to his new position technical training, and experience as an engineer in the United States government employ, as salesman and sales manager of the Diehl Mfg. Co., and as manufacturers' representative handling a number of mechanical lines.

R. J. Doty, who for the last three and one-half years has been in charge of the steel foundry of the Isaac Johnson Co., Spuyten Duyvil, N. Y., has resigned his position to become associated with the Sivyer Steel Casting Co., Milwaukee, Wis. The company is enlarging its plant and installing an additional three-ton electric furnace to take care of its growing business among the motor truck, tractor, and general machinery manufacturers.

George A. Willard, for many years a manufacturer of lathes in Cincinnati, Ohio, has sold the Willard Machine & Tool Co. to G. Mattman and Thomas L. Bratten. Mr. Mattman was formerly European representative of the Cincinnati Milling Machine Co., and Mr. Bratten held an executive position with the Employers' Liability Corporation, and is well known in the trade. Mr. Willard will retire from business and take a much needed rest at his summer home in Michigan.

F. H. Tackaberry, general agent of the American Steel Export Co., Woolworth Bldg., New York City, sailed July 7 for South America. Mr. Tackaberry will visit the principal South American cities—Rio de Janeiro, Sao Paulo, Buenos Aires, Montevideo, La Plata, Rosario, Valparaiso, Santiago, etc., his object being primarily to collaborate with the company's factory agents and acquaint them with the market conditions in the United States for iron and steel and engineering and contracting.

OBITUARIES

H. C. Mather, president of the Moore Oil Co., Cincinnati, Ohio, was drowned June 26 in Lake Superior near Calumet, Mich.

Casimir von Philp died July 5 at Ocean City, N. J., aged sixty-four years. He was born in Sweden, but came to the United States nearly forty years ago. Since 1890, he was connected with the Bethlehem Steel Co., at Bethlehem, Pa., for a considerable period as chief engineer and recently as manager of the machinery department. As an engineer, his career was marked by unusual ability and originality. His inventions included improvements in rolling mills and special features of heavy forging equipment produced at the Bethlehem works. He was a member of the American Society of Mechanical Engineers, the American Society of Swedish Engineers, and the Engineers' Club of New York. He was also recently appointed a member of the John Ericsson Memorial Commission.

COMING EVENTS

August 30—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

August 30-September 1—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Museum of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

September 25-28—Twenty-second meeting of the American Foundrymen's Association, Boston, Mass.; Copley-Plaza Hotel, headquarters. The registration booth will be in the Mechanics' Bldg., where the exhibition of foundry and machine shop equipment and supplies will be held. A. O. Backert, secretary-treasurer, 12th and Chestnut Sts., Cleveland, Ohio.

September 27-29—Informal congress and reunion of American and Canadian engineers and architects of Norwegian birth or descent in Chicago at Chicago Norske Klub, 2346 N. Kedzie Blvd., Logan Square, Chicago, Ill.

SOCIETIES, SCHOOLS AND COLLEGES

Brown University, Providence, R. I. Circular on the new course in engineering containing illustrations of the laboratory equipment and statement of the requirements for the degree of bachelor of science in engineering.

Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Pamphlet outlining the evening courses offered by the institute in engineering, chemistry, physics, mathematics, drawing, history, economics and languages. The season 1917-1918 begins October 1 and continues until the courses are completed.

Y. M. C. A. Industrial Department, 124 E. 28th St., New York City. Pamphlet outlining the organized industrial extension work undertaken by the City Association Among Industrial Workers for the benefit of workers in factories and shops throughout the country. The work comprises educational, social, physical, religious and general activities.

Electric Power Club at its annual meeting held in Washington, D. C., June 11-12, elected C. L. Collens, of the Reliance Electric & Engineering Co., president; F. S. Hunting, of the Fort Wayne Works of the General Electric Co., vice-president; and C. H. Roth, of Roth Bros. & Co., secretary-treasurer. A resolution tendering to the government the use of the manufacturing plants of the members and offering the services of the committees was passed.

NEW BOOKS AND PAMPHLETS

Constitution of the United Nations of the Earth. By Edgar D. Brinkerhoff. 22 pages, 6 by 9 inches. Published by the Pamphlet Publishing Co., Fall River, Mass.

This remarkable document is virtually a paraphrase of the Constitution of the United States adapted for the united nations of the earth as visioned by the author.

Oxy-acetylene Welding Practice. By Robert J. Kehl. 105 pages, 5½ by 8¼ inches; 111 illustrations. Published by the American Technical Society, Chicago, Ill. Price, $1.

The work is a practical presentation of the processes of welding, cutting and lead burning, with special attention to welding practice for steel, cast iron, aluminum, copper and brass. It is illustrated with many examples showing how to handle the torch and to prepare work for welding. Examples of automobile repair are included, thus making the work of special interest to owners of garages and others concerned with motor car repairs.

How to Make High-pressure Transformers. By F. E. Austin. 46 pages, 4½ by 7⅛ inches; 21 illustrations. Second edition. Published by Prof. F. E. Austin, Box 441, Hanover, N. H. Price, 65 cents.

The first edition of this book was published in 1914. It is essentially a work on experimental electrical engineering written with regard to the well-known fact that to learn things we must do things. The student is instructed in the theory of high-pressure transformer design by designing and making a transformer. The work is both practical and technical, but not too highly technical to place it beyond the comprehension of men having a good high school education. It contains data that should be of use to engineers who wish to brush up on the principles of electrical engineering.

Machine Drawing. By Ralph W. Hills. 22 pages, 6 by 9 inches; 119 illustrations. Published by the McGraw-Hill Book Co., New York City. Price, $1.

Many books have been published on mechanical drawing; these may be divided into two general classes: first, those that teach drawing for drawing's sake, and, second, those that teach mechanical drawing for the purpose of making the student a practical draftsman or to give him the knowledge that will enable him to make use of mechanical drawing to the best advantage. This work is an excellent example of the second class. The material is the first half of the instruction papers in machine drawing, as developed and used by the Extension Division of the University of Wisconsin. The subject matter deals with instruments and materials, principles of mechanical drawing, screws and screw fastenings, sections, technical sketching, tracing, assembly and detail drawings. Some useful data are included which afford good examples for practice in making up tables. The work is one that we recommend to students whether in school or engaged in home study.

Locomotive Valves and Valve Gears. By Jacob H. Yoder and George B. Wharen. 272 pages, 6 by 9 inches; 274 illustrations. Published by D. Van Nostrand Co., New York City. Price, $3 net.

This work is, we believe, the first special treatise on valves, valve gears and valve setting published which may be recommended to railway mechanics as a practical guide for locomotive valve setting and a treatise on the common and uncommon types of valve gears. It explains the construction and action of the plain slide valve, the piston valve, and the valve gears used to operate them, as applied to locomotives, and is based on notes used in schools for apprentices on the Pennsylvania Railroad. The authors state in the preface that the book had been prepared to meet the general desire among railroad shop men to acquaint themselves with the valves and valve gears applied to modern locomotives, and to master the principles of valve motion as a preparation to valve setting. Valve motion and valve setting have always appeared to many shop men as more or less of a mystery, and it is the aim of the work to enable those interested to acquire first-hand knowledge. The subject matter is given in seven chapters, the contents of which are as follows: Locomotive Valves and Valve Gears; Stephenson Valve Gear; Walschaerts Valve Gear; Baker Locomotive Valve Gear—Southern Locomotive Valve Gear—Joy Valve Gear—Young Locomotive Valve, Valve Gear, and Reverse Gear—Gooch Stationary Link—Allen Valve Gear—Effects of Altering the Valve and Its Events; Locomotive Valve Setting; Steam Engine

Indicator and the Indicator Diagram. The illustrations and directions for valve setting leave little to the imagination, the steps pursued by the practical valve setter in securing the data required for adjustment of the eccentrics and eccentric rods being clearly and specifically described. The book is one that we heartily recommend to all railway students and others interested in locomotive valve motion.

NEW CATALOGUES AND CIRCULARS

Warner Hammer Co., Cromwell, Conn. Price list of Warner hammers and edge tools.

Metalwood Mfg. Co., Detroit, Mich. Bulletin B-44 of the Metalwood inverted type adjustable forming press, No. 121.

Metalwood Mfg Co., Detroit, Mich. Circular B-53 of the Metalwood No. 79 hydro-mechanical banding press for banding shells from 3 to 5 inches.

Standard Alloys Co., Pittsburg, Pa. Pamphlet entitled "Uranium in Steel," presenting comparative tests of uranium and other high-speed steels.

Day & Zimmermann, Inc., Philadelphia, Pa., has issued a bulletin showing typical industrial plants throughout the country constructed by this company.

Link-Belt Co., Chicago, Ill. Book 258 entitled "The Ideal Drive for Textile Machinery," illustrating Link-Belt silent chain installations in textile mills.

Cummings Ship Instrument Works, Boston, Mass. Bulletin descriptive of the Gary-Cummings torsion meter for determining the horsepower transmitted by shafts.

Hisey-Wolf Machine Co., Cincinnati, Ohio. Bulletin 1403, describing "Hisey" portable electric surface grinders, made for use with either direct or alternating current.

Oakley Chemical Co., 26 Thames St., New York City. Information sheet 857 on munitions manufacture, illustrating uses of "Oakite" cleaning and cutting compounds.

Stanley Belting Corporation, 32-40 S. Clinton St., Chicago, Ill. Circular of Stanley woven cotton belting, made in single, double and triple thicknesses and in all widths up to forty-two inches.

Peter A. Frasse & Co., Inc., 417 Canal St., New York City. July stock list giving sizes in stock ready for immediate shipment of Frasse electric tool steel, drill rods, steel shafting and strip steel.

Messer Mfg. Co., 117-121 N. 7th St., Philadelphia, Pa. Catalogue of Messer portable oxy-acetylene apparatus for welding and cutting; regulating valves, welding blow-pipes and acetylene generators.

Nagle Corliss Engine Works, Erie, Pa. Bulletin 27, illustrating and describing Nagle-Corliss Class A-E and B-E steam- and power-driven air compressors with capacities from 3 to 8000 cubic feet of free air per minute.

Sunderland Machinery & Supply Co., 1006-1010 Douglas St., Omaha, Neb. Circular of the Fox arbor press No. 4, having capacity for work 19 inches diameter. The movement of the ram is 17½ inches and the leverage 60 to 1.

Sprague Electric Works of General Electric Co., 527-531 W. 34th St., New York City. Bulletin 48923 of Type W, one- to six-ton electric hoists, giving specifications, dimensions, and weights, and showing a few uses of standard Type W hoists.

Whitman & Barnes Mfg. Co., Akron, Ohio. Catalogue 90, 158 pages, 4¾ by 7¼ inches, containing tables of dimensions and prices for twist drills, reamers, drop-forgings, drop-forged and screw wrenches, spring cotters, and flat spring and riveted keys.

General Electric Co., Schenectady, N. Y. Bulletin 42014 entitled "Headlights and Turbo-generators for Steam Locomotives," describing a turbo-generator set, designed to meet the rigid requirements of locomotive headlight service, and giving diagrams showing the assembly.

Detroit Twist Drill Co., Detroit, Mich. Catalogue 18, 251 pages, 5 by 7½ inches, containing tables of dimensions and prices for twist drills, reamers, counterbores, milling cutters, end-mills, etc. Special sections are given for millimeter sizes of twist drills and reamers.

Buffalo Forge Co., Buffalo, N. Y. Catalogue 256 of Buffalo exhaust fans for the removal of shavings, sawdust, smoke, fumes, etc., containing also engineering data and extracts from state laws regarding the provision of exhaust fans in manufacturing plants as required by law.

Manufacturers Equipment Co., 169-179 N. Jefferson St., Chicago, Ill. Circular illustrating "M. C. E." three-jaw air-operated chucks, which are furnished in two styles—semi-universal and full universal. The chucks are made in five sizes, ranging from 8 to 18 inches diameter, inclusive.

Manufacturers Equipment Co., 169-179 N. Jefferson St., Chicago, Ill. Catalogue of labor-saving devices, including two-jaw air chucks, hinge collet chucks, milling machine chucks, air cylinders, air valves, air vises, bath cock millers, self-opening dieheads, forming tools and collapsible taps.

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. Bulletin 34-Y treating of gas- and gasoline-driven air compressors. The "Simplate" flat disk air inlet and discharge valves with which these compressors are equipped enable high compressor speeds and efficiencies to be obtained.

Oakley Chemical Co., 26 Thames St., New York City. Information Sheet 860 on "Oakite" for cleaning metal parts preparatory to plating. Photomicrographs of oil emulsified by "Oakite" and oil saponified by caustic, are reproduced to show their fundamental difference of action in cleaning metal surfaces.

Hammel Oil Burning Equipment Co., Inc., 409 Pine St., Providence, R. I. Catalogue of the Hammel oil burning apparatus, showing applications to steam and water-tube boilers of horizontal and vertical types; oil pump sets; oil burner governors; and oil firing valves. A list of users of the Hammel burners and furnaces is included.

R. D. Nuttall Co., Pittsburg, Pa. Circular of the Nuttall one-piece expansion joint for pipe lines, which is offered as a leak-proof device requiring no packing and eliminating loops and U-bends from pipe lines. The Nuttall expansion joint is of the accordion type, the corrugations being machined from a solid blank, and not molded or bent to shape.

Bilton Machine Tool Co., Bridgeport, Conn. Bulletins 203 to 221, illustrating and describing automatic gear milling machines, automatic manufacturing milling machines, drill presses built in single-spindle and gang types, automatic cam-feed drill presses, horizontal milling machines, rotary blow riveting machines, automatic worm milling machines, and universal gear hobbing machines.

Chesnutt Mfg. Co., 1301-1303 Independence Ave., Kansas City, Mo. Booklet descriptive of the "Eleveyor," an elevating truck equipped with service swivel casters, which is so designed as to enable it to meet a wide range of work under difficult conditions. The "Eleveyor" elevates the load and then conveys it wherever desired. The book contains reproductions of letters of recommendation from various users of the "Eleveyor."

Stroh Steel-Hardening Process Co., Pittsburg, Pa. Catalogue descriptive of the Stroh Process, which is a method for casting the finest alloy steel together with ordinary soft steel in one solid piece. The resultant casting has a wear-proof alloy steel stratum on the wearing surfaces, while the body is composed of any desired steel and is in no way affected. Illustrations of gears, car wheels, and many large castings made by this process are shown.

Henry Disston & Sons, Inc., Philadelphia, Pa., has inaugurated a monthly house organ for its employes, the first issue of which was published in July. The title of the publication is "Disston Bits," which has a double significance, "bits" being another name for the teeth of inserted-tooth saws, one of the company's products. The announced purpose of the publication is the stimulation and crystallization of good-will and fellowship among the employes, and it is the editorial policy that all illustrations, cartoons, and editorial matter be the work of the employes themselves. The new publication, "Disston Bits" will not in any way conflict with the "Disston Crucible," the trade organ of the company, which has been issued for several years, as the objects and purposes of the two publications are dissimilar.

TRADE NOTES

Cooper Hewitt Electric Co., manufacturer of mercury vapor lamps, has moved its Philadelphia office from 124 S. 8th St. to the Drexel Bldg.

E. R. Senn & Co., manufacturers of "Belt-ol," a scientific oil for treating leather belts, have removed their offices to more spacious quarters at 52 Vanderbilt Ave., New York City.

J. N. Lapointe Machine Co. of Massachusetts, Hudson, Mass., has been organized for machine building, and a one-story cement factory building 80 by 300 feet is being erected. Ralph Lapointe is general manager.

Crosman Stamping Co., Ypsilanti, Mich., is a concern recently incorporated to do general stamping and die work. George J. Crosman is president and treasurer; A. E. Sanford, vice-president; and Lewis H. McLouth, secretary.

Bickett Machine & Mfg. Co., Cincinnati, Ohio, manufacturer of horizontal and vertical milling machines, has added a large office and engineering department to its plant, which occupies the entire second floor of the main building. The lower floor is now required for manufacturing alone.

Phoenix Mfg. Co., Eau Claire, Wis., has moved its Cleveland office from 1430 W. Sixth St. to 913-15 Engineers Bldg., in order to obtain larger quarters, which are required to care for the increase of business. W. L. Harrison is the eastern representative in charge.

Chesapeake Iron Works, P. O. Box 1123, Baltimore, Md., and Westport, Md., are building overhead electric traveling cranes of three-motor direct-current type, having from 5 to 25 tons capacity. The company also builds five-motor double-trolley cranes of any span, having capacity up to 50 tons.

Carlton Machine Tool Co., Cincinnati, Ohio, has moved to 2994 Spring Grove Ave., where a new factory having about three times the floor space of the old shop has been erected. The new shop is equipped with machinery and appliances that will facilitate the production of the line of radial drilling machines made by this company.

Columbia Machine Tool Co., Hamilton, Ohio, which recently acquired the business of the Ceramic Machinery Co., will manufacture machine tools, making a specialty of shaping machines. A plant, 66 by 190 feet, of brick and steel, is being erected, and will be in operation at an early date. E. S. Rich, formerly with the Hamilton Machine Tool Co., is secretary.

Joseph F. Wangler Boiler & Sheet Iron Works Co., St. Louis, Mo., has moved its general offices from 1517 N. 9th St., to 911-912 Federal Reserve Bank Bldg., 415 Pine St. The company was established in St. Louis more than fifty years ago to manufacture steam boilers, tanks, and all kinds of boiler plate and sheet iron work. Joseph A. Wangler, who has been with the company for more than twenty-five years, is president.

La Salle Machine & Tool Co., La Salle, Ill., has taken out a life insurance policy for each of its employes in the group plan, the amounts of which are equal to the yearly wages, limited to a minimum of $300 and a maximum of $2000. It is straight life insurance, and the entire cost is paid by the company. Employes participate in the benefits of the plan when they have been in the employ of the company for six months.

Scott-Spencer Automatic Tool Co., Madison Road and N. & W. R. R., Cincinnati, Ohio, was lately organized to manufacture tools and equipment for automatic screw machines, specializing on this work exclusively. Thomas J. Scott, president, and L. B. Spencer, secretary and treasurer, are practical screw machine operators and are thus equipped by experience to design, make, and test equipment for automatic screw machines to suit various needs.

Davis-Bournonville Co., Jersey City, N. J., opened a welding institute August 1, for the purpose of giving competent instruction in the oxy-acetylene art. The institute will be in charge of Henry Cave, technical director. The class will be held at the Jersey City factory of the company, and a charge will be made to cover the cost of oxygen, acetylene, metals and other supplies consumed. Employers using the oxy-acetylene apparatus can arrange to give a limited number of employes this course in welding and cutting.

Electrical Industrial Co., Drammen, Norway, has consolidated with two other concerns in Norway—the Holm-Hansen Electrical Co., Sandefjord, and the Fridtjov Andersens Telepointage, Christiana. The association will continue to manufacture all articles in the electrical line, and will hereafter conduct its business under the name of the National Industrial Co., with main office at Sandefjord, and branch offices at Drammen and Christiania. The association is represented in New York City by Hans Karlsrud, manager of the Drammen branch, 309 Broadway.

J. T. Slocomb Co., Providence, R. I., manufacturer of machinists' tools, is building an addition of two stories to the main building 60 by 100 feet, making the building four stories in height. Another addition in the rear of the main building was erected last winter and has been in use for the past three months. The main office, stock-room and shipping rooms, will be located on the fourth floor and automatic elevator service will be provided. The additions made in the past year and a half provide facilities that more than double the production.

General Electric Co., Schenectady, N. Y., has erected a building at the Schenectady plant affording approximately 20,000 square feet floor space, which will be devoted exclusively to the manufacture of industrial heating devices. Continuous operation and the most productive grouping of machines have been obtained by the use of individual motor drive, direct-current motors being employed which range up to twenty-five horsepower. Many of the machines were developed especially to meet the unique requirements for machining, assembling and testing heating devices.

Acme Die-Casting Corporation, 5 Bush Terminal Bldg., Brooklyn, N. Y., has issued a statement to the effect that the suit recently brought against it by the Doehler Die-Casting Co. for infringement of patent No. 1,156,093 is limited strictly to the use of certain alloys of aluminum die-cast by a certain process. It does not cover aluminum zinc, aluminum manganese, or aluminum alloys containing 8 per cent or less of copper or more than 20 per cent of copper. The suit does not in any way affect the product and present business of the corporation, as it covers a process not now in use.

Cincinnati Grinder Co., Cincinnati, Ohio, manufacturer of plain, cylindrical, universal, and internal grinding machines, is building a modern plant on Colerain Ave., in the heart of the West End manufacturing district. The new plant will afford 35,000 square feet of floor space and will be modern in its equipment and appointments. The building is of brick and steel construction with saw-tooth roof, and will have a two-story front. The offices will be on the second floor, which is 40 by 96 feet. The rapid growth of the concern has made larger and better facilities for manufacturing imperative. Provision has been made for further extending the plant as the need for more room is felt.

Willard Machine & Tool Co., Cincinnati, Ohio, manufacturer of the Willard 13-inch tool-room lathe, has been sold to G. Mattman and Thomas L. Bratten. The firm name has been changed to Willard Machine Tool Co. Mr. Mattman is well known in the machine tool trade, having been for several years the European representative of the Cincinnati Milling Machine Co. He came to the United States from France in 1904 and worked in the shop for four years, learning the American way of building machinery. He has had wide experience both in the production and selling end. Mr. Bratten, although never identified with the machine tool industry, is also well known to the trade in and about Cincinnati, having held an executive position with the Employers' Liability Corporation, Ltd. For the present, the company will continue to manufacture the Willard 13-inch lathe, which will be somewhat improved, but the intention is to add other machine tools to the line in the near future.

Are Good Tools

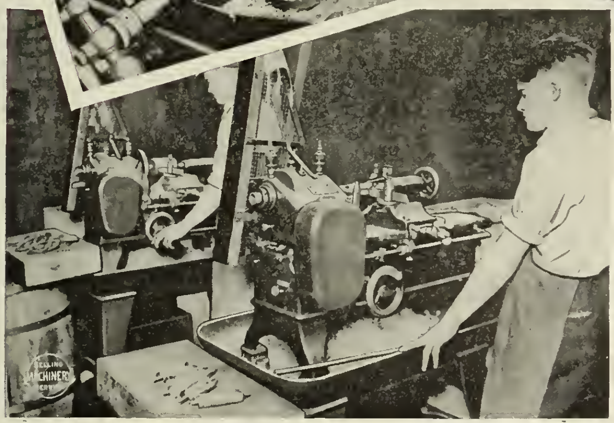
For manufacturing, they are particularly good tools. That's the opinion of the Goulds Manufacturing Company of Seneca Falls, N. Y.—and they ought to know.

The picture shows a set-up of Celfor Drills nosing their way through the flange of a 5¼″ x 16″ Triplex Plunger Pump. Eight drills find their way through a solid two-inch flange in one minute and forty-five seconds—and only one grinding each day.

That is drill economy and a production record of an unusual sort—yet common enough for Celfor Drills. The Goulds people use them on every job where holes are ½″ or over. There are sound reasons why. Let us tell you of them.

CLARK EQUIPMENT COMPANY

Successor to
CELFOR TOOL COMPANY
BUCHANAN, MICHIGAN, U.S.A.



Why Tie up an Engine Lathe on Plain Turning?

The P-C Manufacturing Lathe

Just as fast, just as efficient and immeasurably more economical is the Porter-Cable Manufacturing Lathe. Here are two P-C Lathes at the Stromberg-Carlson Telephone Manufacturing Company's plant, Rochester, N. Y. One is turning armatures; (92 punched steel blanks) the cut is intermittent; the diameter must be 1.480″, held with a 0.001″ limit. The operator starts the cut across the armature at a speed of 140 r. p. m. and a feed of 0.040″ per revolution, and goes right on filing armatures that have already been turned. All he does to the machine is take off finished work and start new work.

The other job is turning rough cast iron generator gears, 3.526″ diameter, mounted 12 on an arbor. About 1/16″ stock is taken off; limit is within 0.001″ of standard size. When the blanks are finished the operator takes them, arbor and all, over to the two gear cutting machines that cut the teeth. He keeps them going in addition to his P-C Lathe and is by no means overworked.

Porter-Cable Manufacturing Lathes are practical, hard-working machines. They take big cuts, turn big chips, insure big output. They save money on work not over 9″ diameter by 18″ long, and are ideal for duplicating parts in quantity.

We'll be glad to go over P-C advantages in detail and tell specifically what our machines are doing for others. Write us.

The Porter-Cable Machine Co.
SYRACUSE N. Y., U. S. A.

Foreign Representative: Benjamin Whittaker, 2 Norfolk Street, Strand, London


The Lesson of the Airplane
Accuracy in
Manufacture
The airplane has reached a point in its development where it becomes, in the opinions of men who should know, the greatest single factor in the greatest war ever fought. It is confidently expected to prove the deciding factor. It is already known as the "Eyes of the Army" without which that army is almost helpless.
GREENFIELD TAP &
BRANCHES:
New York, 28 Warren Street
Chicago, 13 So. Clinton Street
London, 149 Queen Victoria Street
GREENFIELD,

G T D

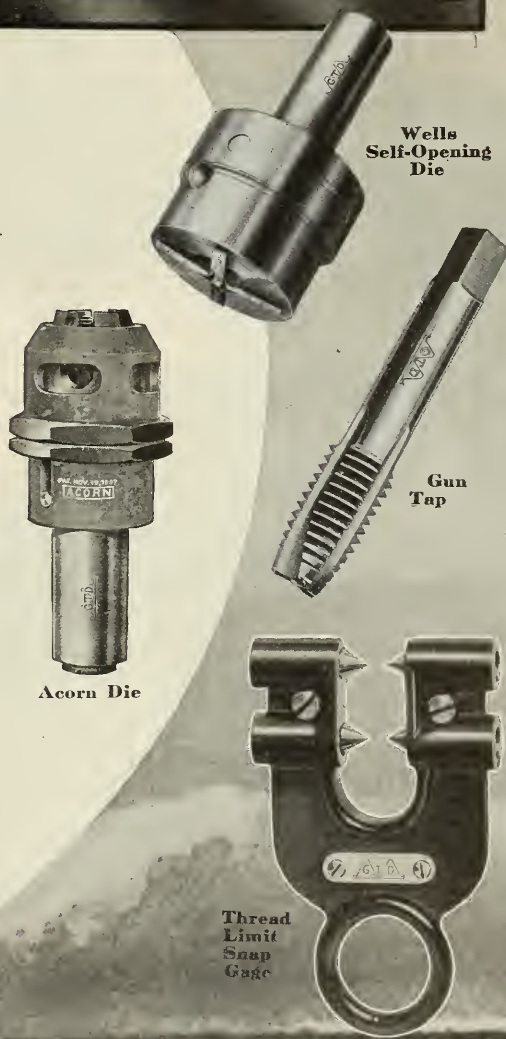
REG. U. S. PAT. OFF.

It is easy to moralize—to draw a lesson from this event or that—after it is all over. One lesson we learned quickly from the world war, however—the absolute necessity for accuracy in manufacture. It got to the manufacturers in this country fast. It was an expensive lesson to some—a lesson that once learned will never be forgotten.

First machinery, then shells, now ordnance and airplanes—where would we be without means and methods for duplicate manufacture?

The making of precision tools and measuring instruments is a fine art. G. T. D. Screw Cutting Tools and G. T. D. Standard Gages for both screw thread and cylindrical work have been developed to a high point of efficiency. They have helped many munitions and ordnance makers over the rough spots. They can help you. They can save money for you. They are invaluable if you make duplicate mechanical parts.

Let us send more information on this subject.



DIE CORPORATION

MASS., U. S. A.

DIVISIONS: Wells Bros. Company. Wiley & Russell Mfg. Co. A. J. Smart Mfg. Co. F. E. Wells & Son Co. Nutter & Barnes Co. Canadian Factory, Wells Bros. of Canada, Ltd., Galt, Ont.

Courtesy of Pesacola Board of Trade

GODDARD
Milling Cutters and Hobs

Are Made Right

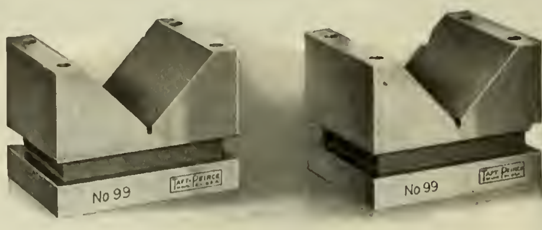
They Give Satisfaction

Quick Deliveries

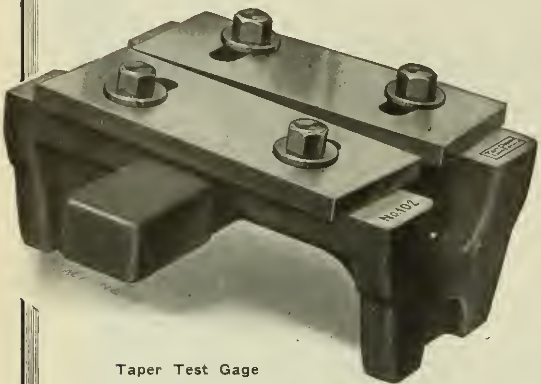
Goddard Tool Co.

Chicago, Ill.
Detroit, Mich.
U. S. A.

TAFT-PEIRCE
WOONSOCKET RHODE ISLAND, U.S.A.



Hardened Steel V-Blocks



Taper Test Gage

TAFT-PEIRCE

Tool Room Specialties

In these days of shop activity, any factor or equipment which might help you keep output strictly in line with promises of delivery, should receive careful consideration. No shop aids have proved more efficient in this respect than Taft-Peirce Tool Room Specialties. If you are still making your own, the substitution of these tools will save buying extra materials, save work in your tool room, do away with congestion in tool room and the retarding of production sure to result. These specialties, manufactured in quantities and standardized, are unvarying in their accuracy.

A careful consideration of their advantages should convince you that real shop efficiency demands their adoption. Write for Catalogue B for further details.

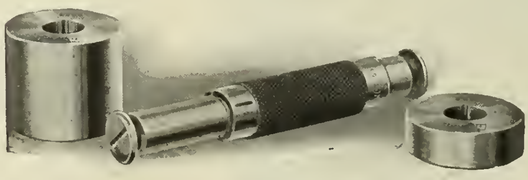
THESE and other T-P small tools are standardized and are manufactured in quantities. You can secure duplicates at any time.

The Taft-Peirce Mfg. Co.

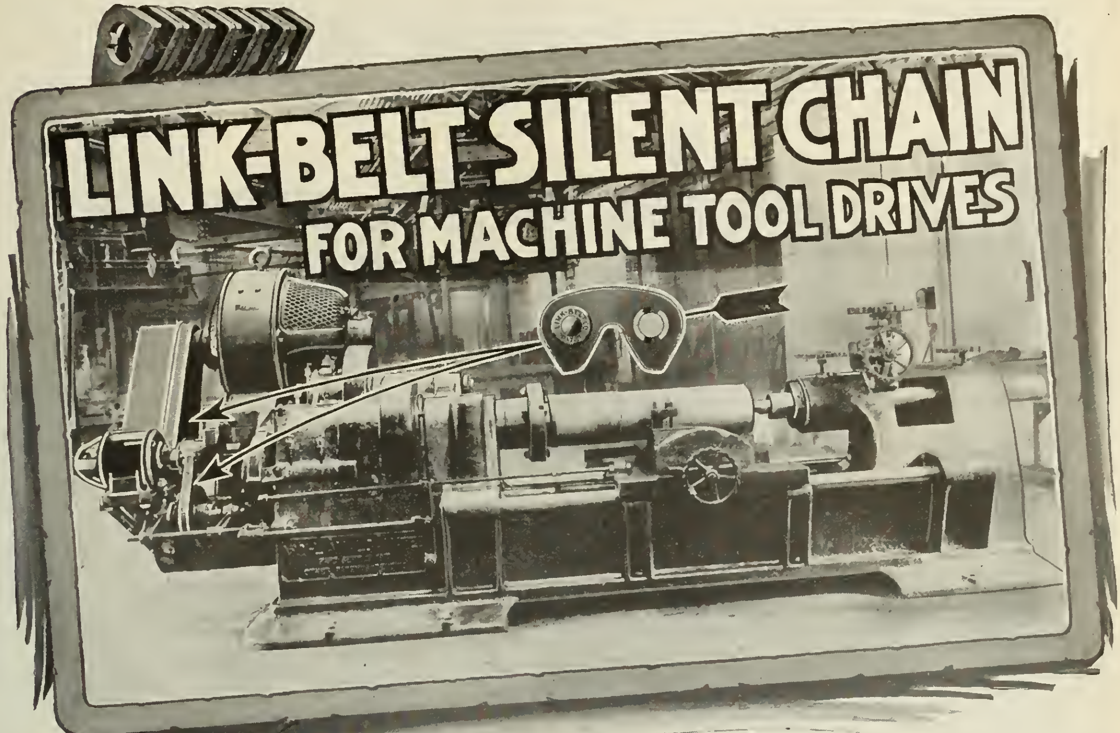
WOONSOCKET RHODE ISLAND

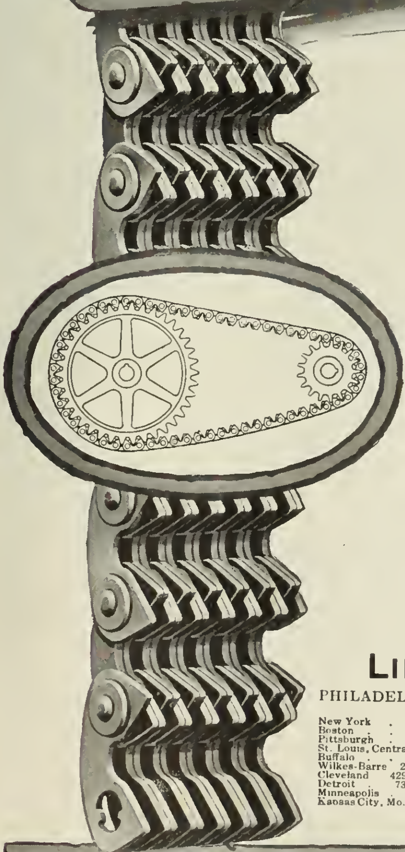
New York, Woolworth Building
Detroit, Majestic Building

Measuring Iron No. 200



Double-end Internal Limit Gage

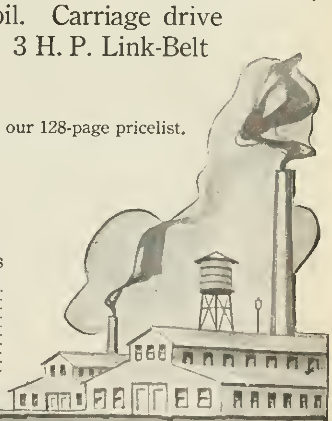




POSITIVE drives insure intensive production from machine tools. Modern machines, motors, high speed steel and Link-Belt Silent Chain make continuous, rapid production a reality—assure the fulfillment of munition contracts, both as to output and character of product.

The machine illustrated was made by the Amalgamated Machinery Corporation for the Midvale Steel Company to be used for turning 296 mm. French shells. The forgings are approximately 12 inches in diameter and 44 inches long, the turning time being 19 minutes each. The 50 H. P. Link-Belt Silent Chain Drive operating the spindle is fully encased and runs in a bath of oil. Carriage drive in both directions is through a 3 H. P. Link-Belt Silent Chain Drive.

Write for Link-Belt Data Book No. 125, our 128-page pricelist.



LINK-BELT COMPANY

PHILADELPHIA CHICAGO INDIANAPOLIS

New York . . 299 Broadway
Boston . . . 49 Federal St.
Pittsburgh . . 1501 Park Bldg.
St. Louis, Central Nat'l Bank Bldg.
Buffalo . . 698 Ellicott Square
Wilkes-Barre 2d Nat'l Bank Bldg.
Cleveland 429 Rockefeller Bldg.
Detroit . 732 Dime Bank Bldg.
Minneapolis . 418 S. Third St.
Kansas City, Mo., 407 Finance Bldg.
Seattle . . . . 576 First Avenue, S.
Portland, Ore. . . 1st and Stark Sts.
San Francisco . . . . 461 Market St.
Los Angeles 161 and 163 N. Los Angeles St.
Denver Lindrooth, Shubart & Co., Boston Bldg.
Louisville, Ky. Frederick Wehle, Starks Bldg.
Knoxville, Tenn. . . D. T. Blakey, Empire Bldg.
Birmingham, McCrossin & Darrah, Am. Tr. Bldg.
New Orleans C. O. Hinz, Hibernia Bank Bldg.
Charlotte, N. C., J. S. Cothran, Com'l Bank Bldg.
Toronto, Can. . Canadian Link-Belt Co., Ltd.

52

Do You Know About

Nichrome

Nichrome is a nickel-iron-Chromium alloy that may be cast up to 1200 pounds. It has the properties of being hard and strong while hot, and resistance to the action of many acids. It is easily machined.

There are a thousand and one uses for Nichrome in connection with apparatus for heat-treating operations; case-hardening boxes, dipping baskets and other apparatus that require strength while hot. Particularly is Nichrome valuable for apparatus that must be alternately heated and cooled. It can be heated and cooled repeatedly without appreciable scaling.

Get this Sample of Nichrome

We would like to demonstrate the qualities of Nichrome to you—and have prepared a little sample which we will send for examination. It may suggest some uses in your own plant, and at any rate, we would be glad to give you all the information you desire.

Write Us

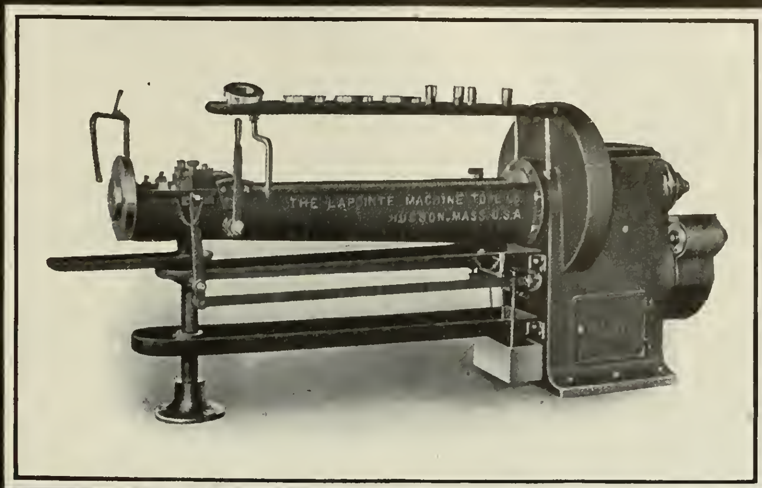
Manufactured under Henderson Patent Number 1,190,652

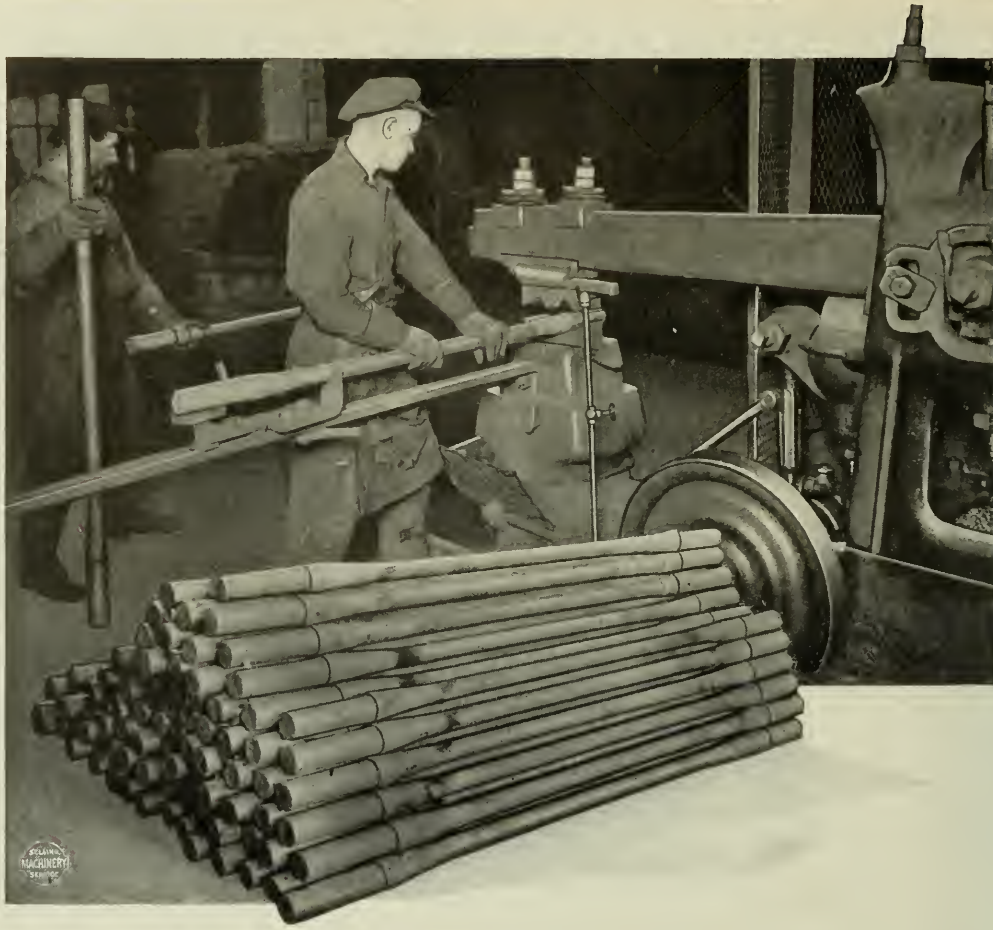
DRIVER-HARRIS COMPANY

CHICAGO
28 So. JEFFERSON ST.

HARRISON, N. J.

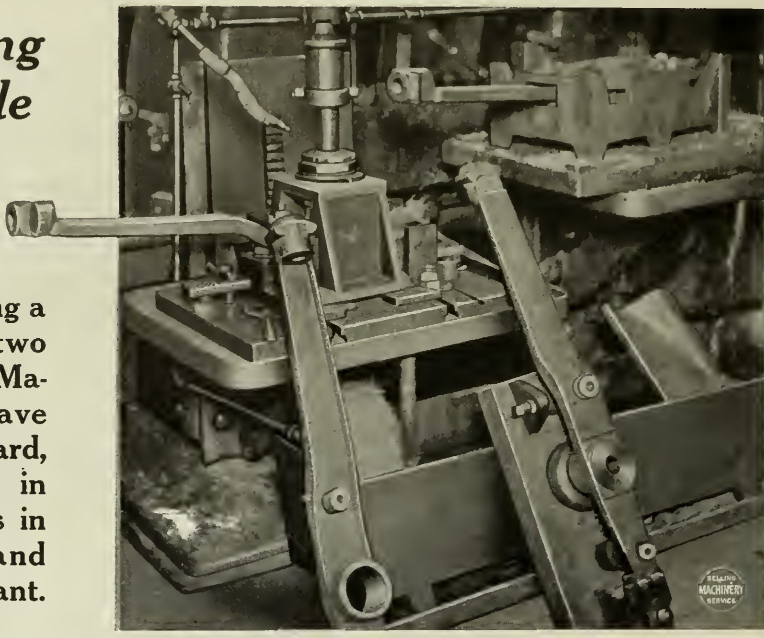
MANCHESTER
ENGLAND


THE LAPOINTE MACHINE TOOL CO.
HUDSON, MASS. U.S.A.

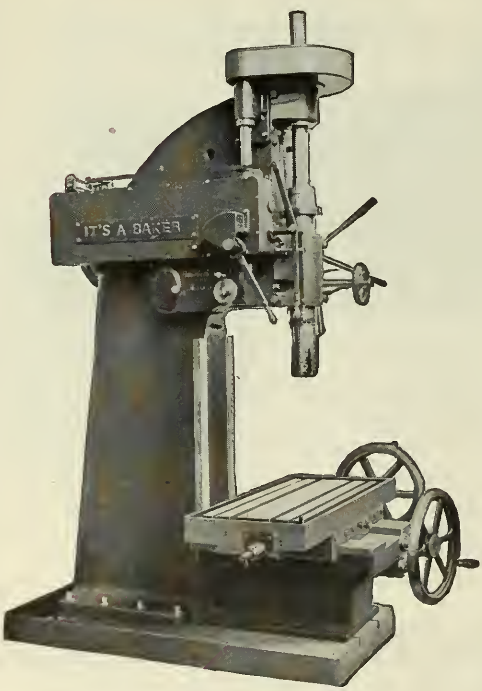


BAKER Drilling Machines

For Making Automobile Parts



We are showing a "close up" of two Baker Drilling Machines that have been doing hard, heavy drilling in steel for years in a New England automobile plant.



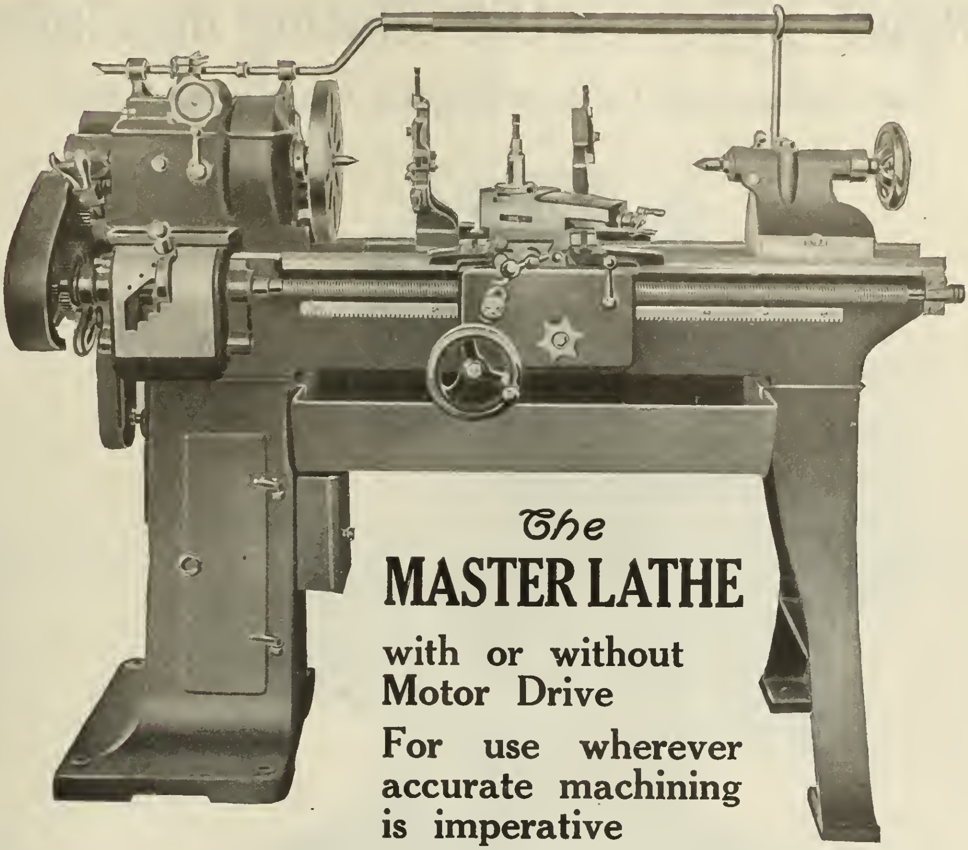
The work is cast steel distance rods. They are first rough drilled, then finish drilled, hollow milled on one side, turned, and hollow milled on the other. Nothing startling in these operations, to be sure; but they throw an interesting light on what machines used for automobile building have to stand up to as a steady job. There is a row of Baker Drilling Machines at this plant—practical, productive, dependable machines that lower costs to the minimum on the work they do.

Baker power, speed, accuracy and convenience make a profitable manufacturing combination no matter what your line. The Baker limit is the limit of what your tools can stand.

Let us work out your boring problem.

BAKER BROTHERS

TOLEDO, OHIO, U.S.A.



The

MASTER LATHE

with or without Motor Drive

For use wherever accurate machining is imperative

THE Master Lathe is a high-grade, geared head tool in a 12½″ swing; of solid construction, rigid throughout, and of an efficient design.

First class in every respect. Is built from the finest materials and under conditions ideal for producing a fine machine. Absolutely guaranteed as to accuracy of performance and perfection in workmanship and material.

The Master Lathe possesses many time-saving features—in addition to the recognized advantage of the geared head which transmits power to the cutting tool without belt slippage, etc.

Length of bed 4′ 8½″; distance between centers, 2′ 6″; speeds of head spindle (6) 28, 46, 85, 135, 225, 418.

Just now, shipment of a few Master Lathes with pulley drive can be made within ten days from the receipt of order. With motor drive attachment, within thirty days from receipt of order.

Send for particulars today

THE MASTER MACHINE TOOL COMPANY

110-112 WEST 40th STREET NEW YORK CITY

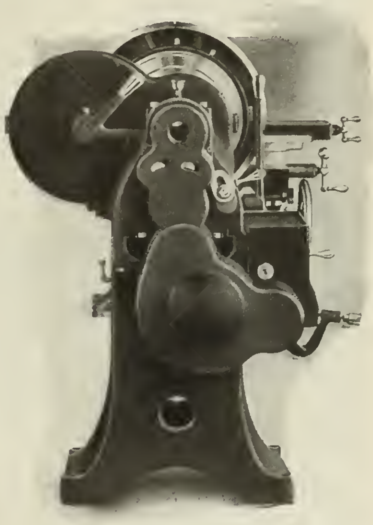
WALCOTTS

Lathes of Superior Endurance

Walcott Lathes are particularly productive in plants where machine tools are driven continually to the last notch of capacity, and on special demands even to carry an overload. To enable them to stand the pace, they are designed along lines heavier than generally followed.

Bearings and wearing surfaces are as large as practicable, much larger than usually found on lathes of corresponding sizes. Parts subject to greatest strain are reinforced, new features have been introduced and standards of design perfected. Every Walcott represents the results of 35 years of lathe building and is a wonder for high production in continuous heavy service.

Walcotts are made in sizes from 14" to 28". Send for circulars.

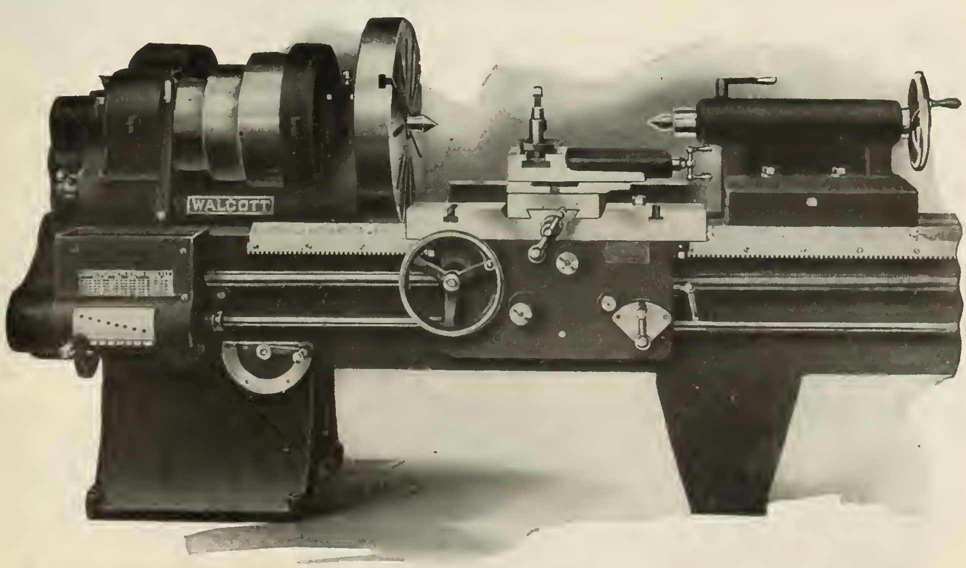


This 28" machine is typical of the line. Bed is extremely heavy; there is a large front way on the bed, a double plate apron with drop forged gears, rigid compound rest, heavy back gear arm reinforced by single-piece gear guard and headstock. Gears are enclosed, feed gears run in oil. Other features as distinctive.

Walcott Lathe Company

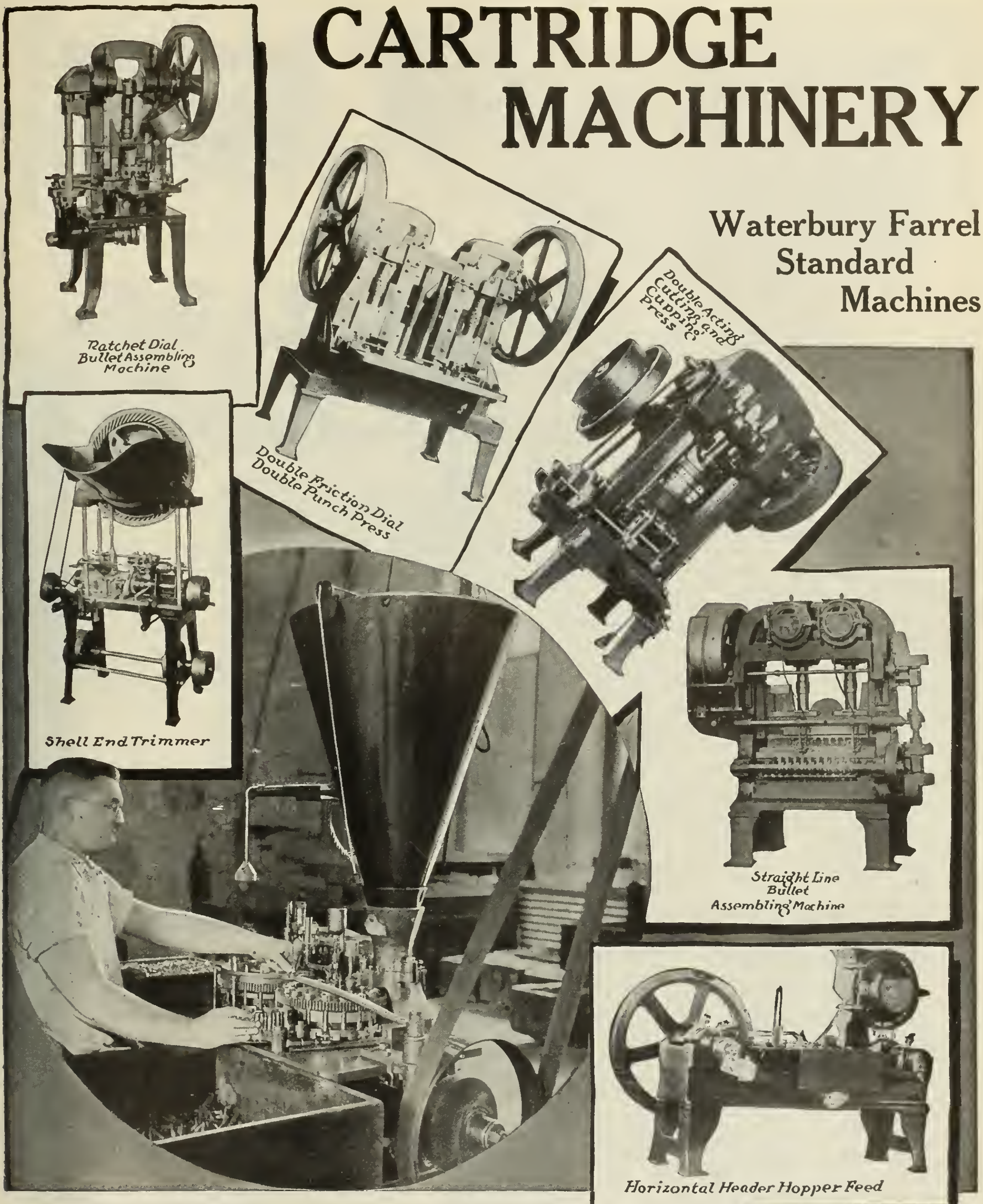
Established 1881

414-420 Jackson St. Jackson, Michigan



CARTRIDGE MACHINERY

Waterbury Farrel
Standard
Machines



Standard Loading Machine in Government Arsenal

The Waterbury Farrel Foundry & Machine Co., of Waterbury, Conn., U. S. A., has appointed me to be the sole manufacturer for export of their entire line of Cartridge and Shot Shell-Making Machinery. Proposals and Estimates covering complete plants or separate units required for export will be furnished on request.

FREDERICK S. BLACKALL

WOOLWORTH TOWER NEW YORK, U. S. A.

RELIANCE MOTOR

"Just the Ticket" for a Bolt-Threading Machine

This is the word of the operator who runs this double-spindle Acme Bolt Threading Machine in one of the best equipped street-railway shops in the Middle West.

To keep his daily output at top notch it is necessary to have a dependable drive giving plenty of power at the right speed for all sizes of bolts. This 5 H.P. Type AS Reliance Adjustable Speed Motor gives just the results he wants.

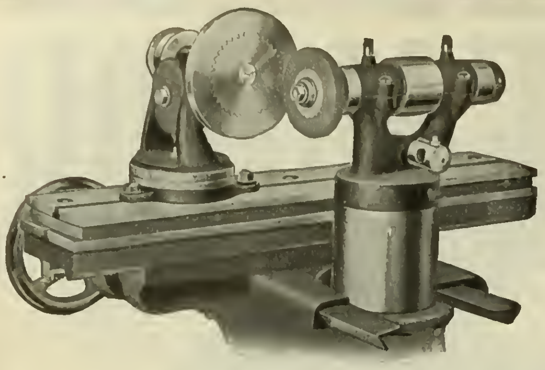
Type AS Motors run at any speed and develop full power over ranges as great as 1 to 10. They make machine tools turn out more work.

Get Our Folder 10M for Details

Reliance Electric & Engineering Co.

1056 IVANHOE ROAD
CLEVELAND, OHIO

Branches: New York, Philadelphia, Pittsburgh, Toledo, Chicago



Greenfield

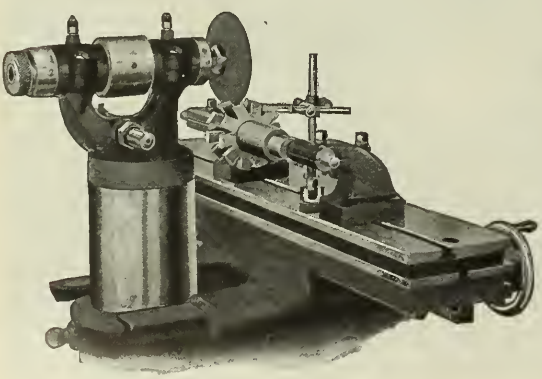
Trade Mark Reg. U. S. Pat. Office

Universal Grinder

We know of no tool room or general grinding job—surface, cylindrical, internal—within the capacity of a machine of this size that the Greenfield Grinder cannot handle easily and efficiently. We have made the "Greenfield" a rigid, accurate, smooth running machine, and supply as regular equipment attachments which make it a truly universal grinder. Changes from one job to another are quickly made; controlling wheels are directly in front of operator no matter what the set-up. The Greenfield Grinder is conceded by experienced operators to be one of the most practical and economical all-around grinders on the market.

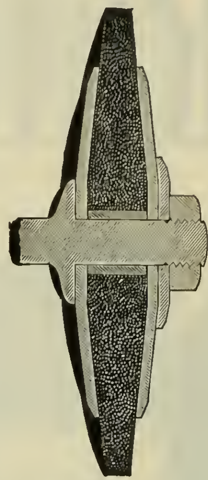
Write for the catalog.

THE GREENFIELD MACHINE COMPANY
GREENFIELD, MASS., U. S. A.



Safety First and Always

There can be no grinding wheel accidents in the shop equipped with Safety Grinding Wheels and Safety Collars. These wheels are tested at the factory at speeds 50 per cent higher than actual practice demands, and they're held in the collars with such a bulldog grip that pieces couldn't possibly fly, even though the unusual happened, and a wheel did break. They are perfectly safe at maximum speed. You owe it to your workmen to make your shop safe; you owe it to yourself as a sound business investment.



Full Line of Wheels, Grinding Machines and Grinding Room Equipment in Catalog.

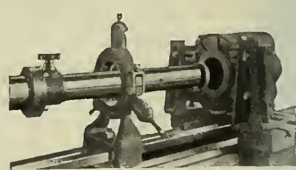
THE SAFETY EMERY WHEEL COMPANY
SPRINGFIELD, OHIO, U. S. A.

FOREIGN REPRESENTATIVES: Farmer & Co., London. Adler & Eisenschitz, Milan. Allied Machinery Co. of America, Paris.

Perfection Cylinder Grinder

Strong, Durable, Convenient

Designed for automobile cylinder grinding on hollow spindle lathes swinging 14" or over. Has centering device, micrometer adjustment, is easily set up and detached. Two models.

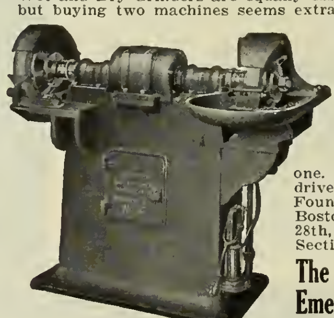


Write for Details

WOOD & SAFFORD MACHINE WORKS
GREAT FALLS MONTANA

REAL GRINDING ECONOMY

Wet and Dry Grinders are equally essential in most shops—but buying two machines seems extravagance.



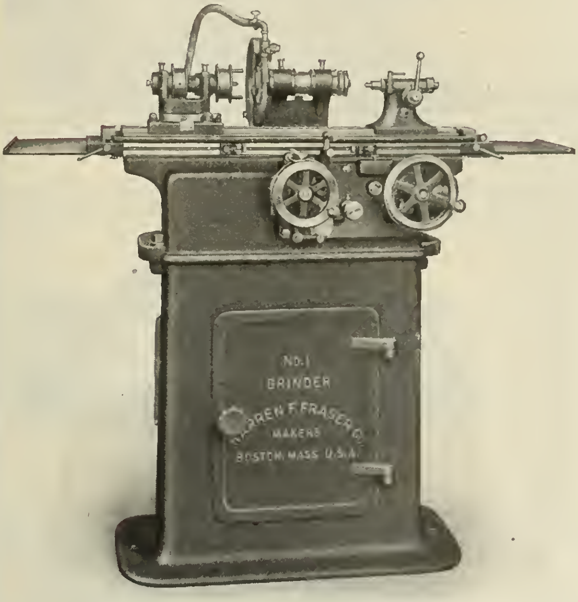
Here is the solution—

The Bridgeport Combination Wet and Dry Grinder—a complete Wet Tool Grinder at one end—a Dry Grinder at the other—does the work of two machines—costs little more than one. 3 sizes—belt or motor driven. See our exhibit at Foundrymen's Convention, Boston, September 25th to 28th, 1917, Booth No. 273, Section C

The Bridgeport Safety Emery Wheel Co., Inc.
Bridgeport, Conn., U. S. A.

FRASER UNIVERSAL GRINDER

The Logical Machine for Varied Grinding



No other similar machine offers greater speed and all-round convenience in changing from one set-up to another than the "Fraser." It's only a matter of a few minutes, after finishing an internal grinding operation, for instance, to make ready for either cylindrical or surface work.

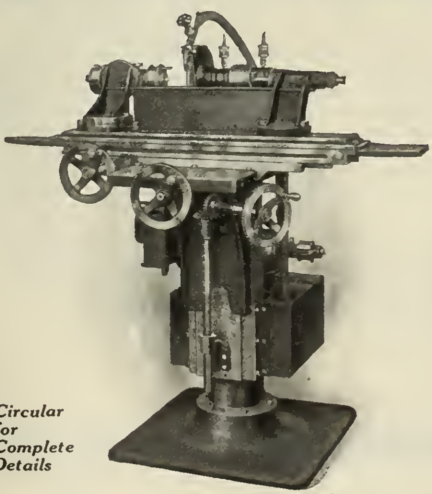
For internal grinding, capacity is 8″ outside diameter, for cylindrical grinding 8″ diameter by 20″ length, for surface grinding work up to 6″ in width and 20″ long.

Some of the more striking features of design are: Variable table movement as low as 5/8″, large bearings, double end wheel taking spindle for wheels up to 1/2″ face and 8″ diameter, box type base, three point suspension for upper part of machine, unit construction of apron permitting feed mechanism to be removed as a unit, two wheel speeds, four table speeds, five work rotation speeds. Let us tell you all about the possibilities of the "Fraser" for fine grinding on tools, gauges, jigs and fixtures as well as for production work within its range.

Detailed description on request.

THE WARREN F. FRASER CO.
Freeport Street BOSTON, MASS.

The Connecticut Universal Grinder



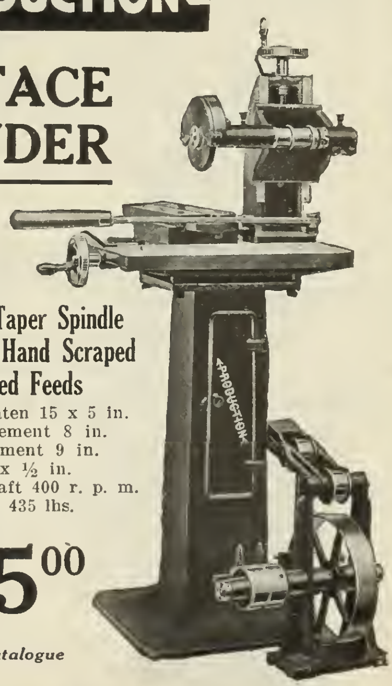
Circular for Complete Details

EXTERNAL, internal, surface and cutter grinding can be handled on this machine with remarkable ease and adaptability. The unique column construction allows the table to swing in a complete circle, and with the head fastened to the column, any position is available without twisting the belt. The Universal Headstock is fitted with draw-back attachment to receive special collets for grinding small cylinders—a valuable feature for tool room work.

Middlesex Machine Works
MIDDLETOWN CONN., U. S. A.

PRODUCTION

SURFACE GRINDER



Adjustable Taper Spindle
All Surfaces Hand Scraped
Graduated Feeds

Surface of Platen 15 x 5 in.
Traverse Movement 8 in.
Vertical Movement 9 in.
Stone 6 x 1/2 x 1/2 in.
Speed of c/shaft 400 r. p. m.
Weight 435 lbs.

$125.00

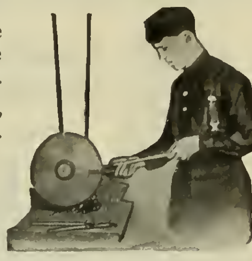
Write for Catalogue

NEW JERSEY MACHINERY EXCHANGE
NEWARK NEW JERSEY

This Substitute is Better than the Original

DIAMO-CARBO Emery Wheel Dressers wear longer and give more uniform service than diamond point dressers. We'll send you one on trial, to prove it, if you are willing to be convinced. Diamo-Carbo is much less expensive than diamond points—so much so that each wheel can have its own dresser.

The quality is uniform, which can not be said of diamond point dressers, since the shortage of diamonds puts many inferior stones on the market. Send trial order today.



Number 3, 10 inches long..........$3.50
Number 5, 12 inches long..........$4.00

The
DESMOND-STEPHAN MFG. CO.
URBANA, OHIO, U. S. A.

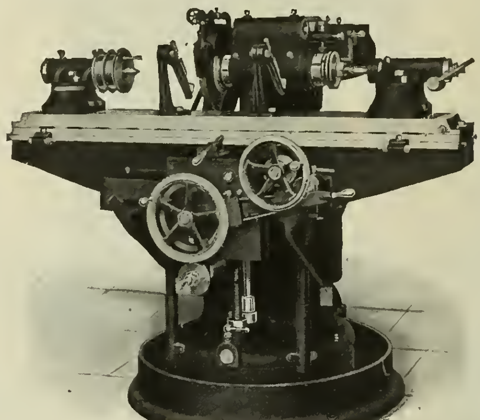
Alfred Herbert, Ltd., Agents for Great Britain. The Canadian Desmond-Stephan Mfg. Co., Ltd., Hamilton, Ont., Distributors for Canada.

We Will Gladly Send a Copy of Catalogue Listing Our Entire Line.

The Wheel that Completes a Good Grinder

The wheel's the thing. You can "get by" with most any machine; but it's the wheel, after all, that does the work. Star Grinding Wheels complete a good machine. They are accurate, uniform in quality, long wearing —and they're needed in every shop.

STAR CORUNDUM WHEEL CO.
DETROIT MICHIGAN



A Whole Grinding Department

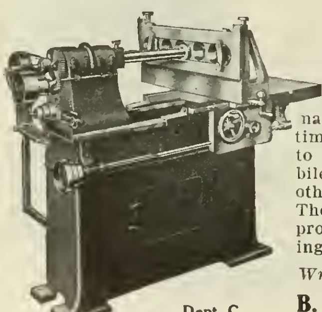
The Thompson Universal Grinder combines in a single machine means for handling every possible grinding operation within ordinary range. The head is fixed, work table being adjustable to any position to the wheel, rendering possible plain grinding, surface, edge, die, cutter and internal grinding. It's truly a universal machine with a full measure of strength, accuracy and convenience incorporated to insure high working efficiency.

Write for full particulars.

The Thompson Grinder Company
SPRINGFIELD OHIO, U. S. A.

Schmidt's Internal Grinders

Equip NOW



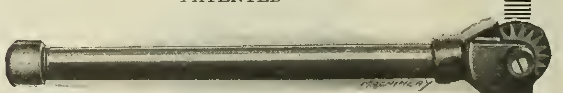
Dept. C

Here is a grinder that sells at a popular price and does the work of machines costing three times as much. Designed to grind worn automobile cylinders and do other internal grinding. There is a handsome profit in cylinder grinding.

Write for Particulars.

B. L. SCHMIDT CO.
Davenport, Iowa, U.S.A.

PATENTED



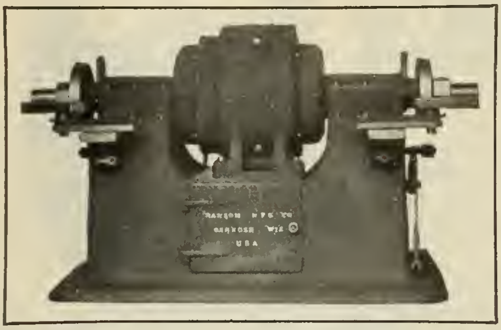
A Tryout—A Big Reorder

Invariably a trial (sometimes a skeptical one) of this improved dresser means a big reorder. The largest shops in the country recognize the superiority of the "Brandenburg" Emery Wheel Dresser, and are adopting it because the "Brandenburg" measures up to their rigid requirements.

THE "BRANDENBURG"

is a cost cutting, efficient dresser, in which the cutters are automatically lubricated by flake graphite fed from the hollow handle. Greatly saves the cutters and eliminates the cost of lubrication. Standard cutters are used. Let us help you cut costs.

THE HETHERINGTON-McCABE CO.
PIQUA, OHIO, U. S. A.



Above cut shows our No. 48 Motor Driven Grinding Machine. It is built to do the heaviest kind of grinding and especially in steel foundries.

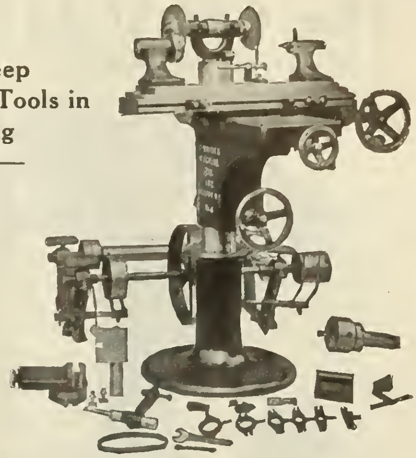
Size of wheels 24 x 4" Weight about 4000 lbs.
Size of journals 15 x 3¼" H. P. of motor 10

As shown above, it is equipped with Ransom Patent Speed Controller and without guards. Different types of guards can be furnished.

If interested, send for our Catalogue.

Ransom Manufacturing Co.
OSHKOSH, WISCONSIN, U. S. A.

To Keep Your Tools in Cutting Order—



SIMMONS UNIVERSAL TOOL AND CUTTER GRINDER

You know the advantages of sharp tools; but do you know the merits of the Simmons Tool and Cutter Grinder? It not merely keeps tools sharp, but puts an *accurate* edge on them. In addition to grinding cutters, reamers, counterbores, twist drills, etc., it is adapted for cylindrical and internal grinding. The efficiency of the Simmons "Universal" includes prompt delivery service.

Write for description.

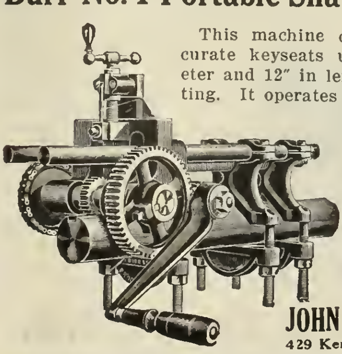
SIMMONS MACHINE COMPANY, Inc.
987 Broadway, ALBANY, N. Y. — 1001 Singer Bldg., NEW YORK CITY

Tell Us What You Grind

and we will tell you the wheel to use. Unless you get *the* wheel made for the particular grinding you do, results cannot be the best — therefore Sterling Service goes with Sterling Wheels. Catalog.

The Sterling Grinding Wheel Co.
TIFFIN, OHIO
Selling Agency: New York, 75 Barclay St.
Chicago Store: 30 N. Clinton St.

Burr No. 1 Portable Shaft Keyseater

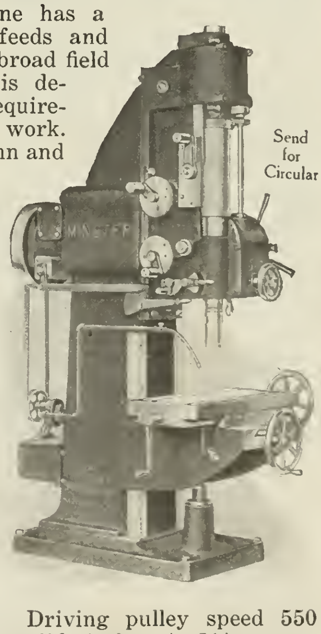


This machine cuts absolutely accurate keyseats up to 5" in diameter and 12" in length without resetting. It operates without chatter or jar, is very fast, easy to set up and remove, and can be used in practically any position. Has automatic feed and adjustable depth gauge.

JOHN T. BURR & SON
429 Kent Ave., Brooklyn, N. Y.

THE MINSTER HI-DUTY DRILL

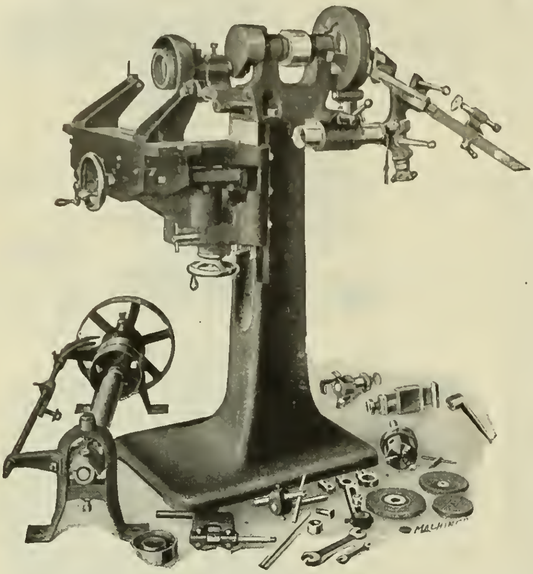
This new machine has a wide range of feeds and speeds, covers a broad field of drilling and is designed to meet requirements of modern work. The massive column and heavy table give ample rigidity for heavy duty; a special spindle construction provides for small high speed drilling as well as heavy work; flood lubrication of all gears, ball thrust bearings on pulley and spindle and correct balance insure smooth running. Driving pulley speed 550 R. P. M. Drills in solid steel up to 2½".

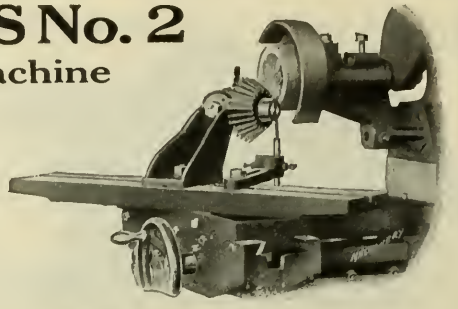


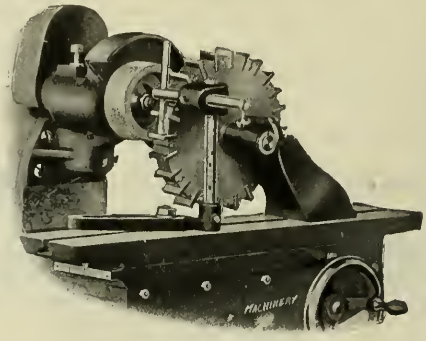
Send for Circular

THE MINSTER MACHINE CO.
MINSTER OHIO, U. S. A.

The GRAND RAPIDS No. 2
A Really Universal Grinding Machine







Not a toy—Not a makeshift—Not "The best possible for so low a price"—But THE BEST MACHINE FOR YOUR TOOL ROOM IRRESPECTIVE OF PRICE—And yet the price is low.

Fully illustrated circular free on request—Don't fail to ask for yours.

GRAND RAPIDS GRINDING MACHINE CO. 29 Ottawa Avenue, N. W. GRAND RAPIDS, MICHIGAN, U. S. A.

A Modern Grinder at a Moderate Price

Wells Grinder No. 184

F. E. WELLS & SON COMPANY GREENFIELD, MASS. U.S.A.

You can grind almost anything with the Wells No. 184 Cutter and Reamer Grinder, and the Swivel Table permits grinding at any angle.

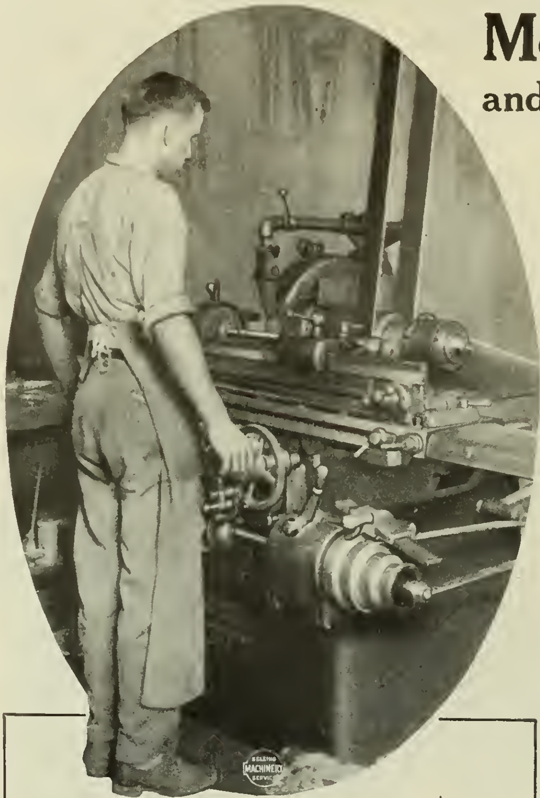
Cup wheels can be used as easily as any other as the swivel table is fitted with vertical adjustment—an advantage which no other low-priced tool grinder possesses. The table revolves entirely around the head, the slides have both horizontal and transverse movement, and the top slide swivels for taper work. All slides are hand scraped and fitted with gibs for taking up the wear. Suindle is ground, thoroughly protected by dust caps and has spring take-up for end thrust.

A rapid and dependable machine for general shop use.

Complete line in Catalog 11
Send for it now—don't wait

F. E. WELLS & SON COMPANY, Greenfield, Mass., U.S.A.

Mostly Figures—
and Worth Looking Over



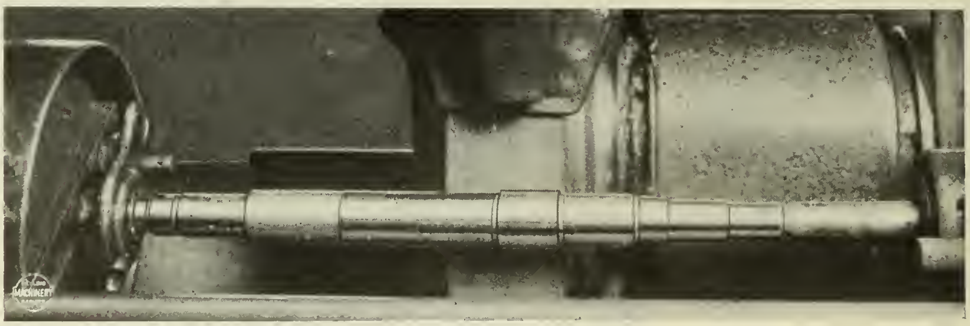
We are indebted to the Robbins & Myers Company, Springfield, Ohio, for facts, figures and photographs of some remarkably good grinding operations. The work is point 30 Corona Steel armature shafts 12.899″ long with nine diameters to turn as follows:

1st Diameter:	0.6875″	+ 0.0005″	— 0.000″
length	0.968″	+ 0.005″	— 0.005″
2nd Diameter:	0.798″	+ 0.002″	— 0.000″
length	1.157″	+ 0.005″	— 0.005″
3rd Diameter:	0.875″	+ 0.001″	— 0.000″
length	0.625″	+ 0.005″	— 0.005″
4th Diameter:	1.001″	+ 0.000″	— 0.0005″
length	1.391″	+ 0.005″	— 0.005″
5th Diameter:	1.125″	+ 0.005″	— 0.005″
length	1.094″	+ 0.005″	— 0.005″
6th Diameter:	1.001″	+ 0.000″	— 0.0005″
length	4.703″	+ 0.005″	— 0.005″
7th Diameter:	0.8135″	+ 0.000″	— 0.0005″
length	1.312″	+ 0.005″	— 0.005″
8th Diameter:	0.7876″	+ 0.001″	— 0.000″
length	0.531″	+ 0.005″	— 0.005″
9th Diameter:	0.6595″	+ 0.0005″	— 0.000″
length	1.118″	+ 0.005″	— 0.005″

The operator grinds 50 to 60 shafts on one diameter, then dresses the wheel and grinds the next diameter until the shaft is completed, dressing the wheel between each diameter. The wheel used is a 14″ x 2¼ Norton 24-M. Wheel speed, 5500 feet per minute; work speed 70 feet per minute. Output per 11-hour day, 110 complete shafts.

The Norton Limit is the Grinding Limit

Let us tell you more about Norton Grinding—show what it can do for you.



NORTON GRINDING COMPANY, Worcester, Mass., U.S.A.

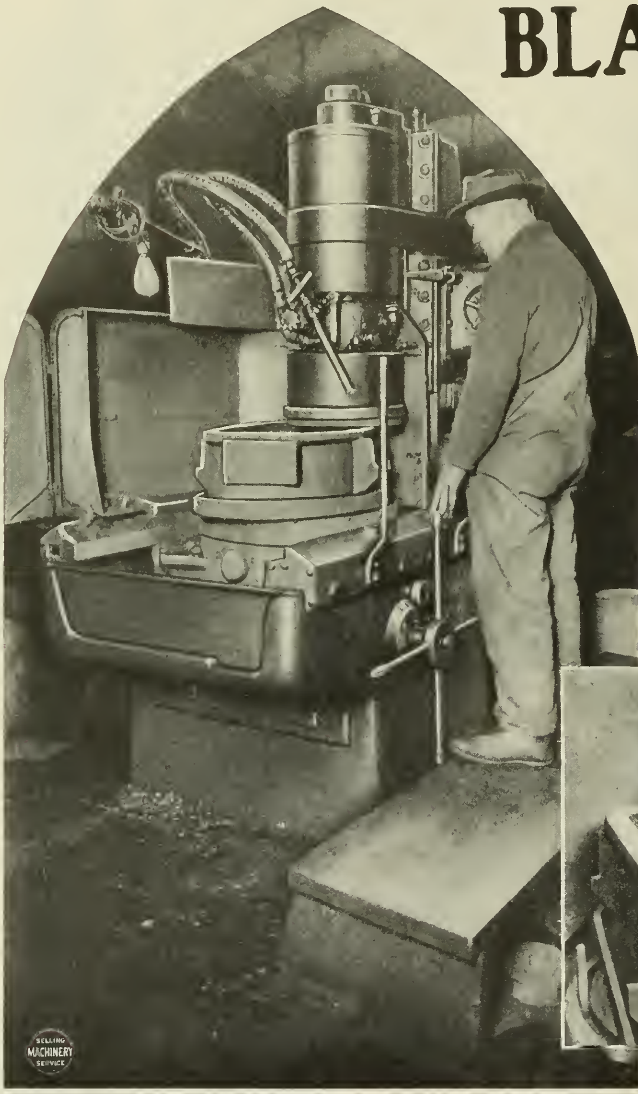
CHICAGO STORE: 11 North Jefferson Street

AGENTS: Vonnegut Machinery Co., Indianapolis, Ind. Robinson, Cary & Sands Co., St. Paul, Minn.; Duluth, Minn. Manning, Maxwell & Moore, Inc., St. Louis, Mo. Henry Prentiss & Co., Inc., New York, N. Y., Boston, Mass., Buffalo, N. Y., Rochester, N. Y., Syracuse, N. Y., Scranton, Pa. The Motch & Merryweather Machinery Co., Cleveland, O., Detroit, Mich., Pittsburgh, Pa., Cincinnati, O. Eccles & Smith Co., San Francisco, Cal., Los Angeles, Cal., Portland, Ore. The Canadian Fairbanks-Morse Co., Montreal, Que., Toronto, Ont., Vancouver, B. C. C. T. Patterson Co., Ltd., New Orleans, La. Kemp Machinery Co., Baltimore, Md. W. E. Shipley Machinery Co., Philadelphia, Pa. Alfred Herbert, Ltd., Coventry, England, Paris, France, Milan, Italy. Post Van der Burg & Co., Rotterdam, Holland. The F. W. Horne Company, Tokio, Japan. Iznosskoff & Company, Petrograd, Moscow and Ekaterinburg, Russia. N-8

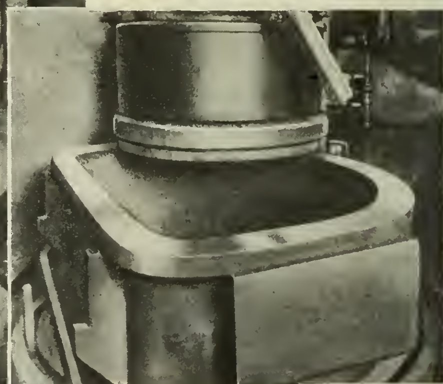

The New YANKEE
Drill Grinder
All it has cost the owner of this "New Yankee" for ten years' drill saving service is the *price of oil and grinding wheels.*
Granted a first-class drilling machine, the chief factor essential to high production is accurately ground drills. "New Yankee" accuracy is positive and uniform. The machine is so simple a wide-awake boy can run it.
Over Ten Years' Service and Not a Cent for Repairs
It does its work so efficiently that from 50 to 75% is saved on drill costs. There's a "New Yankee" to meet every modern drill grinding requirement Write for catalog No. 106.
Wilmarth & Morman Co.
2180 Monroe Ave., N.W.
Grand Rapids, Mich.
Manufacturers of Drill Grinders, Surface Grinders, Universal Grinders.

Five Years' Heavy Work for this

BLANCHARD GRINDER



The Blanchard is a rapid producer. These chilled cast iron mouth pieces for retorts, for example, are faced off on one side at the Leetsdale plant of the Riter-Conley Mfg. Co., Pittsburgh, Pa., at an average of twenty minutes per piece. From each one of these mouth pieces ⅛ of an inch of chilled cast iron is removed, enough to square up and clean up the surface.



The all over size of the face is approximately twenty inches by thirty inches, and the flange is one and one-half inches wide.

This Blanchard Grinder has been run by comparatively inexperienced labor since 1912, and has given excellent satisfaction. We can show you thousands of illustrations of Blanchard grinding varying from work as large as this down to the smallest of punchings from thin sheet metal, all handled efficiently and economically as well as accurately.

Let us send more details.

THE BLANCHARD MACHINE COMPANY

64 STATE STREET CAMBRIDGE, MASS., U. S. A.

DOMESTIC AGENTS: Henry Prentiss & Co., Inc., Motch & Merryweather Machinery Co., Marshall & Huschart Machinery Co., W. E. Shipley Machinery Co., Kemp Machinery Co., Robinson, Cary & Sands Co., Pacific Tool & Supply Co. CANADA: Williams & Wilson, Ltd., A. R. Williams Machinery Co., Ltd. GREAT BRITAIN: Burton, Griffiths & Co., Ltd. FRANCE: Aux Forges de Vulcain.

"ABRASIVE" GRINDING WHEELS
EXCLUSIVELY

Mr. Storekeeper in one of the steel casting companies has seen a good many grinding wheels come—and go. Then he saw Abrasive Wheels enter the lists, and not only stay, but crowd every other grinding wheel out. It takes "bite," and plenty of it, to handle his company's grinding efficiently and economically. There's "bite" in every abrasive grain. Moreover, Abrasive Wheels are uniform. When a man asks for a duplicate of the wheel he's been using, he gets that particular wheel's "twin."

They've Got the "Bite"

Abrasive Wheels are a sure aid to lower production costs. If your work is material of high tensile strength it calls for "Boro-Carbone" Wheels. For low tensile strength materials we recommend "Electrolon" Wheels. Should you have grinding problems, don't worry about them—send them to us.

New Abrasive Catalog on request.

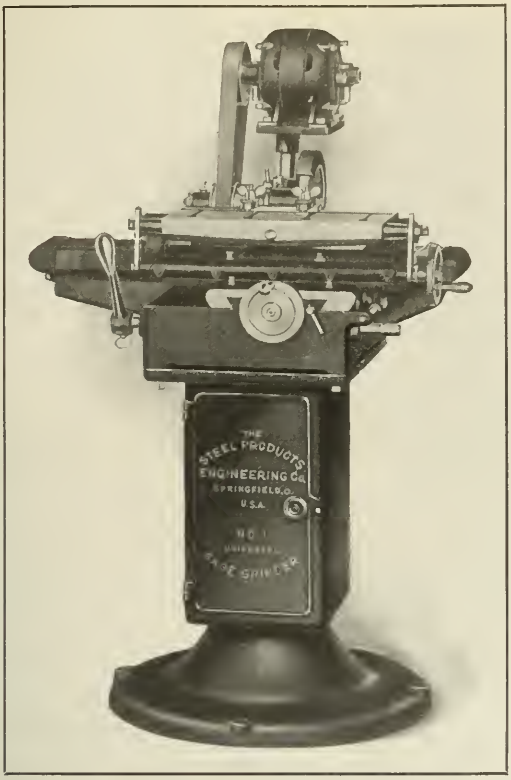
ABRASIVE COMPANY
BRIDESBURG PHILADELPHIA, U.S.A.

Chicago Branch, 566 W. Washington Blvd.

"ABRASIVE"
GRINDING WHEELS

ABRASIVE ORDER No. B 87180
CUSTOMER ORDER No. 13159
SIZE 18x2x2
GRAIN 14 GRADE Q FACE No.
SHAPE SAFETY
TESTED AT 1925
SPEED RECOMMENDED
R. P. M. 1925 to 1275
Speed within above range is dependent on condition of machine, method of grinding and safety appliances used.

Abrasive Material Co.
BRIDESBURG, PHILADELPHIA, U. S. A.
Chicago Branch. 566 W. Randolph St.
Retain tag for duplicate order. (OVER)



Gauge Grinding

With this machine you get the very highest degree of accuracy with the least possible expense.

Particular attention is called to the flat table and the provisions that have been made for quick, easy adjustments. It is very simple throughout and easy to operate.

Are you familiar with all the details that have helped to make this machine a success?

Let us help you acquire them.

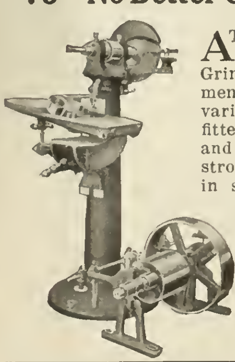
THE STEEL PRODUCTS ENGINEERING CO.
SPRINGFIELD OHIO

Bryant Chucking Grinder Company

Springfield, Vermont, U. S. A.
Detroit Office: 924 Dime Bank Bldg., Detroit, Mich.

Builders of One, Two and Three Spindle Chucking Grinders.

$75.00 No Better Grinder for the Money



AT this price the "Waterbury" Toolroom Die and Surface Grinder is surely a paying investment. It is adapted for a wide variety of work, is fast and accurate, fitted with up-to-date conveniences and means for compensating wear, strong and rigid throughout, lasting in service. Better values for the money would indeed be hard to find.

Detailed description on request

The Blake & Johnson Co.
WATERBURY, CONN.

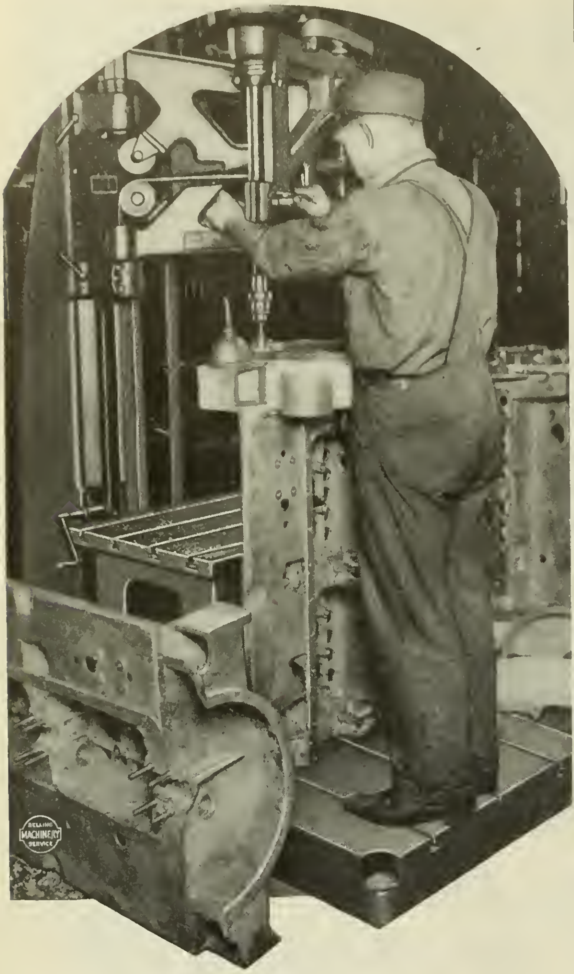
Solid Comfort in Grinding

The DILLON Electric Grinder

For High Speed and Steady Work try the Dillon

overcomes the usual grinding troubles. The motor is rugged and dustproof. Large shaft of high carbon steel and S K F ball bearings insure perfect balance. Extra heavy wheel guards, broad grinding rests, generous water cup and conveniently placed snap switch control make the "Dillon" safe and easy to operate.

THE DILLON ELECTRIC COMPANY
CANTON OHIO, U. S. A.



THE HAMMOND RADIAL

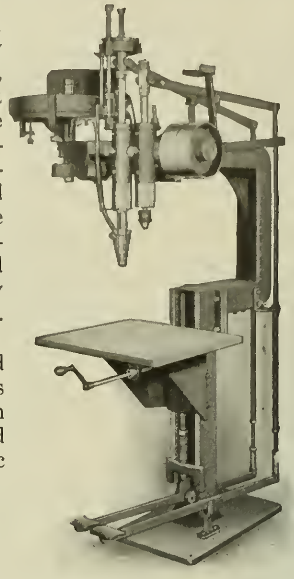
As a Manufacturing Machine

The shop in which this photograph was secured is known as the "little shop with the big production," and the "Hammond" plays no small part in enabling it to merit the distinction. For example, on this crankcase job, eight 5/16" holes are drilled, and eight 3/8"-16 P holes tapped at one setting, operation necessitating bolting flywheel to the case and taking down again when finished. Regardless of this detail, 120 cases—1920 holes—are completed every 9½ hours. "Hammond" service pays here—will pay in your shop, too. Try it.

THE HAMMOND MFG. CO.
CLEVELAND, OHIO

Save Time and Avoid Inaccuracy

Many an able man can't set a screw straight by hand, but any intelligent boy can operate the Reynolds Automatic Screw Driving Machine and average two to five times greater output than by hand methods. Every screw sets true.



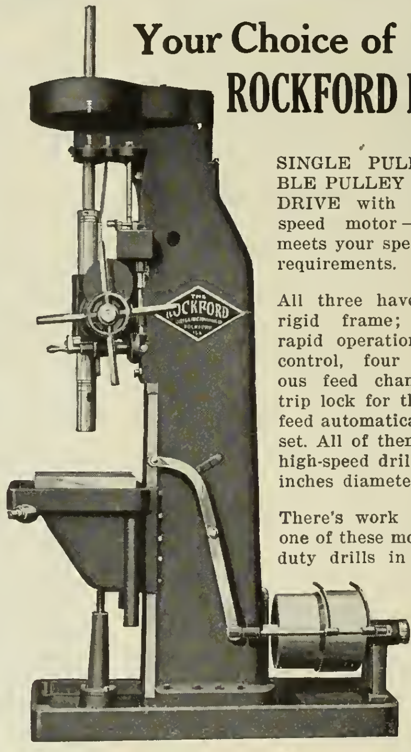
Adapted for wood or metal. Screws may be driven flush or to any desired depth by automatic adjustment.

Catalogue Gives Details—write for Yours Today

Our Record is 18,000 Screws set in 10 hours

REYNOLDS PATTERN & MACHINE CO.
MASSILLON, OHIO

Your Choice of Three ROCKFORD DRILLS



SINGLE PULLEY, DOUBLE PULLEY or DIRECT DRIVE with variable speed motor — whichever meets your special drilling requirements.

All three have the same rigid frame; the same rapid operation and easy control, four instantaneous feed changes and a trip lock for throwing out feed automatically at point set. All of them will drive high-speed drills up to 2½ inches diameter.

There's work for at least one of these modern, heavy duty drills in your shop.

Write for Booklet

Rockford Drilling Machine Company
ROCKFORD ILLINOIS

Dreadnought
HIGH SPEED STEEL

Makes Durable Inserted Tooth Cutters

Dreadnought tools stand up in a noteworthy way under hard usage. For example, here's a tool 14″ diameter with 17 inserts of ⅝″ square Dreadnought High Speed Steel, that works like a charm in sandy iron castings. The work is part of a clothes pressing machine, is 13″ wide at widest part, and 39″ in length. Notwithstanding the edge-dulling nature of the work, this Dreadnought Cutter cleans up a round 200 castings before the inserts have to be re-ground. Dreadnought is the prince of steels for hard service cutters, lathe and planer tools, etc. Economical production depends to a great degree on the wearing and working qualities of your tools.

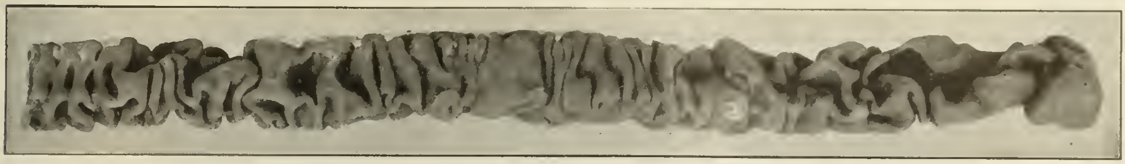
Unless you know your present tool equipment is the most profitable for your work, give Dreadnought Steel a trial.

HALCOMB STEEL COMPANY

SYRACUSE NEW YORK

Branches: Chicago, Cleveland, Philadelphia, Boston, New York

Remarkable Ductility of "NATIONAL" Pipe



170 quarts of nitroglycerine failed to crack this piece of "NATIONAL" Casing. The terrific force of the explosion reduced the length from about 18 feet to less than 6; although crushed, twisted and distorted there was no fracture.

"NATIONAL" Pipe for Mechanical Purposes

This piece of 10-inch "NATIONAL" Casing dropped 236 feet through a 12½-inch hole without fracturing the material. Although the end is distorted, as the thread protector was driven up over the threads by the force of the impact, THE MATERIAL SHOWS NO SIGN OF FRACTURE.

1440 feet of 8¼-inch "NATIONAL" Casing dropped 200 feet in a well, and as a result of the impact on solid stone three sections of the casing were telescoped with NO SIGN OF FRACTURE.

These three illustrations should be convincing proof of the extraordinary ductility of "NATIONAL" Pipe. No mill test ever devised could equal the terrific strains effected by the unusual accidents which produced the results shown.

¶ It is therefore a reasonable deduction that as "NATIONAL" Pipe has withstood such enormous forces without a fracture in the material, it is essentially qualified to withstand the strains incident to the mechanical uses for which it is recommended.

¶ As a matter of fact "NATIONAL" Pipe is used for thousands of parts of different machines which are used for thousands of different purposes.

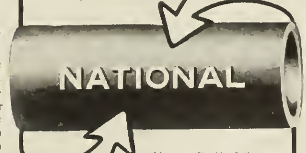
¶ The inherent ductility of "NATIONAL" Pipe lends itself most satisfactorily to mechanical manipulations, and in service withstands without failure the jars and shocks to which the incessant vibrations of machinery are inevitably subjected.

¶ To readily identify "NATIONAL" material and as protection to manufacturer and consumer alike, the practice of National Tube Company is to roll in raised letters of good size on each few feet of every length of welded pipe the name "NATIONAL" (except on the smaller butt-weld sizes, on which this is not mechanically feasible on these smaller butt-weld sizes the name "NATIONAL" appears on the metal tag attached to each bundle of pipe).

AWARDED GRAND PRIZE

¶ When writing specifications or ordering tubular goods, always specify "NATIONAL" pipe, and identify as indicated

LOOK FOR THE MARK



Name Rolled in Raised Letters on National Tube Company Pipe

¶ In addition, all sizes of "NATIONAL" welded pipe four in. and under are subjected to a roll-knobbling process known as Spellerizing to lessen the tendency to corrosion, especially in the form of pitting. This Spellerizing process is peculiar to "NATIONAL" pipe, to which process National Tube Company has exclusive rights.

AWARDED GRAND PRIZE

¶ "NATIONAL" pipe was awarded the GRAND PRIZE (highest possible award) at Panama Pacific International Exposition, 1915

NATIONAL TUBE COMPANY, General Sales Offices Frick Building PITTSBURGH, PA.

DISTRICT SALES OFFICES: Atlanta Boston Chicago Denver Kansas City New Orleans New York Omaha Philadelphia Pittsburgh St. Louis St. Paul Salt Lake City
PACIFIC COAST REPRESENTATIVES: U. S. Steel Products Co., San Francisco Los Angeles Portland Seattle
EXPORT REPRESENTATIVES: U. S. Steel Products Co., New York City.


RCS
Red Cut
Superior
The Nationally Known First Quality
HIGH SPEED STEEL
PROCLAIMED
By the Men Who Use It
THE BEST FOR ALL
MACHINE WORK
VANADIUM-ALLOYS STEEL CO.
PITTSBURGH, PA. WORKS AT LATROBE, PA.
Carried in Stock in These Warehouses:
E.T. WARD'S SONS 44 Farnsworth St. BOSTON, Mass.
GEO. NASH CO. 304 Hudson St. NEW YORK N.Y.
FIELD & CO. Inc. 721 Arch St. PHILADELPHIA, Pa.
VANADIUM-ALLOYS STEEL CO. PITTSBURGH, Pa & LATROBE Pa
GEO. NASH CO. 646 Washington Blvd. CHICAGO, Ill.


Properly Treated Alloys and Metals That Answer Any Condition or Requirement
PRECISION DIE CASTINGS
protect you against the burden of increased cost of materials.
The Precision Organization is *precise* in die making—in alloying metals—in castings and in deliveries.
Our representative will gladly call and show you samples.
PRECISION DIE CASTING CO.
INCORPORATED
SYRACUSE, N. Y.
Castings in aluminum alloys, all bearing metals, spelter and lead.
Special requirements given prompt attention. Representatives in New York, Cleveland and Detroit.

ELECTRITE URANIUM STEEL

This planer hand is happy—and with good reason. He has a lot of stock to remove from the plate he is finishing and he has a tool that will carry a good cut—an Electrite Uranium High Speed Steel Tool. He is planing 40—50 point carbon steel with a 1/16 inch speed and a 1/2 inch deep chip. The reason for the staying quality in Electrite Uranium High Speed Steel is due largely to the element Uranium that is introduced by the most modern steel working practice. Uranium gives this steel a toughness that is unattainable in other ways.

Besides Electrite Uranium we make "Mangano" oil hardening non-shrinkable die steel; "Select" die steel for hot work and hot trimming dies; "Renown" die steel, which is a special vanadium steel; also chrome and tungsten magnet steels.

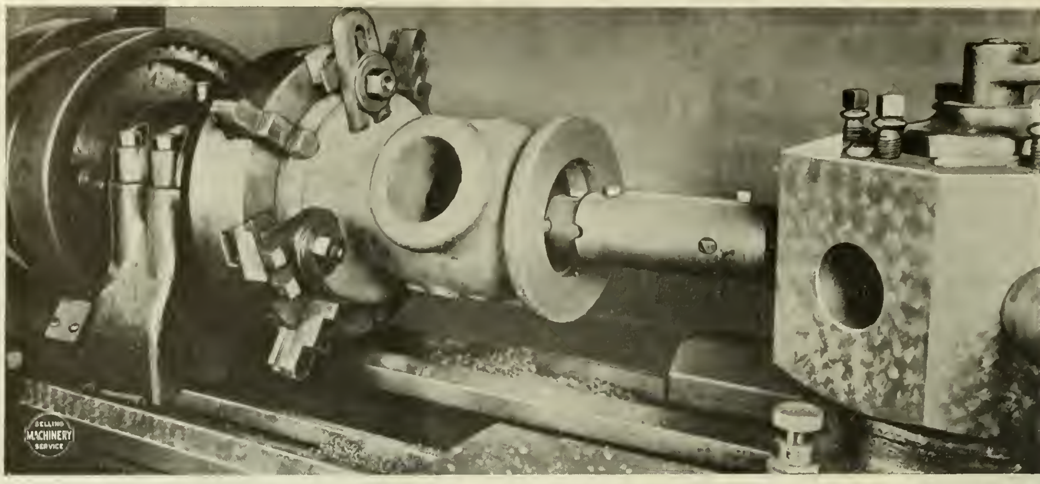
Try us on your next steel order.

"The Smile that Won't Come Off"

Photograph and data through courtesy of Mackintosh, Hemphill & Company, Pittsburgh.

LATROBE ELECTRIC STEEL CO., LATROBE, PA.

LATROBE ELECTRIC STEEL CO. 165 Broadway, New York City, N. Y.
LATROBE ELECTRIC STEEL CO., 1001 Ford Bldg., Detroit, Mich.
LATROBE ELECTRIC STEEL CO., 2802 Union Central Bldg., Cincinnati, O.
LATROBE ELECTRIC STEEL CO., Commercial Trust Bldg., Philadelphia, Pa.
MR. GEORGE F. HARTMAN, 664-66 Spitzer Bldg., Toledo, O.
BETZ-PIERCE COMPANY................................Cleveland, O.
McMINN & QUIGLEY STEEL CO., 40 Central St., Boston, Mass.
ELECTRIC METALS COMPANY, First National Bank Bldg., Pittsburgh, Pa.
HOYT-NOE STEEL COMPANY, Monroe and Jefferson Sts., Chicago, Ill.
THE DICKERSON COMPANY............................Dayton, O.
C. W. BALDY..................198 Cleveland Ave., Buffalo, N. Y.
JNO. H. HEIMBUECHER METALS CO., 514 North Third St., St. Louis, Mo.
C. W. RICKARD..Seattle, Wash.



BLUE CHIP HIGH SPEED STEEL

Boosts Boring and Turning Output

The work is cast iron valve bodies which are made in large quantities by a New England manufacturer. When higher production was required heavier turning lathes were installed, but no change was made in the tools. It was a *Blue Chip High Speed Steel* job on the old machines; the same tools are handling it now under a drive that means *100% increase in output.*

The work is particularly hard on tools; material is hard and scaly; for boring and facing the tool must work from the end of a 12″ bar, on a casting that overhangs 12″ from the faceplate; cut varies from 1/8″ to 3/16″ deep and not a chatter mark is to be seen. Tools made from *Blue Chip High Speed Steel* stand all the power the heaviest machines are capable of pulling. For turning and boring tools, taps, dies, reamers, etc. Write us.

Blue Chip

FIRTH-STERLING STEEL CO.

McKEESPORT, PA., U. S. A.

Boston Cleveland Philadelphia Chicago New York Pittsburgh

BECAUSE of the superior qualities of Atlas Steel Balls, they are used by most Ball Bearing manufacturers —in many of the finest automobiles and by 90% of the machine tool manufacturers.

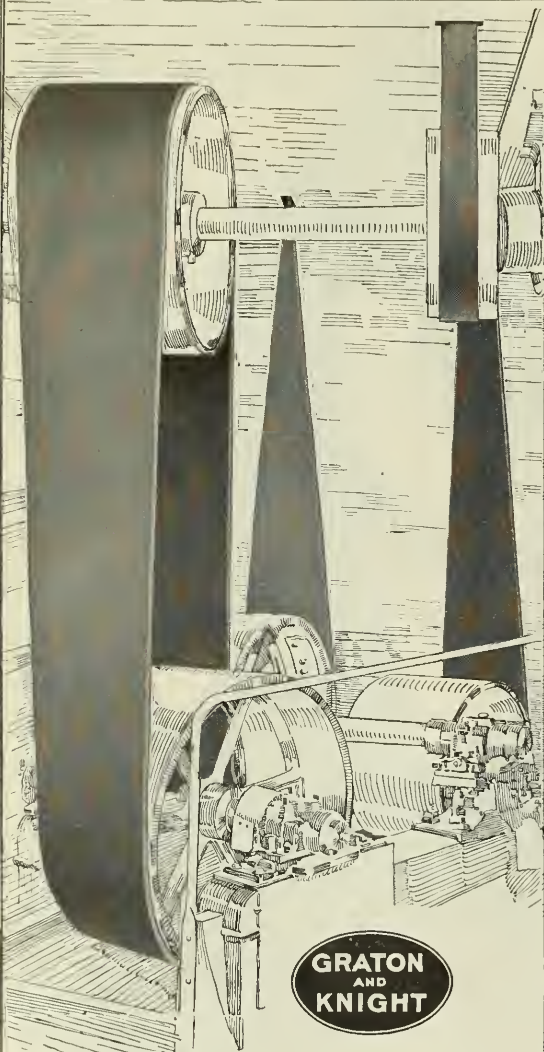
The superior quality of Atlas Steel Balls cannot be duplicated.

ATLAS BALL CO.
Glenwood Ave. at 4th St.
PHILADELPHIA, U. S. A.

Guaranteed true to $\frac{1}{10000}$ of an inch

GRATON & KNIGHT
Standardized Series
LEATHER BELTING

Tanned by us for belting use



24" Spartan Double Belt, one of Graton & Knight Standardized Series Leather Belts, on Five Pulley Quarter Turn Drive. Great Falls Bleachery & Dye Works, Somersworth, N. H.

It Begins in the Tannery

Leather is the standard belting material

To us, the largest belting makers in the world, every possible belting material lies open for selection and use. But the belting experience of generations points to the unescapable fact that leather has the properties necessary to make good belting.

Leather that is properly tanned for belting is tough, flexible, durable and prehensile. It preserves the natural softness and mobility of the skin, ensuring an effective grip on the pulley surface.

We have standardized these requirements of perfectly tanned belt leather. The standard in each case is the highest *working* efficiency in the finished belt.

Since the market cannot supply tanned belt leather that continuously measures up to Graton & Knight Standards, we tan our own hides. Last year we tanned 285,000 of them, in our own tannery. We tanned them for *belts*. We tanned them to definite and uniform standards of belting requirements.

This standardization of material is the foundation of Graton & Knight quality.

It makes the Standardization of Graton & Knight Belts an actual, practical thing.

Think what other standardized products have done for you—and consider the standardization of belting on that basis. Let us send you complete information on the subject.

The Graton & Knight Mfg. Company

Oak Leather Tanners and Makers of Leather Belting

Worcester, Massachusetts, U. S. A.

BRANCHES

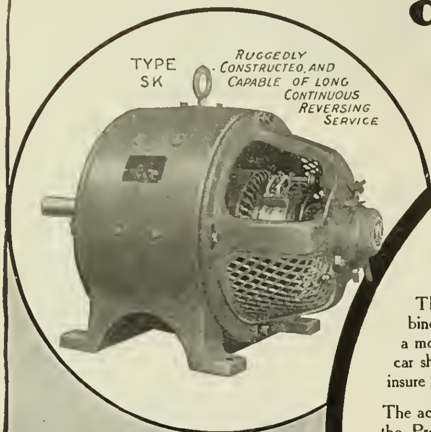
Atlanta, Boston, Chicago, Cleveland, Detroit, Fall River, Kansas City, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Seattle, St. Louis, Leicester, England.

SELLING AGENTS

Graton & Knight Mfg. Co. of Texas, Dallas, Texas. Graton & Knight Mfg. Co. of Wisconsin, Milwaukee, Wis. Graton & Knight Mfg. Co. of California, San Francisco, Cal.

Westinghouse

Reversing Planer Motors and Control



The Right Motor At The Right Time

The right motor is that one which will give you the most intense production, combined with high efficiency and utmost reliability. And NOW is the right time for such a motor. Our government must depend primarily for means of transportation upon the car shops, and it naturally follows that the car shops should employ those methods which insure MAXIMUM OUTPUT in MINIMUM TIME with HIGHEST EFFICIENCY.

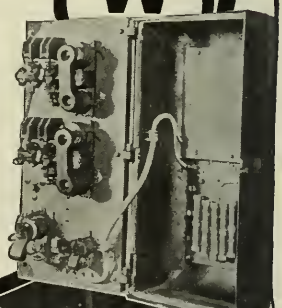
The accompanying views show a portion of the machine shops of the Pressed Steel Car Co. of Pittsburgh and the Westinghouse Reversing Planer Motors employed on these planers. Westinghouse Automatic Control, also installed, so simplifies the work of the operator that there is no loss of time.

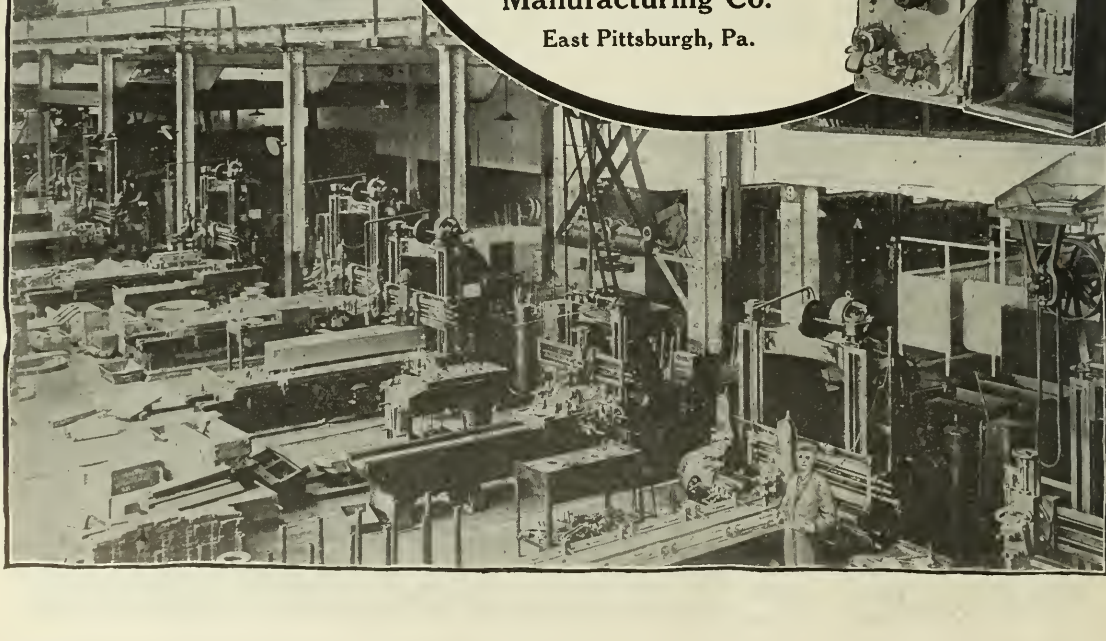
It has taken a great deal of study of machine tool practice to bring our Motors and Control Equipment up to their present acknowledged high standard. Let us help you put your plant on the most efficient basis NOW. It's the right time.

Send for Book No. 3042.

Westinghouse Electric & Manufacturing Co.

East Pittsburgh, Pa.





A Page From a Carborundum Service Man's Note Book says:

"Our Customer Considers this an Extraordinarily Good Performance"

The job is grinding, rough from the sand, chilled iron rolls on a Landis special grinder. The rolls are 32 inches long, 16 7/16 inches in diameter and 7/16 stock is removed. It takes the Carborundum Wheel, 24 grit, L grade, G 3 + bond just 4 3/4 hours to do the work.

¶ The finish is uniform, the wheel cuts clean and it loses but 1/15 of an inch.

¶ It is the unbeatable grinding combination that gets these results. —The right wheel, Carborundum service and a good grinding machine.

What can this service do for you?

THE CARBORUNDUM COMPANY
NIAGARA FALLS, N. Y.

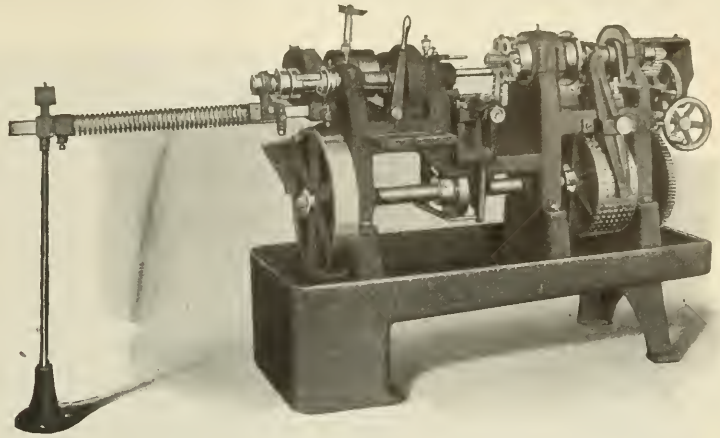
NEW YORK CHICAGO PHILADELPHIA CLEVELAND CINCINNATI BOSTON PITTSBURGH MILWAUKEE GRAND RAPIDS

The Chicago Automatic

Built Around the Cornerstone of Simplicity

Chicago Automatic Machine Company
Chicago, Illinois, U. S. A.

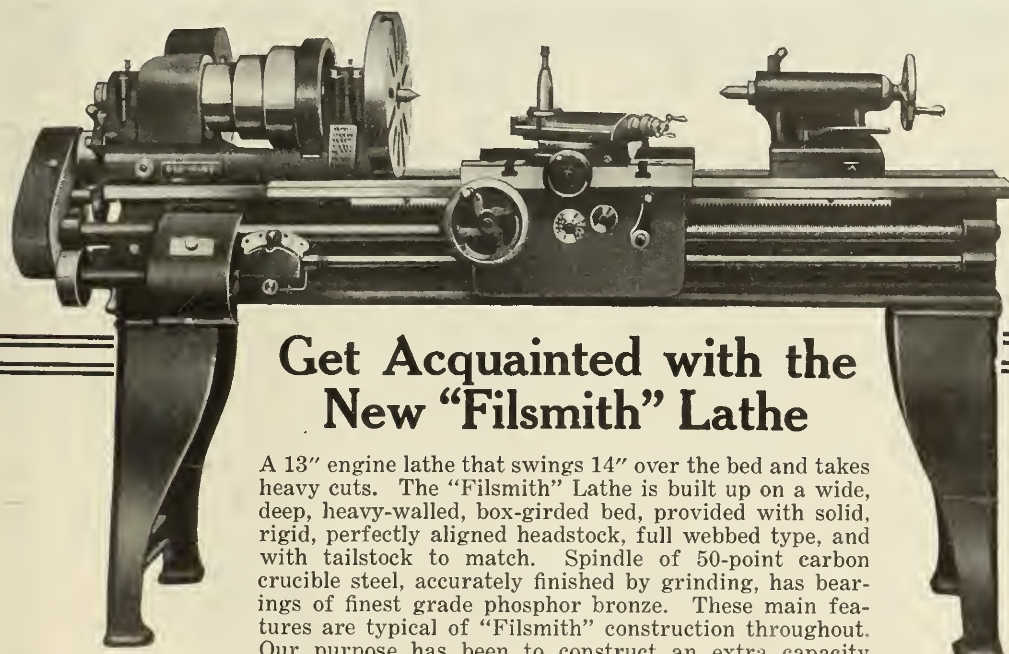
Eastern Representative
John MacNab Machinery Co.
90 West St., New York
John MacNab, Hyde, England



The Chicago Automatic Screw Machine

owes a great deal of its serviceability to simple design. There are no complicated mechanisms or involved systems of cams to cause trouble; no countershafts and overhead belts to waste power and interfere with additional equipment, spindle speeds suitable for any stock are obtained by changing two gears on the spindle head; threads are cut withopt slowing spindle speed by means of a die holder revolving in the same direction as the spindle but at higher speed. A clutch mechanism indexes the turret and skips holes not in use. The machine is rigidly built throughout, maintaining alignments and accuracy of work under long, continuous operation.

Write for complete description.

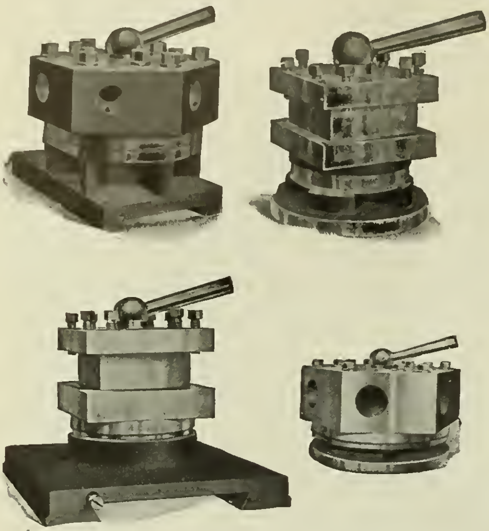


Get Acquainted with the New "Filsmith" Lathe

A 13″ engine lathe that swings 14″ over the bed and takes heavy cuts. The "Filsmith" Lathe is built up on a wide, deep, heavy-walled, box-girded bed, provided with solid, rigid, perfectly aligned headstock, full webbed type, and with tailstock to match. Spindle of 50-point carbon crucible steel, accurately finished by grinding, has bearings of finest grade phosphor bronze. These main features are typical of "Filsmith" construction throughout. Our purpose has been to construct an extra capacity small lathe—accurate, rapid and economical to use. We have succeeded. Let us show you. *Details on request.*

THE PHILIP SMITH MFG. CO., Sidney, Ohio

PHOENIX
Turret Attachments



A Necessity in the Modern Shop

Phœnix Attachments are adapted for a multitude of lathe operations that ordinarily require special tools; being particularly well fitted for handling economically, the "shortjobs" so difficult for either turret or engine lathe.

It is an easy matter to attach them to the cross slide of any engine lathe; they are perfectly rigid when set up, extremely easy to use, and are readily released by a three-quarter turn of the handle.

If you'd like to get 100% efficiency from your engine lathes, you'll want to know more about them.

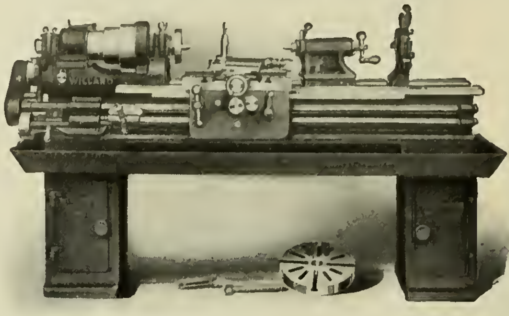
Complete description on request.

PHOENIX MANUFACTURING CO.

EAU CLAIRE WISCONSIN

CLEVELAND OFFICE: 1430 WEST 6th STREET

The WILLARD 13" Engine Lathe



FITTED with cabinet legs and pan base, is especially adapted for tool room and school purposes. Extra powerful drive permits handling work beyond the ordinary small lathe range. Convenient operation makes for speed. Rigid construction insures uniform accuracy. The "Willard" swings full 13", has complete range of feeds, stands hard driving, is complete in every detail.

We should like to tell you more about these exceptional machines. May we?

The Willard Machine Tool Co.

CINCINNATI OHIO, U. S. A.

W & P PLANERS

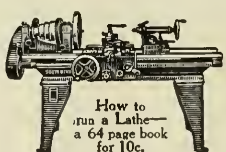
Planers with rigidity, strength and power to meet the heaviest demands.

We build rapid, accurate, long service planers of every type, know planer requirements from A to Z, and will be glad to help you pick the machine best suited to your work.

Write for particulars.

WOODWARD & POWELL PLANER CO.

WORCESTER MASS., U. S. A.



How to run a Lathe—a 64 page book for 10c. Postpaid, coin or stamps.

SOUTH BEND LATHES
For the Machine and Repair Shop

A Practical Lathe at Low Price. 11-inch to 18-inch Swing. **Straight or Gap Beds.** Send for free catalog.

SOUTH BEND LATHE WORKS

426 E. Madison St., South Bend, Ind.

ENGINE LATHES

18" to 48" Swing

THE BOYE & EMMES MACHINE TOOL CO.

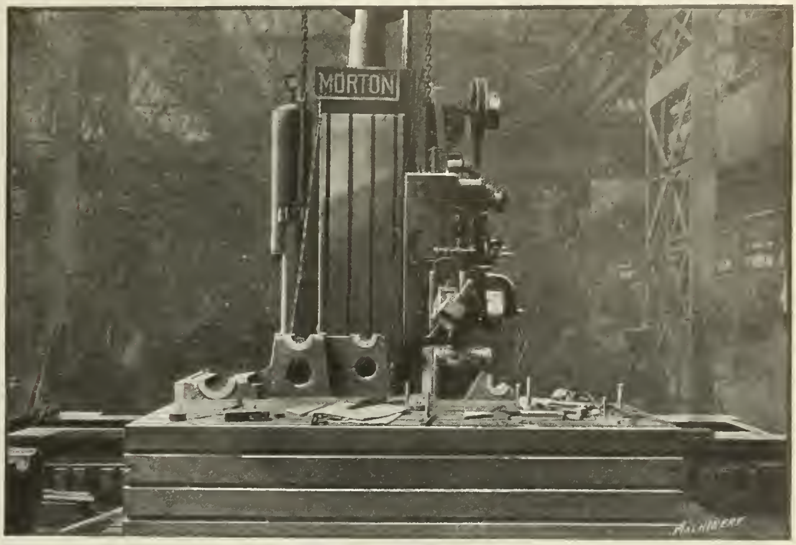
Cincinnati, Ohio

The Morton Draw-Cut Traveling Head Planer

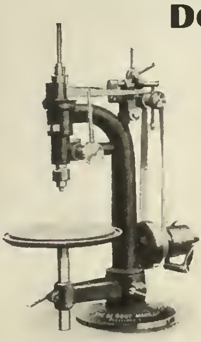
Unequaled for Manufacturing or General Shop Work

MORTON MFG. COMPANY
Muskegon Heights
MICHIGAN

THE remarkable adaptability of Morton Planers makes them profitable machines in any shop. Their range is practically unlimited. They are ideal for general requirements, and so simply designed and flexible that they can be readily adapted for any special work. Compared with the housed planer, the Morton requires but half the floor space and one-fourth the power, may be used either as a portable or a stationary machine, can be reversed into a push cut planer if desired, and handles all boring and milling easily and accurately regardless of the size of the piece. Convenient, powerful—and needed in most shops. *Send for Bulletin 8D.*



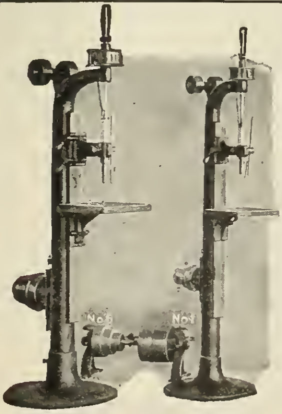
Demco High Speed Drilling Machine



Our new machine's maximum speed is 12,000 R. P. M. Drives 3/16" to 3/8" drills at proportionately slower speed. Ball bearings are used throughout; high carbon, heat treated, accurately ground spindle has 3-jaw geared nut chuck of key type; three speed changes by simply moving a lever. We have built a sturdy, high-grade small-hole drilling machine, bench or floor type, that not only increases output but minimizes drill breakage—a marvel of speed and accuracy. Furnished with either square or round table.

Write for full description.

THE DE MOOY MACHINE CO.
706 Frankfort Ave., Cleveland, O.



No. 1 Drill—14"

265 lbs., Capacity 1/2"

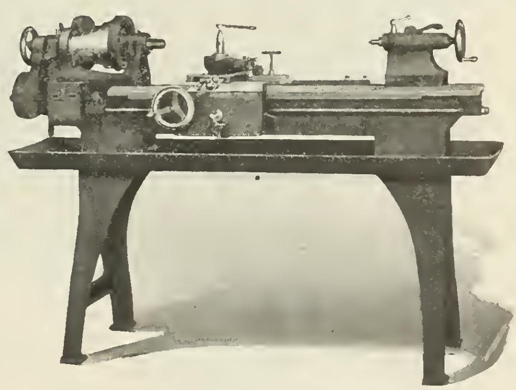
No. 5 Drill—16"

430 lbs., Capacity 3/4"

A splendid line of single spindle drilling machines.

Manufactured by
FRANCIS REED CO.
43 Hammond Street
Worcester, Mass.

Worcester 11" Tool Room Lathe



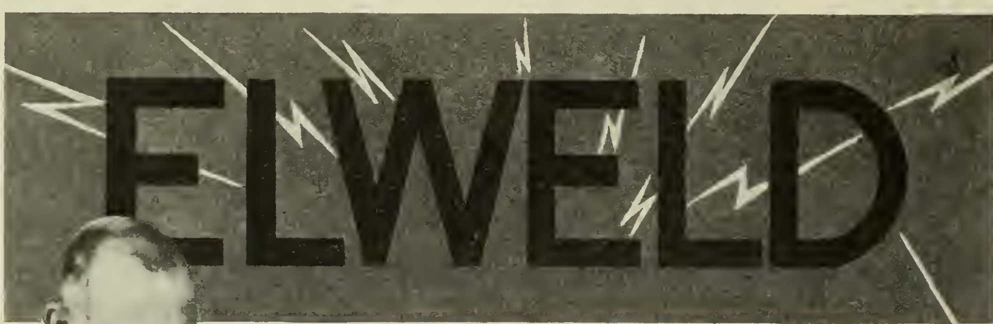
This simply designed, steady-going, efficient machine is built along the same general lines of our Standard 11" Lathe, with the addition of Steel Pan, Taper Attachment and Draw-in-chuck. The Taper Attachment is graduated and can be easily set for turning; Draw-in-chuck operates by means of a closer and split collet of tool steel, hardened and ground. The lathe swings 12 3/4" over bed, 8" over carriage, cuts threads from 2 to 40, takes turning tools 1/2" x 1". *Write for further details.*

WORCESTER LATHE COMPANY
68 Prescott St. WORCESTER, MASS.

700 ELWELD TOOLS

For One Concern

That Would Indicate They Were Good Tools Wouldn't It?



These 700 tools were made from so-called scrap—short pieces of high speed steel that could no longer be used to advantage in the usual manner. We Elwelded these pieces to tool steel shanks, conforming to sizes designated, and 700 new high speed tools resulted at a fraction of their first cost. Compare this cost with that of new tools and it'll be an eye-opener.

And don't overlook the significance of the repeat orders we've had from these people. The fact that they've come back again and again for more Elweld tools surely proves that they're saving money and we're giving satisfaction.

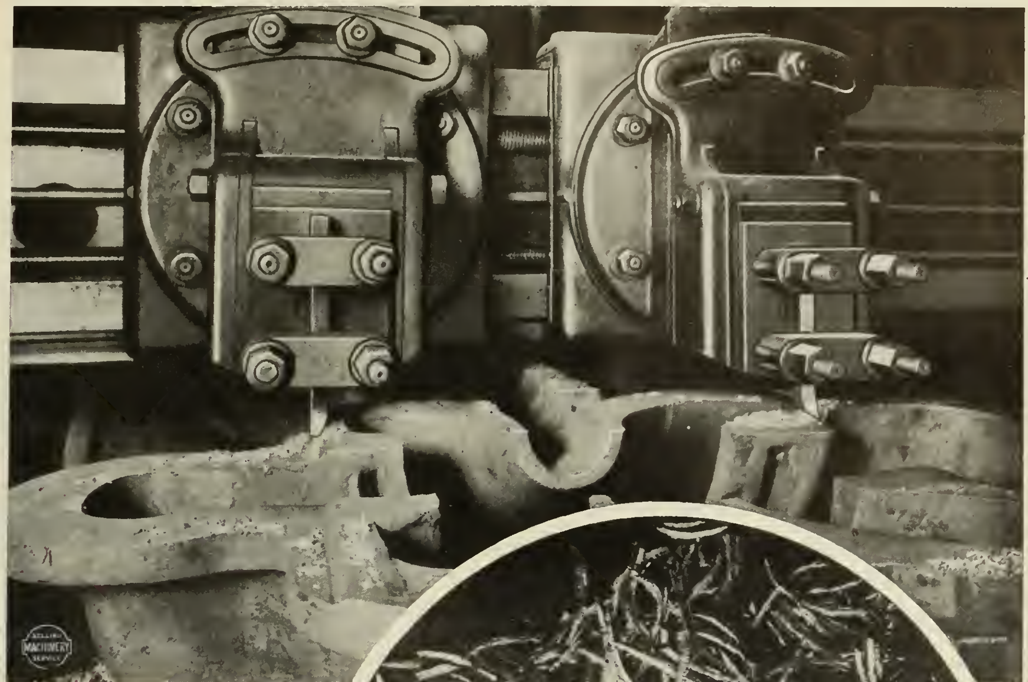
Let us show you a sample of our work. We're increasing our capacity again and can give your specifications prompt attention. Any tools from 1½″ x 2½″ down to ½″ x 1″.

We do commercial butt welding also, large or small, and will be glad to figure with you.

The Electric Welding Co.

(Superior Viaduct)

Cleveland Ohio



These are

High Speed Steel Tools

Would You Believe it?

This job is typical of some of the work put up to Uranium tools. These two pump casing castings are made of acid-proof bronze, an exceptionally tough metal to cut; the chips shown are full size and indicate how short the metal flakes under the cutting action. Uranium steel tools are the only tools that stood up under this work.

You, no doubt, often meet just such tough planing or turning propositions and then you need Uranium for best results.

Your own steel man can tell you about Uranium High Speed Steel; if not, consult us

Standard Alloys Company

Forbes & Meyran Avenues PITTSBURGH, PA.

THE SHAW ELECTRIC CRANE COMPANY

WORKS MUSKEGON, MICHIGAN

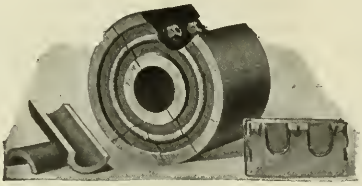
SALES OFFICES IN ALL PRINCIPAL CITIES

MANNING, MAXWELL AND MOORE, INC.

PRINCIPAL OFFICE – 119 WEST 40TH. ST., NEW YORK.

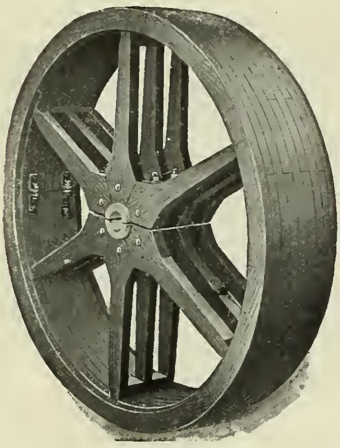
GILBERT PULLEYS

COST LITTLE and SAVE MUCH



Gilbert Wood Split Pulleys cost less than split iron or steel pulleys. Being much lighter, they require less expensive shafting and hangers, put less weight on the bearings, and so reduce power loss through friction.

It has been authoritatively proved that wooden pulleys require nearly 50 per cent less belt tension than iron—for equal power. Reduced tension prolongs belting life and further reduces journal friction and strain on the shafting.



Gilbert Wood Split Pulleys wear as long as iron, give as good or better service, and save money in every way.

Send for Catalog.

SAGINAW MFG. CO.

SAGINAW, W. S. MICHIGAN

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GET OUR OFFICIAL BLUE BOOK

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DETROIT	SAN FRANCISCO, CAL.

NEED THRUST BEARINGS QUICK?

Specify "ROCHESTER"

We make them—big bearings, good bearings. Balls, all sizes, any material. Speedy delivery on early orders. Write for circulars.

ROCHESTER BALL BEARING COMPANY, Inc., ROCHESTER, N. Y.

FREE BOOKLET SHOWING HOW TO SAVE HANDLING EXPENSE

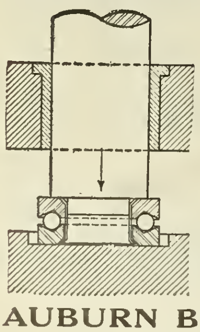
How to enable 1 man to do the work of 4 or 5—how to meet the labor shortage—by using the

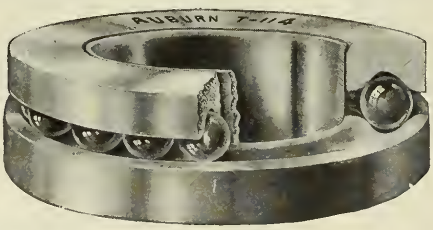
BARRETT MULTI-TRUCK

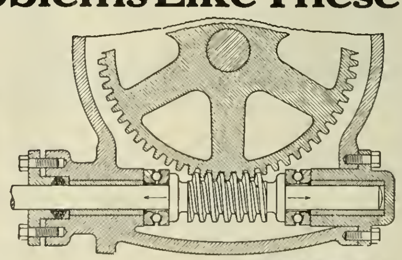
BARRETT-CRAVENS CO.

750 Transportation Bld'g. Chicago, Ill.

Auburn Ball Thrusts Solve Problems Like These





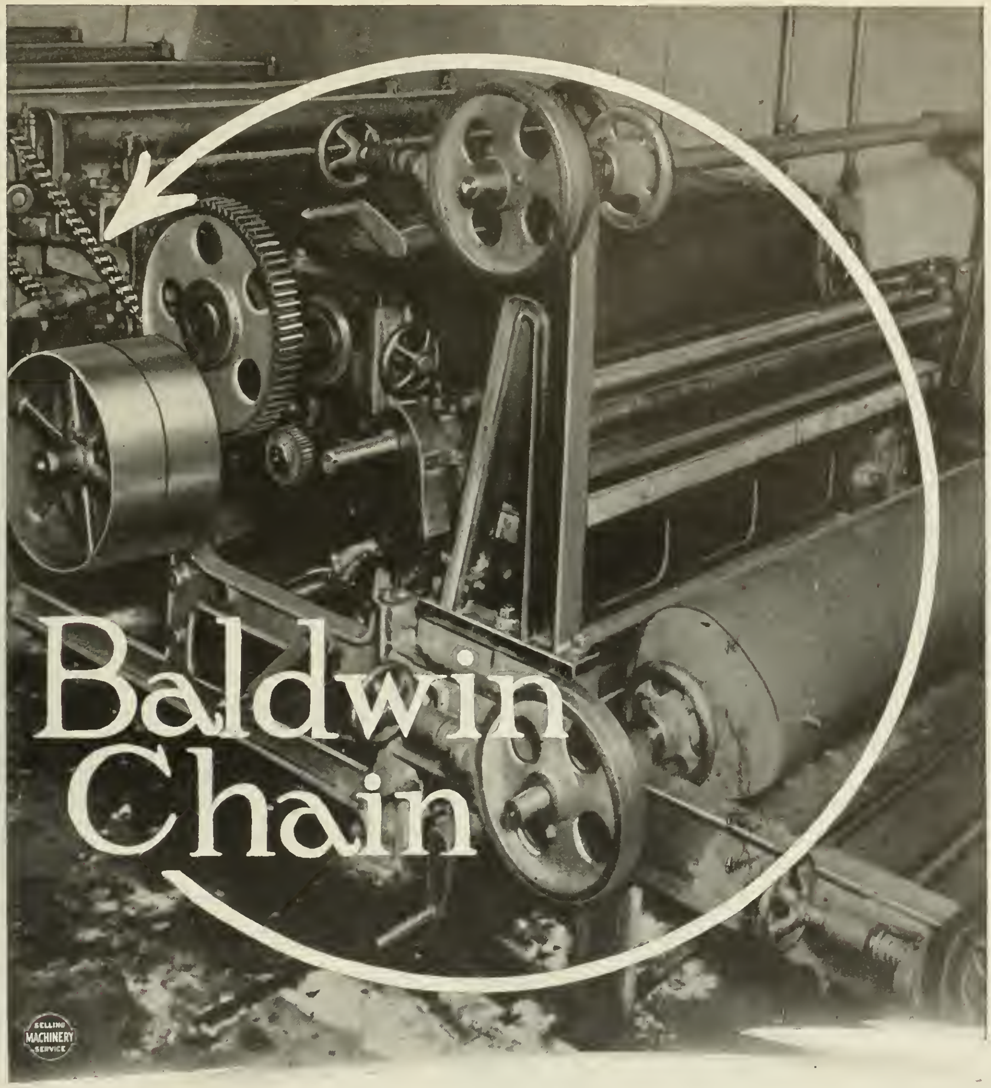


State your needs or ask for bulletins.

Steel, Brass and Bronze Balls

AUBURN BALL BEARING COMPANY, 33 Elizabeth Street ROCHESTER, N. Y.

Trade Mark



Another Special Machine

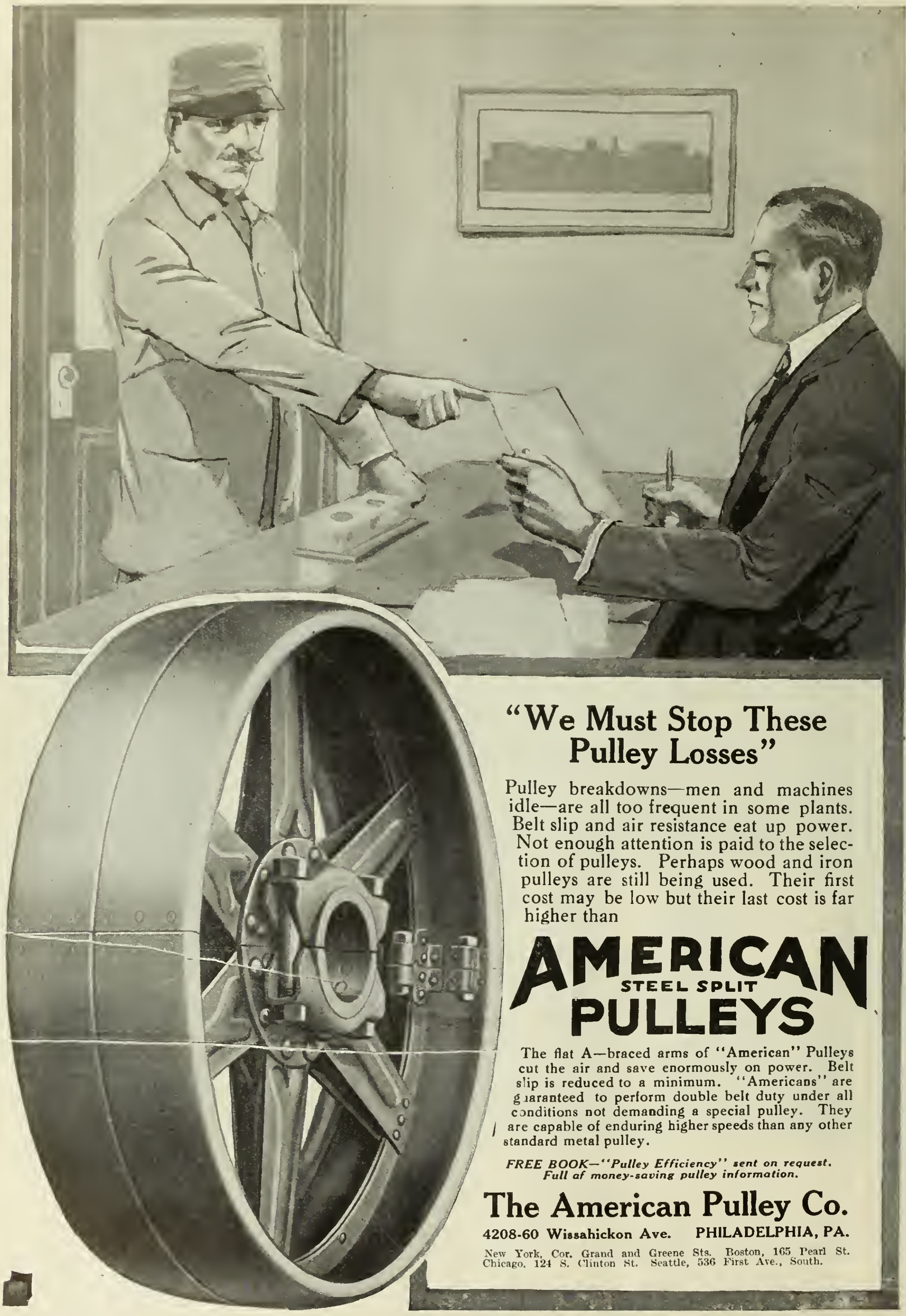
On Which Part of the Drive is Baldwin Chain

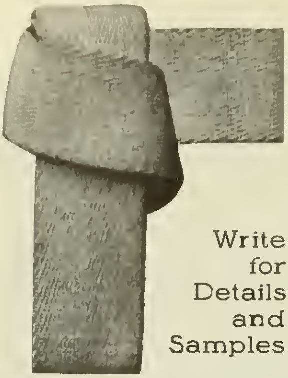
This is a paper corrugating machine, designed by the Potdevin Machine Company, Brooklyn, N. Y., and the drive to the upper rolls is a Baldwin Special Roller Chain, the center distance between sprockets being approximately two feet. The advantage of chain over gears or belts for many purposes has been demonstrated by the above concern to its complete satisfaction—and the chain selected is "Baldwin."

Baldwin Chain is good chain. It has many uses and many advantages.
May we tell you more about it? Address Department ''S''.

Baldwin Chain & Mfg. Co., **Worcester, Mass., U.S.A.**

AGENTS: C. D. Schmidt, 276 Canal St., New York City. W. D. Foreman, 1425 Michigan Ave., Chicago, Ill. N. A. Petry Co., Inc., 1309 Race St., Philadelphia, Pa. Walter H. Williams, 175 Massachusetts Ave., Boston, Mass. M. A. Bryte, 788 Mission St., San Francisco, Cal. Motor & Machinists Supply Co., Kansas City, Mo. M. & M. Co., Cleveland, Ohio. Neustadt Automobile & Supply Cc , St. Louis, Mo. C. J. Smith Co., St. Paul, Minn.


"We Must Stop These Pulley Losses"
Pulley breakdowns—men and machines idle—are all too frequent in some plants. Belt slip and air resistance eat up power. Not enough attention is paid to the selection of pulleys. Perhaps wood and iron pulleys are still being used. Their first cost may be low but their last cost is far higher than
AMERICAN
STEEL SPLIT
PULLEYS
The flat A—braced arms of "American" Pulleys cut the air and save enormously on power. Belt slip is reduced to a minimum. "Americans" are guaranteed to perform double belt duty under all conditions not demanding a special pulley. They are capable of enduring higher speeds than any other standard metal pulley.
FREE BOOK—"Pulley Efficiency" sent on request. Full of money-saving pulley information.
The American Pulley Co.
4208-60 Wissahickon Ave. PHILADELPHIA, PA.
New York, Cor. Grand and Greene Sts. Boston, 165 Pearl St. Chicago, 124 S. Clinton St. Seattle, 536 First Ave., South.



Write for Details and Samples

TRY A GILMER ENDLESS BELT

For driving high-speed machinery—light grinding machines, polishing heads, drills, motors, etc.—the Gilmer Endless Woven Belt is without equal. It is dependable, insures smooth, even running, is pliable and does not slip.

Gilmer Belts are long lived—do not stretch, are not affected by oil, dust or moisture and are adapted for special conditions.

Made in single or double thickness, any specified length; regular widths from ½ to 6 inches—specials to specifications.

L. H. GILMER CO., Tacony, Philadelphia, Pa.

95% of All Cars Carry Them

Not *One* Report of Breakage

A MARVELOUS record has been made by Hoover Balls in *service*. We make 25,000,000 *new* balls *daily*. During the *four* years of our 800% production increase, with *billions* of balls in *service*, not a *single* case of breakage has been reported.

The Hoover chrome steel, hard surface, tough center construction *eliminates breakage* by providing for steel contraction and expansion and allowing for fatigue in service. Our research laboratory will build *the* right ball for *your* service. Booklet free.

Hoover Steel Ball Company
Ann Arbor, Mich.

HOOVER Steel Balls

GWILLIAM SERVICE

BALL and ROLLER BEARINGS

ANNULAR—Single and Double Row
BALL THRUST—All Types
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AUTOMOBILE, MOTOR BOAT and TRUCK BEARINGS

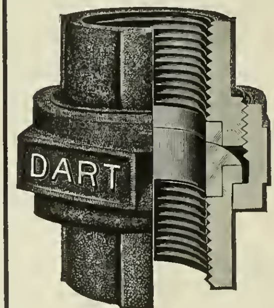
STEEL BALLS

Sole Agents for the United States of
THE BOWDEN PATENT WIRE MECHANISM
for the transmission of reciprocating motion through a Flexible and Tortuous Route

THE GWILLIAM COMPANY
Engineers and Specialists

NEW YORK, 253 W. 58th St. Phone: Columbus 8355
PHILADELPHIA, 1314 Arch St. Phone: Walnut 3497

Like the Statue of Liberty



The life of a pipe union is limited by the capacity of the seats to resist rust and corrosion. Take a look at Bartholdi's statue, which has been exposed to the elements for 30 years, and you will get an idea of the lasting quality of the "bronze to bronze" seats of Dart Unions.

A sample sent on request, also complete list of Dart Ells, Tees, Flanges, etc.

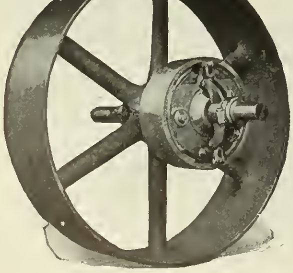
E. M. Dart Mfg. Co.
Providence Rhode Island

The Fairbanks Co., Sales Agents. Canadian Factory: Dart Union Co., Ltd., Toronto.

F. BROWN'S PATENT FRICTION CLUTCH COUPLINGS AND PULLEYS

FOR HIGH SPEED — FOR HEAVY DUTY

ENGINEERS — ESTABLISHED 1854 — FOUNDERS
THE A. & F. BROWN CO.
79 BARCLAY ST. NEW YORK
MACHINISTS — MILLWRIGHTS

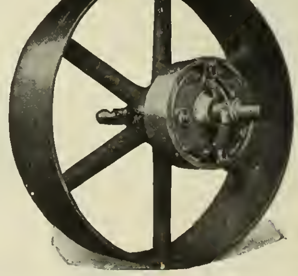


FRICTION CLUTCH PULLEY

POWER TRANSMISSION MACHINERY

GEARS

FOR MOTOR, MACHINE, MILL OR POWER PLANT
ROPE DRIVES A SPECIALTY



FRICTION CLUTCH PULLEY

We lay out, make the drawings, furnish the material, and erect it. Special machinery built to drawings and specifications.

WORKS:—ELIZABETHPORT, N. J.

The Pedrick Column Boring Machine Is Needed In Your Shops This Minute

Orders are coming in for this machine in groups — not singly. And as soon as its merits are generally appreciated larger numbers will be wanted.

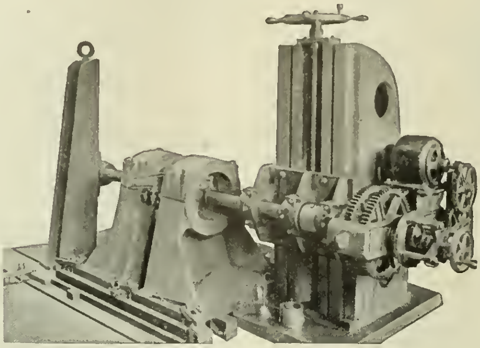
Even a casual inspection will impress these facts:

Simplicity
Range of Work
Power
Moderate Price

The unusual boring capabilities of the machine afford new methods of doing work. The boring bar may be passed through the work with a cutter head traveling along the bar to do the boring, or the bar feeds in the regular manner with the cutter keyed fast or operating auxiliary boring bars. The machine may be set-up in a permanent position or it may be taken to the work.

If you need more boring machines these advantages must appeal to you. We have the machine; it has been tried out and is not an experiment.

Send for your circular now.



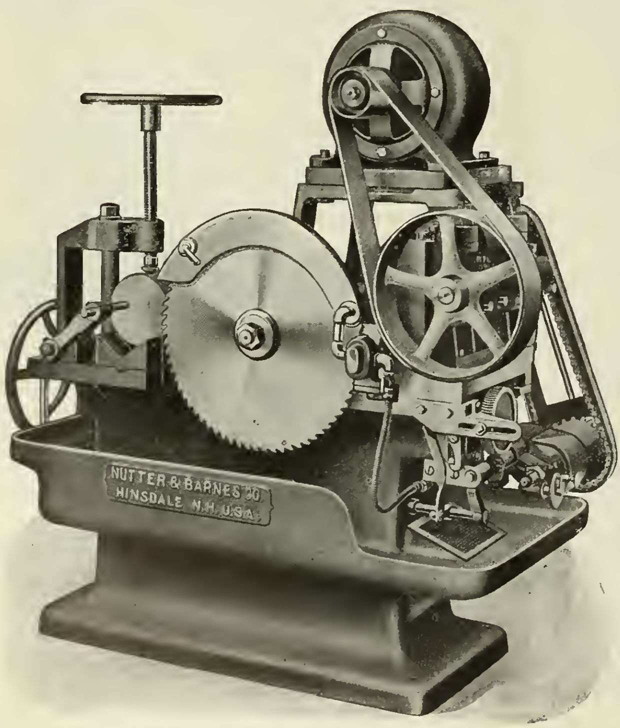
Boring and Facing a Pair of Pedestals

PEDRICK TOOL & MACHINE COMPANY

3639 North Lawrence Street
PHILADELPHIA, PA.

Manufacturers of Portable Cylinder Boring Bars, Crank Pin Turners, Pipe Benders, Portable Milling Machines, etc.

Nutter and Barnes Cutting-Off Machines



Massiveness without clumsiness, convenience without superfluous parts, speed, accuracy and range—all combine to put these machines in a distinct class. Size of saw considered, their capacity is greater than any other cutting-off machine; their economy in blades and saw kerf is remarkably high, while their ability to stand hard, driving service is a factor that insures highest returns on the investment.

Complete Details in Catalog.

NUTTER & BARNES CO.

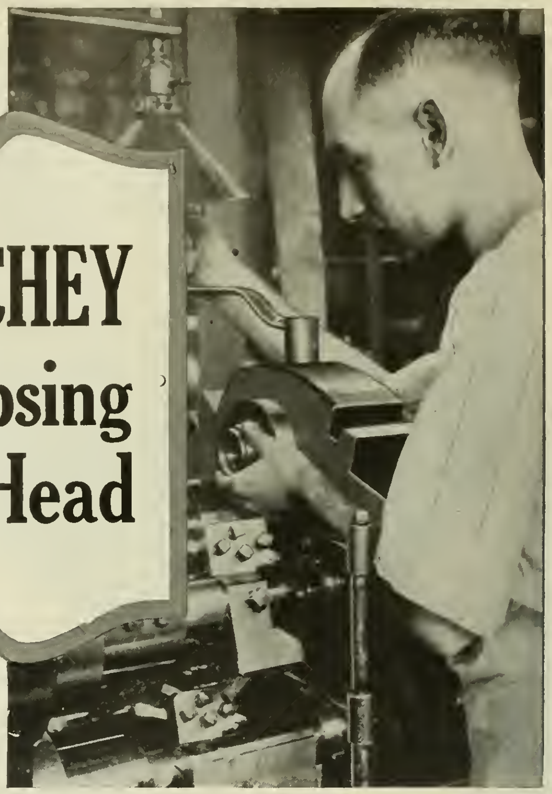
The Metal Cutting-Off Machinery Specialists

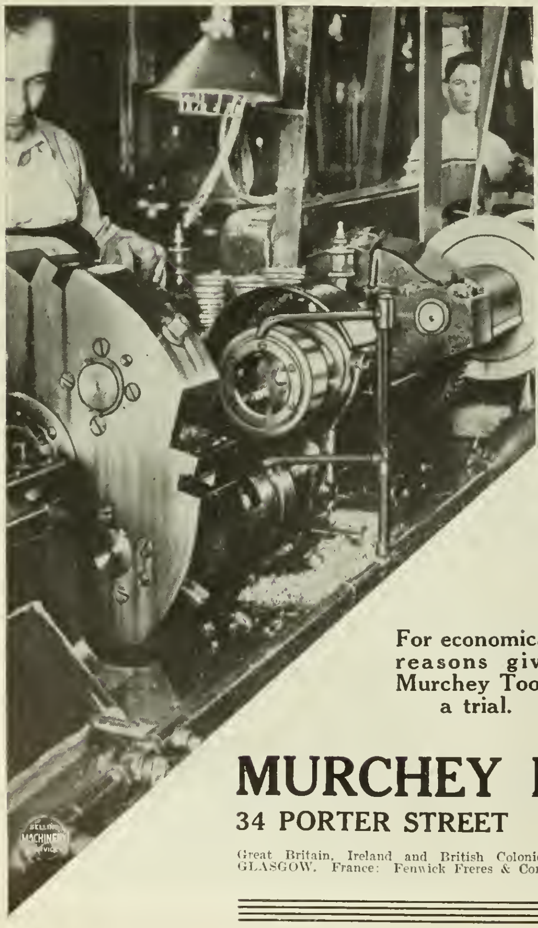
HINSDALE - NEW HAMPSHIRE

13 South Clinton Street, Chicago

FOREIGN AGENTS: England, Alfred Herbert, Ltd., Coventry, England. Scandinavia, Wilh. Sonesson & Co., Ltd., Malmo, Sweden; Copenhagen, Denmark. Russia, C. Schinz, Petrograd. Allied Machinery Co. of America, 19 Rue de Rocroy, Paris, France; Via XX Settembre 12, Turin, Italy; 16 Seidengasse, Zurich, Switzerland; Ekaterininskaya 6, Petrograd, Russia; Malaya Lubianka 16, Moscow, Russia. Spain, Socieded General de Representaciones, Madrid. Australia, A. Asher Smith, Sydney. South America, A. G. Burbanks, Buenos Aires, A. R. DOMESTIC AGENTS: Swind Mchy. Co., Philadelphia, Pa. Patterson Tool & Supply Co., Dayton, Ohio.

MURCHEY Collapsing Die Head





750 in 10 Hours

These pictures were secured recently from a western manufacturer who has a habit of short-cutting his way to results with the best equipment that can be bought.

They show Murchey Die Heads—12 of 'em—operated on 12 New Britain Automatics, cutting the threads in nose pieces for 3″ shells. Thread is 2½″ diameter, 20 pitch Wentworth, 5 threads to the piece.

The Murchey "Automatic" combination turns out accurately threaded nose pieces at the rate of *750 in 10 hours*, each machine, or *9000 in 10 hours* from the twelve.

Murchey Tools are high speed thread cutters. Their work is clean cut, accurate, finely finished and economically done. Practically every threading operation can be handled with taps and dies picked from the Murchey stock. If special tools are required we can furnish them in short order.

For economical reasons give Murchey Tools a trial.

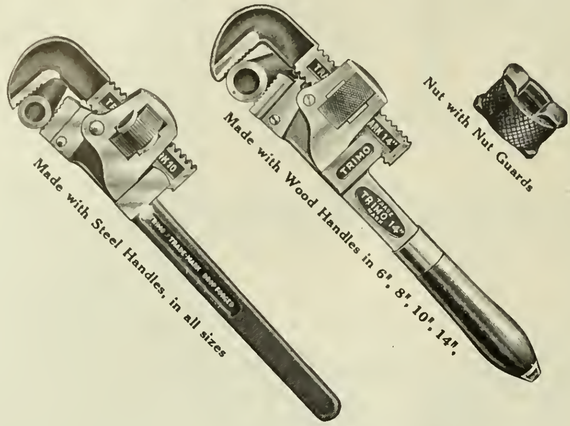
MURCHEY MACHINE & TOOL CO.

34 PORTER STREET **DETROIT, MICHIGAN**

Great Britain, Ireland and British Colonies, Coats Machine Tool Company, Limited—LONDON — NEWCASTLE-ON-TYNE — GLASGOW. France: Fenwick Freres & Company, 8 Rue de Rocroy, PARIS.

When Ordering STILLSON WRENCHES Demand TRIMO with the Steel Frames and Nut Guards

Of all Stillson Wrenches TRIMO is the Best

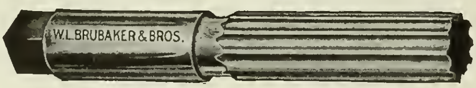


SEND FOR CATALOG No. 38.

Made by TRIMONT MFG. COMPANY

55-71 Amory Street **Roxbury, (Boston), Mass.**

BRUBAKER TOOLS



No detail of equipment bears more directly upon production than small tools. Machines may be first class, workmen thoroughly competent, but output will never reach the mark it should unless the tools complete the triangle. If you are still retarding output by the use of inferior tools it's time Brubaker's got a chance. Brubaker Tools are quality tools through and through. They embody the best in design, material and workmanship. They will reduce screw cutting costs, insure good work and are dependable under all conditions.

Send your next order to Brubaker.

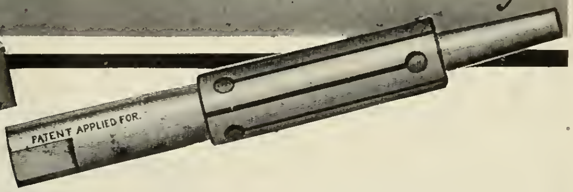
W. L. BRUBAKER & BROTHERS

MILLERSBURG EASTERN REPRESENTATIVES: F. E. Harrison, 50 Church Street, New York. W. Searls Rose, 50 Church Street, New York. **PA., U. S. A.**

CHAMPION

TOOL HOLDERS — MANDRELS

for Heavy Cuts — *Hold Securely*



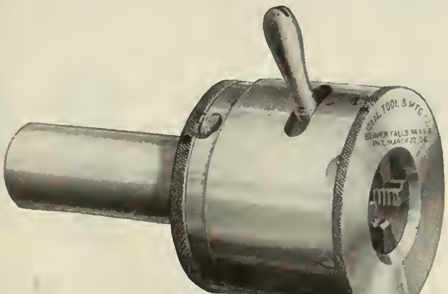
Not only for heavy cuts, but also for reducing tool costs. Champion Tool Holders are made with the big head construction which gives solid support to the cutter proper, permits taking the heaviest cuts on modern machines, saves 75 per cent of high-speed steels and lowers grinding costs. Adapted for planer, shaper or lathe and made in all types.

Champion Expanding Mandrels hold securely because they expand uniformly and grip positively *without distorting* the work. One of the greatest economies you can make is to junk your whole stock of solid mandrels for Champion Expanding Mandrels.

Let us show you.

THE WESTERN TOOL & MANUFACTURING CO., Springfield, Ohio, U.S.A.

FOREIGN AGENTS: Alfred Herbert, Ltd., Great Britain, Italy, France, etc. V. Lowener, Copenhagen, Stockholm. Spliethoff, Beeuwkes & Co., Rotterdam. W. R. Grace & Co., Chili, Peru and Bolivia.



IDEAL ALL WAYS

Manning, Maxwell & Moore, Inc.,
119 W. 40th St., New York City.

Swind Machinery Co.,
Widener Bldg., Philadelphia, Pa.

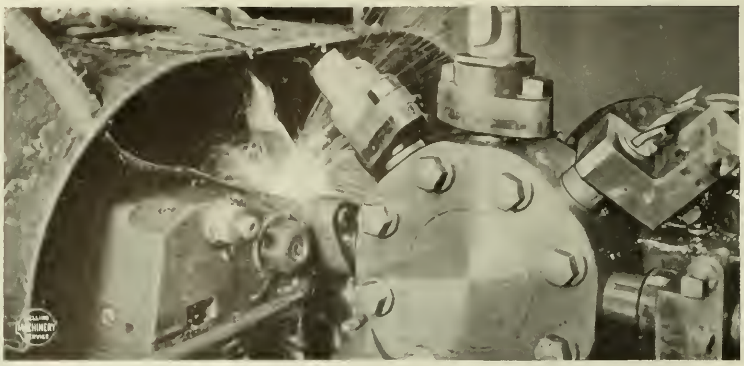
H. E. Barton Tool Co.
106 South Jefferson St., Chicago, Ill.

IDEAL DIES

Are big time savers. They make it possible for you to obtain clean, straight, absolutely accurate threads at a fast rate of production. They are simple in construction; have fewer parts than any other similar tool; can be quickly and easily taken apart; cut either right or left hand threads. Prompt deliveries on both dies and chasers.

THE IDEAL TOOL & MFG. COMPANY

BEAVER FALLS, PENNA.



Climax Mineral Lard Oil

Best for Many Purposes

CLIMAX Mineral Lard Oil is a scientific combination of the best fatty oils and has been used successfully for 40 years for all manner of cutting operations. It can be used as a base for many cutting oils or can be used straight, and if desired may be readily converted into a water solution by the addition of a small quantity of sal soda and water. It prolongs the life of tools and increases output; does not gum, separate or turn rancid; does not cause infection in open wounds. Truly, for many purposes Climax is without an equal.

Send for samples and give Climax a thorough tryout on your machine.

FISKE BROS. REFINING COMPANY

24 STATE STREET Manufacturers of the well-known Magic Soluble Oil and Magic Cutting Compound **NEW YORK CITY**

THREADING OIL

Can save you money. First, because it means longer life for your dies by really keeping them cool. Second, because it goes twice as far as the best of winter-strained lard oil, and third, because a threading job treated the Ex-El-Ard way need never be done over—smooth, firm threads the first time.

Here's the big reason for Ex-El-Ard's superiority, and it's worth remembering. **There is only 2% of free fatty acid (the deadly enemy of all metals) in Ex-El-Ard, while the best grade of lard oil has seldom less than 6%.**

Your jobber or the manufacturers will be mighty glad to send you a ten-gallon can of Ex-El-Ard on thirty days' free trial, and will be equally glad to have you return it if it doesn't live up to their claims.

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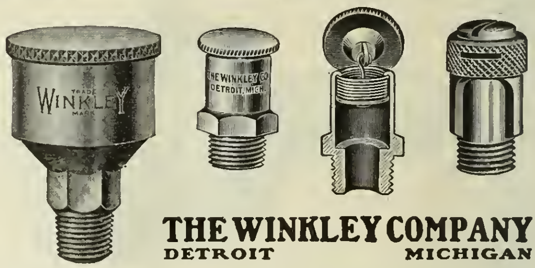
GREASE CUPS

OILERS AND OIL CUPS

Send for Catalogues today.



THE WINKLEY COMPANY

DETROIT MICHIGAN

SPECIALIZED ON OIL CUPS

Style-C Style-E Style-I Style-B Style-T

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GITS OIL CUPS

Give perfect satisfaction where others fail. State style and size in which you are interested, and we will send free samples and catalog.

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GITS BROS. MFG. CO.
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Style-Z

HIGHEST QUALITY LOWEST PRICES

If Germany Saves the Oil from Waste, Why Shouldn't We?

"A recent report says that Germany has discovered a new process for extracting oil from cleaning waste. It is estimated that 18 million Kilograms of oil have thus been recovered."—From the *New York Evening Mail.*

OAKITE

CLEANS WASTE AND CLOTHS

from 50 to 150 times at a cost of ½ cent per pound for waste and ⅛ of a cent per cloth.

A thorough soaking in OAKITE Solution, then a simple steam wash, and waste is absolutely clean and a better absorbent than when new.

OAKITE cleans on a new principle. It emulsifies oils and greases—breaks them up into finely-divided particles, thus destroying their adhesive nature. This is a purely physical action. That is why the oil may be reclaimed from waste and cloths and used over and over again. It is not affected chemically or physically—does not lose any of its original properties.

OAKITE absolutely will not injure fibres—neither will it injure the hands. It contains no acid, lye, sal soda, caustic, soap, washing powder, grease, fat or oil.

Our Service Department will show you how to save oil which is ordinarily thrown away. We have a staff composed of men who know cleaning from every angle. Their services are freely at your disposal. Send for one of them and let him demonstrate OAKITE in your plant for you.

Thirty-day Trial Offer

Write for details of our offer to send a barrel of OAKITE on thirty days' trial subject to the terms of our Positive Guarantee

OAKLEY CHEMICAL COMPANY

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MACHINERY FORGINGS

When you're in the market again for high-grade forgings let us show you why we should fill all your orders in the future.

We can make any forging that a manufacturer of machinery needs, and have the facilities to insure prompt deliveries regardless of the detail of specifications. We offer choice of material and finish and you'll find our prices right.

Let us quote on that next order.

The Machinery Forging Company

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No. 10

BRONZE

For Grinder, Lathe and other Machine Tool Bearings

Booklet upon request.

Lumen Bearing Company

BUFFALO, N. Y., U. S. A.

Established 1902

MOBERG DIE CASTINGS

We do not claim to be the only die casting concern in the country, but have customers who say we are.

C. J. MOBERG, Inc., Beach St., Mt. Vernon, N. Y.

FLEXIBLE STEEL TUBING

For Supplying Lubricant to Machine Tool Cutters

Strong, durable and warranted tight. No packing. All steel construction. Made in sizes ⅛ to ¾".

We are supplying many big machine tool builders—why not you? Write for details and samples.

WHEELOCK MFG. CO., Wheelock, Vt.

The price of tin has been sky-rocketing for some months, and its rise does not seem to be spent.

Present purchasers of Genuine Babbitt Metal are obliged to pay an almost prohibitive price.

This is reason enough for you to get acquainted with Ajax Bull Babbitt, even if it did not have greater anti-frictional qualities, if it did not wear longer, and if it were not sold at a much lower figure.

Write now for an introduction, and remember that it will be to the advantage of your purse.

THE AJAX METAL COMPANY
Established 1880

Main Office and Works, Philadelphia, Pa.
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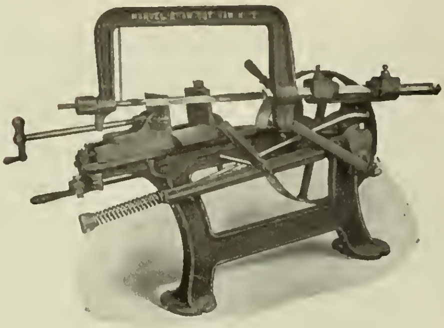
OFFICES

New York, Boston, St. Louis, San Francisco, Chicago, Washington, Pittsburgh, Detroit

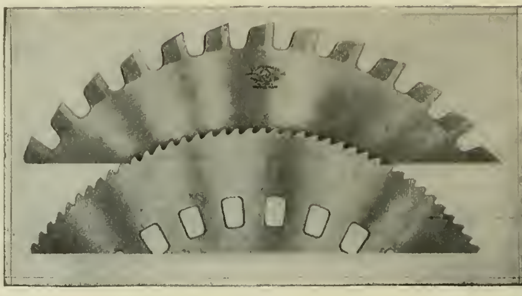
Marvel Draw Cut Hack Saw No. 2



Strong and rigid in construction, accurate, fast and economical in operation. Provided with adjustable stroke, quick-action heavy swivel vise that swivels both ways, automatic stop, means for taking up wear, etc. Capacity on long stroke, 6″ by 6″; on short stroke 8″ by 8″. Blades 12″ to 17″. One of the most profitable machines of its class from every standpoint, and very moderately priced. *Details in catalog.*

Armstrong-Blum Manufacturing Company
343 North Francisco Avenue
CHICAGO ILLINOIS, U. S. A.

ATKINS
METAL SAWS



We make them for every purpose—hot or cold cutting, and for all makes of machines.

The economy of their use is worth your investigation.

Write for Metal Saw Treatise "M."

E. C. ATKINS & CO., Inc.
The Silver Steel Saw People.
Home Office and Factory - Indianapolis, Ind.
Canadian Factory - - - - - - - Hamilton, Ont.
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Branches carrying complete stocks in all large distributing centers, as follows:

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The HIGLEY
COLD METAL SAW

Catalog furnished by

Vandyck Churchill Co.
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SHAPERS EXCLUSIVELY

12″ to 32″ Stroke

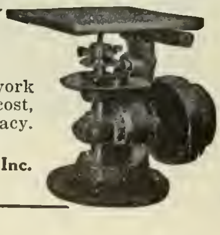
SMITH & MILLS CO.
CINCINNATI, OHIO, U. S. A.

FOREIGN AGENTS: C. W. Burton, Griffiths & Co., London. G. & F. Limbourg Freres, Brussels. Van Rietschoten & Houwens, Rotterdam. Glaenzer, Perreaud & Thomine, Paris. Stussi & Zweifel, Milan.

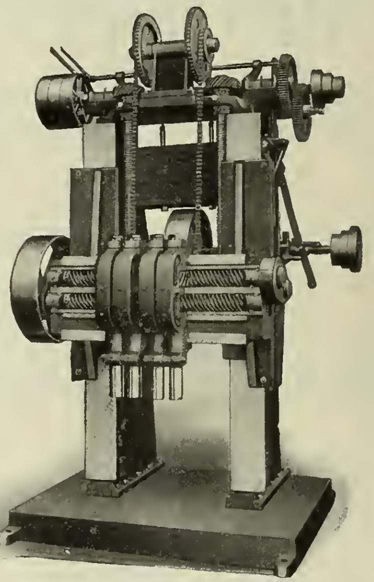
A "HARTFORD" Die Filing Machine

accomplishes many times more work than hand filing, at the same labor cost, and does it with greatest accuracy. More details on request.

THE ROBINSON TOOL WORKS, Inc.
Waterbury, Conn., U. S. A.



The "HOLE HOG" Line



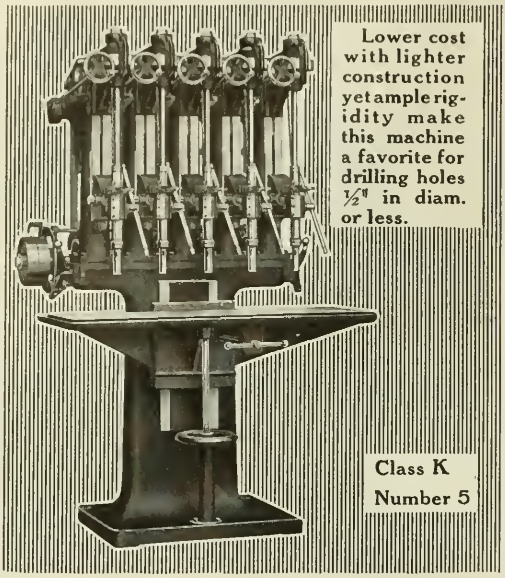
No. 7 D CYLINDER BORER

The type you need for progressive manufacturing of truck and tractor motors.

MOLINE TOOL CO., Moline, Ill.
MULTIPLE DRILLING AND BORING MACHINERY

HENRY & WRIGHT

Drilling Machines



Lower cost with lighter construction yet ample rigidity make this machine a favorite for drilling holes ½" in diam. or less.

Class K
Number 5

The Henry & Wright Mfg. Co.
Hartford, Conn.

ITS TRADE A MARK SIPP

FEATURES

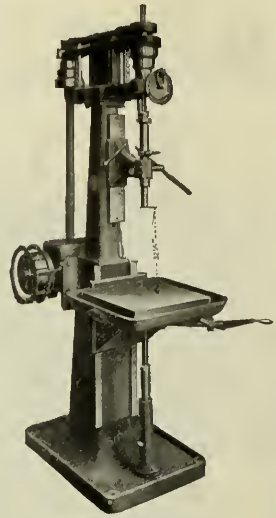
Quick Change Speed
Change in 2 seconds

Most Efficient Drive
No belt troubles

Safety First
All parts protected

Heaviest Drill Made
Yet very sensitive

All Ball Bearings



The Right Speed

You get accuracy and bigger output with

The Sipp Quick-Change-Speed Drill

because the speed can be changed in two seconds, hence the right speed for the job will naturally be used. *Write for Bulletin No. 4.*

THE SIPP MACHINE CO., Paterson, N. J.

"Accuracy First"

and the

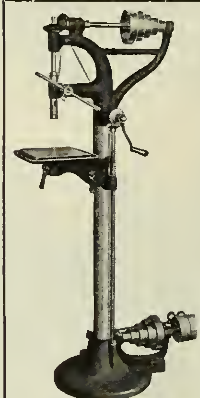
TURNER TURRET

In one of the big shops at Greenfield, Mass., precision drilling, reaming, tapping, etc., are handled on the Turner Turret in a manner that satisfies the demand for accuracy and throws in speed for good measure. On the Turner Turret illustrated the operator is drilling die heads, one hole two diameters, one of which is also reamed. The three tools are indexed automatically, completing the operations and putting through the entire lot in remarkably fast time.

The Turner Turret saves 30 to 60 per cent of time and economizes labor—therefore reduces costs. And it's a mighty wide range machine.

Write for Complete Catalog

Turner Machine Company
DANBURY, CONN. and NEWARK, N. J., U. S. A.
Incorporated with Turner, Atherton & Co., Ltd.
Denton, Manchester and Stockport, England.



THE LINDGREN

13-Inch High Speed Drill

All bearings are bronze bushed and provided with ring oilers. The spindle has ball thrust bearings. The sleeve is graduated in inches.

New lubrication features
No leakage of oil

F.W. LINDGREN CO.
ROCKFORD ILLINOIS, U. S. A.

Radial Drills, High Speed Sensitive and Plain Radial Drills

Manufactured in sizes 2½, 3, 3½ and 4 foot by

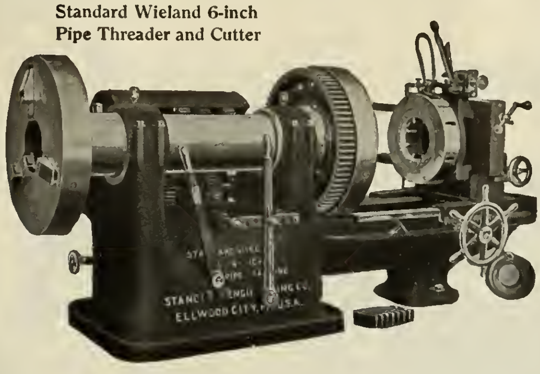
THE CARLTON MACHINE TOOL CO.
Successors to
The William E. Gang Company, Cincinnati, Ohio

JOHNSON 14" SENSITIVE DRILL

A most practical machine for the purpose for which it was built—to drill 9/16" holes and under with speed and accuracy that make for greatest efficiency. The "Johnson" spindle and the other features of construction will interest you. Ask for details.

Johnson Machine Tool Co., Gouverneur, N.Y.

Standard Wieland 6-inch Pipe Threader and Cutter



Thread Pipe Do You? How?

The modern, efficient way is the Standard Wieland way, with a heavy, sturdy, durable machine, simple and positive in operation, fast and accurate in production. This machine costs more and is worth it; character and quantity of output prove it.

A few features: One-piece bed; single-speed pulleys; gear speed changes through semi-steel cut gears; deep chasers, cutting long taper threads in one cut perfectly, steel as well as iron pipe.

Send for the circular.

Standard Engineering Company
Ellwood City Pennsylvania
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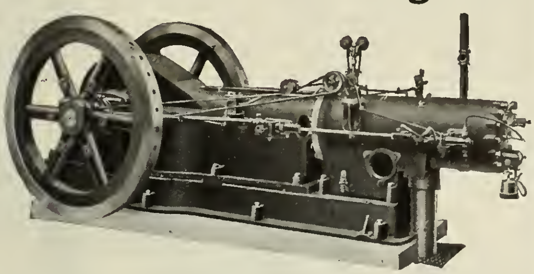
Much Power for Little Money

CAN BE OBTAINED FROM

Giant Fuel Oil Engines



Will operate air compressors, generators, hoists, pumps and machinery of all kinds. Runs on Fuel Oil, Star Oil, Calol, Stove Oil, Solar Oil, Diesol, Kerosene, etc.

Made in sizes 20 to 160 horsepower
Single or Duplex

We also manufacture Chicago Pneumatic Simplate Valve Compressors in 300 sizes and styles, Hummer Hammer Self Rotating Rock Drill, Little Giant Drills, Boyer Hammers and Duntley Electric Tools.

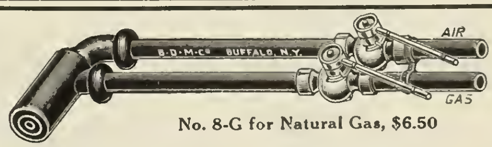
Ask for Bulletin 34-W

CHICAGO PNEUMATIC TOOL COMPANY
1060 Fisher Bldg. CHICAGO — 52 Vanderbilt Ave. NEW YORK
Branches Everywhere G-3

A Machinery Finish for Every Need

The Glidden Varnish Company.
Cleveland, Ohio.

GLIDDEN
Machinery Finishes



No. 8-G for Natural Gas, $6.50

PREHEATING BLOWPIPES

The two most essential points in welding are:
FIRST: The use of a proper sized oxy-acetylene flame.
SECOND: The saving of gas by preheating your work for the oxy-acetylene flame.
The first is under your control in the use of the oxy-acetylene apparatus you have selected.
The second we can aid you in by supplying the proper blowpipe for preheating purposes.
We manufacture blowpipes for use with Coal Gas, Natural Gas, Gasoline Gas and Acetylene Gas, with Air Blast.
Our catalog "B.M.," free for the asking, contains full description and prices. WANT ONE?

BUFFALO DENTAL MANUFACTURING CO., Buffalo, N. Y., U. S. A.

W. S. ROCKWELL CO. INDUSTRIAL FURNACES ESTABLISHED 1888 NEW YORK

Rockwell Furnaces

FOR

ANNEALING	HARDENING	MELTING
FORGING	HEAT-TREATING	TEMPERING

Write for Catalog 21

W. S. ROCKWELL CO., 50 Church St., New York

THE SAUNDERS—
for Quick and Accurate Pipe Threading and Cutting

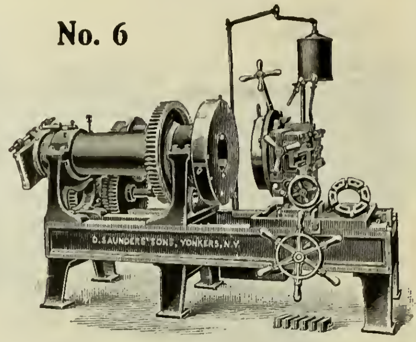
Saunders No. 6 is built for business and embodies every facility for quick and accurate service.

Special gearing gives ample power, without large pulleys and tight belts. Cone pulleys and interchangeable gearing—controlled by lever—vary speeds according to sizes to be cut. The adjustable die head—our patent—with interchangeable chasers, threads from 2½ to 8 inches and releases pipe without stopping or reversing the spindle. There are no complicated attachments—the whole mechanism is direct and easy to operate.

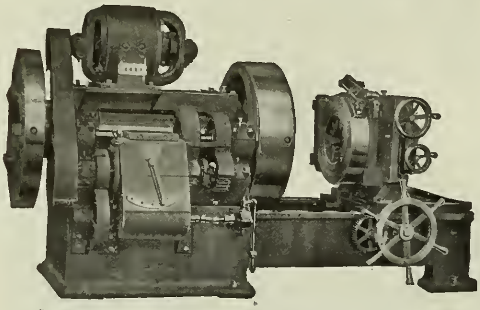
Complete Description in Catalog "P."

D. SAUNDERS' SONS, Yonkers, New York

No. 6



The Method of Drive is an Important Thing in a Pipe Machine



Because a lot of time is wasted if the speed is not just right for every size and material of pipe.

The "Stoever" Pipe Machine

has a single-pulley drive with gear speed variation. This means that the belt speed is constant, not lowest when it should be highest. The belt tension is always proportional to the power transmitted—economy of power. The belt contact is constant and always adequate.

The "Stoever" has a friction countershaft which eliminates shifting belts and saves at least one-third in belting cost.

The gear speed variation affords a speed exactly right for every size of pipe, and for iron or steel. This means maximum cutting and threading speed.

Write for the "Economy" Booklets.

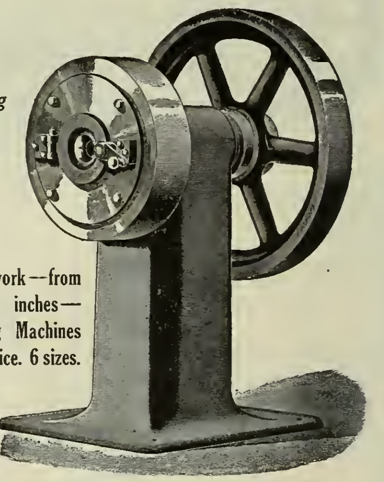
TREADWELL ENGINEERING CO.
Sales Office: 140 Cedar Street, New York
Works: Easton, Pa.

T E 1v

SAVE METAL—
Swage Your Rods and Tubes

Perhaps you have never considered the amount of metal wasted cutting and grinding stock to form. Swaging eliminates this waste and is a process which actually makes the metal stronger and more durable.

Our Catalog is Complete and Interesting.

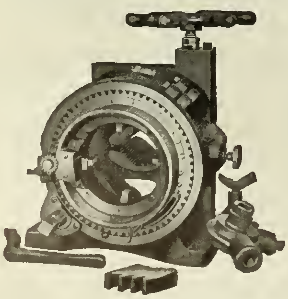


For all small work—from .015 up to 2 inches—Dayton Swaging Machines give the best service. 6 sizes.

THE EXCELSIOR NEEDLE CO., Torrington, Conn.

Coventry Swaging Co., Ltd., White Friars Lane, Coventry, England, Agents for Great Britain. Fenwick Freres & Co., 8 Rue de Rocroy, Paris, France, Agents for France, Italy, Belgium, Spain, Portugal and Switzerland.

The "Forbes" for Better Thread Cutting



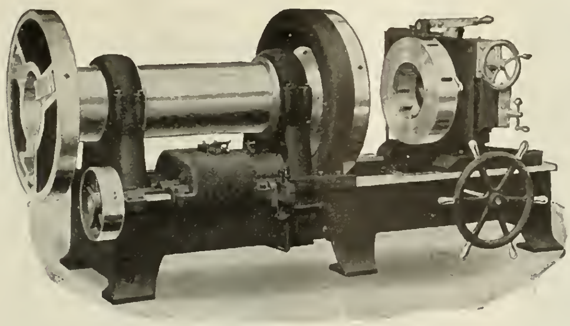
Every user of "Forbes" Machines is firmly convinced that they handle pipe cutting and threading easier, quicker and more accurately than any similar machine. The "Forbes" doesn't have a lot of extra parts; it is complete in itself, can be moved readily from one place to another, has interchangeable parts and adjustments for wear. By reason of these advantages and the exclusive "Forbes" feature of revolving the dies instead of the pipe, one man can easily cut off and thread pipe up to 15″ in diameter.

Full line of "Forbes" machines in catalog.

THE CURTIS & CURTIS COMPANY
8 GARDEN STREET BRIDGEPORT, CONN.

PEERLESS B&K DUPLEX P.D.Q.

PIPE THREADING



DON'T handicap your men with poor tools. Give them pipe machines that can be operated easily and quickly, and with the assurance that the threads will be good. Beveled, high speed steel cut-off tool, speed change gear-box, rotary oil pump and the Peerless Die-head all go to make up a dependable, lasting pipe machine.

Send for the catalog

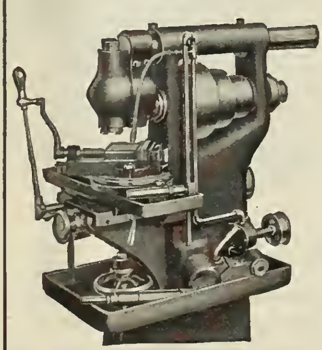
BIGNALL & KEELER MACHINE WORKS, Edwardsville, Ill.

Smalley-General Thread Millers

For Shells and General Use.

SMALLEY-GENERAL COMPANY
BAY CITY, MICHIGAN

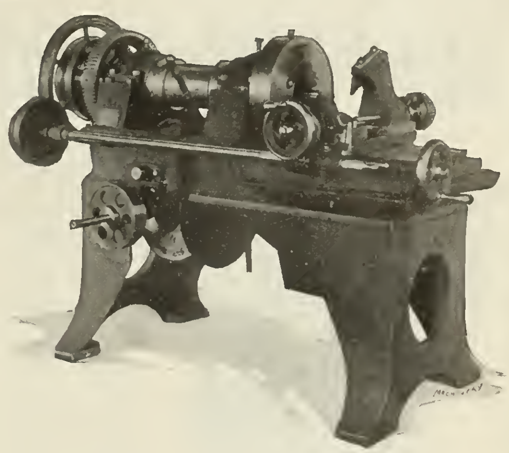
BICKFORD MILLER



Small machine; big range. Does both horizontal and vertical milling on medium and small work and is a star at light finish cutting on duplicate parts. It is accurate, speedy and the easiest kind of a machine to operate. If you are looking for big output on light work, buy a "Bickford."

Write for details

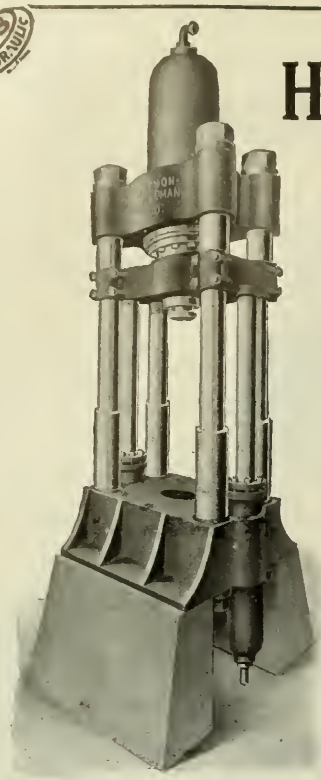
BICKFORD MACHINE CO.
GREENFIELD MASS.



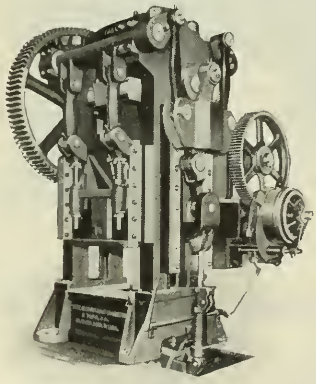
Speed Up your Stock Cutting

The Hurlbut-Rogers Two-tool Cutting-Off Machine will do it. It's a machine of great strength and power, holds stock rigidly, stands hard driving. Cuts are taken in half the time required for a single tool machine. H-R accuracy, speed and ease of operation are trump cards in the game of rapid production. Capacities up to 10".

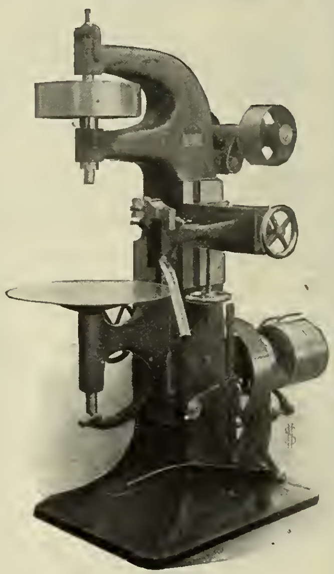
THE HURLBUT, ROGERS MACHINERY CO.
South Sudbury, Massachusetts



600 Ton Hydraulic Press For Piercing Steel Billets



Patent Applied for



THE METALWOOD Crankshaft Straightening Press

Reg. U. S. Pat. Office

This press is built in 20-ton and 35-ton sizes, and is particularly adapted for straightening crankshafts. Both sizes are made in three styles, for direct drive from accumulator line, with built-in pump for belt drive from lineshaft, also as a self-contained and movable unit. The straightening centers are adjustable for length and the steel tracks on which they travel are removable for wear. The machine is rapid in operation and a close degree of accuracy is obtainable through the prompt and exact action of the "Metalwood" Patent Operating Valve.

Let us send more detailed description

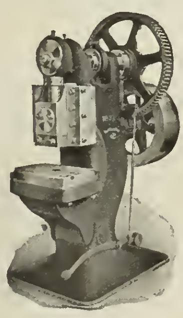
Metalwood Manufacturing Company, Detroit, Mich.

Designers and Builders of High Speed Hydraulic and Special Machinery for all purposes

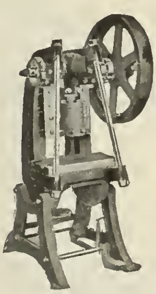
COMPLETE HYDRAULIC INSTALLATIONS.

R. E. Ellis Engineering Co., 549 Washington Blvd., Chicago, Ill., Sales Representatives. For Great Britain and Continent, address Gaston E. Marbaix, Coronation House, 4 Lloyds Ave., London, E.C., England.

Niagara Power Presses



Geared Punching Press



Inclinable Power Press

No matter what your requirements may be, there's a Niagara to answer the call; any size, single and double action, single and double crank, up to 10′ between housings.

Niagara Presses are all of extremely massive design and closely finished to the finest detail. Shafts are forged from high carbon steel, ways of slides and gibs are long and wide, slides are of box construction and ways well braced. Many other features fully described in catalog. Write.

Niagara Machine & Tool Works

BUFFALO, N. Y., U. S. A.

Hydraulic Presses and Pumps

WE specialize in them and build nothing else. Our plant was built, our machinery designed, our organization selected with no other end in view than manufacturing hydraulic press equipment to fit your pressing needs. That we have succeeded is evidenced by the fact that we are doubling our capacity to take care of the business coming to us.

The press shown here is designed for general forcing work in machine, railroad, automobile and repair shops. It is a particularly convenient press for general work and is only one from our extensive line.

Let us submit expert information on any type of hydraulic press for work such as forcing, forming, flanging, forging, drawing, baling, broaching, die, arbor, etc.; also hydraulic pumps. Write us today.

The Hydraulic Press Mfg. Co.

84 Lincoln Avenue

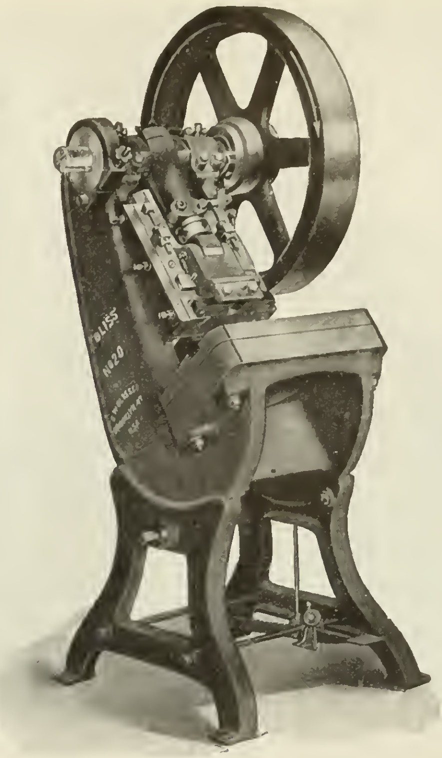
MOUNT GILEAD, OHIO

Branch Offices: Room 1105-R, 39-41 Cortlandt St., New York City; 427-D Guardian Bldg., Cleveland, Ohio; Division B, 32 N. Clinton St., Chicago, Ill.

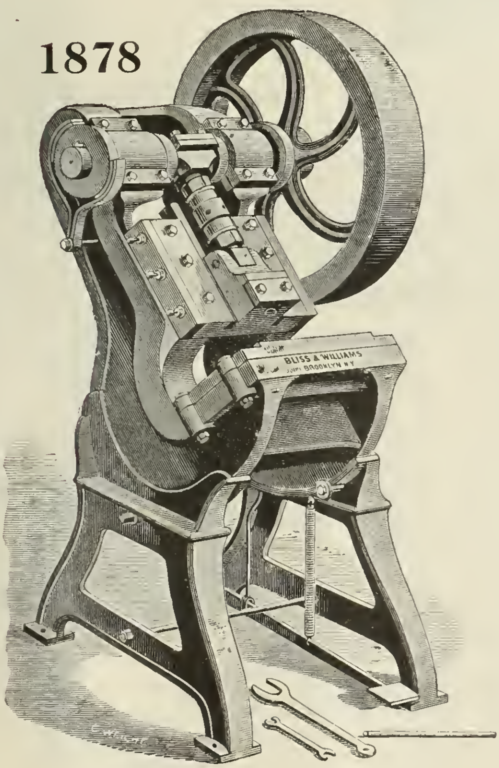
Thirty-Nine Years Young

"We built this Press RIGHT in the beginning."

IT is the exceptional thing in machinery manufacture that a design is so well conceived at its inception as to retain its original form over a long period of time. Still more unusual is a steady increase in popularity and demand.



1917



1878

"BLISS" INCLINABLE PRESSES

afford a striking example of this. Their adaptability to a wide range of work and their wonderful convenience and economy in operation have proved them the most practical of machine tools for manufacturing articles of sheet metal. They have been refined but not changed fundamentally. Their use has extended into so many new lines without imposing material change in design that they have become an accepted standard in the trade. We have devoted especial effort to standardizing their manufacture and providing every desirable improvement. "Section 2A" gives interesting and valuable information. Send for it.

E. W. BLISS COMPANY

1857 1917

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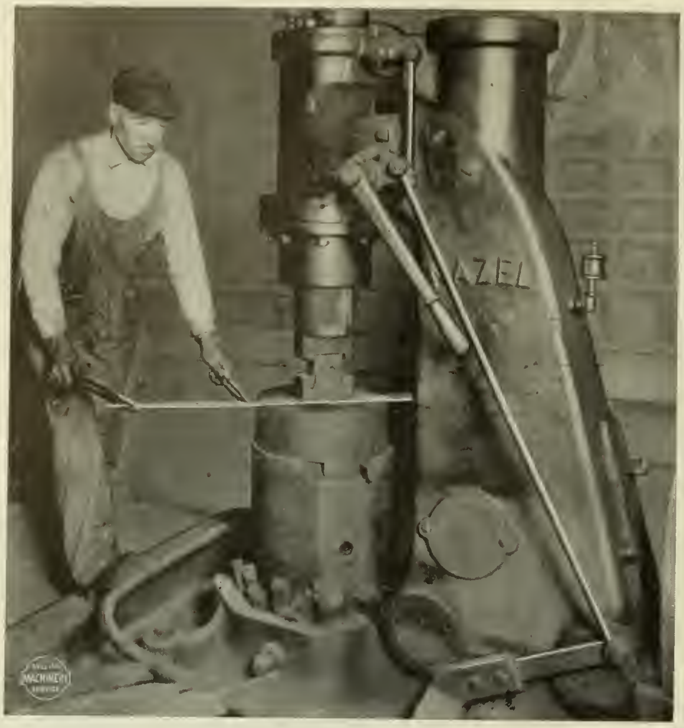
LONDON, S. E., ENGLAND, Pocock St., Blackfriars Road. PARIS, FRANCE, 100 Boulevard Victor-Hugo, St. Ouen.

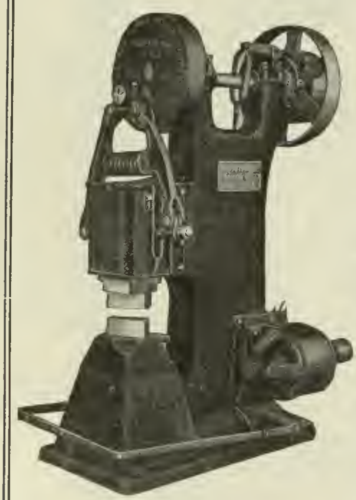


Forging Thin Stock is Hard on a Hammer

Every time the ram of this Nazel Hammer descends, the punch and die come within 1/8" to 1/4" of meeting, the hammer itself absorbing much of the shock of the blow. William H. Horn & Bro., Inc., Philadelphia, have used this hammer constantly for four years on thin tool steel parts for surgical appliances. They say, "It hasn't cost us five cents for repairs."

It takes a hammer built and operated like the Nazel to stand work such as this. There's practically no limit to Nazel usefulness. Ask us questions.

NAZEL ENGINEERING WORKS, Philadelphia, Pa.
4043 NORTH 5th STREET



LITTLE GIANT POWER HAMMERS

Motor or Belt Driven. 250 lb. Ram. 200 r.p.m.

Machine gun rapidity and precision.

Sold on 30 days' free trial.

Prompt shipments. Will easily forge stock 5½ in. square or 7 in. round.

Special dies for any forging purpose.

Also made in 25, 50, 100 and 500 lb. sizes.

Upkeep expense averages less than 2/5 of 1 per cent annually on all our hammers in use from first one sold 24 years ago to last one shipped.

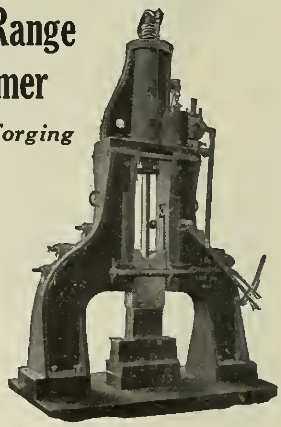
LITTLE GIANT POWER HAMMERS are guaranteed forever against defective material and workmanship. Let us send you one on 30 days' trial. Write your jobber or direct to us.

MAYER BROS. CO.
131 W. Rock St., Mankato, Minn., U. S. A.

MAYER BROTHERS COMPANY MANKATO MINN. U.S.A. LITTLE GIANT

A Big, Wide-Range Steam Hammer

For Heavy Steel Forging



The Erie Double Frame Steam Hammer is the king of hammers for miscellaneous heavy forging. Force and rapidity of blows are easily controlled by hand lever, or hammer may be adjusted to deliver continuous strokes automatically.

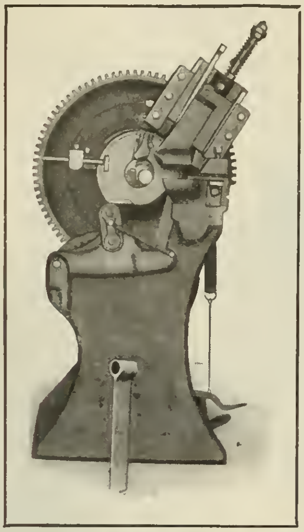
Adapted for steam or compressed air as desired.

"OLD RELIABLE"

has Automatic Safety Stop and other safeguarding devices. Complete details on request.

ERIE FOUNDRY COMPANY
ERIE, PA., U.S.A.

Power Eye Bending Machines



Exceedingly rapid and uniform production of eye bolts at a minimum expense of operation.

Built in sizes for bending stock up to 1½″ in diameter.

Builders also of the Lynch Eye Bender.

Write for catalog describing the Moline Line of Punching, Shearing and Forging Machinery.

Williams, White & Co.
Moline, Ill.
U. S. A.

Pittsburgh Office: 808 House Building
Chicago Office: 933 Monadnock Block
New York Office: C. H. Holbrook, 30 Church Street
Detroit Office: J. C. Austerberry, 924 Dime Bank Bldg.

ELMES

From Photo Taken 1862 of Elmes Employees

60 years of successful business means responsibility and experience building

HYDRAULIC MACHINERY

Charles F. Elmes Engineering Works
222 North Morgan St. Chicago, U. S. A.

Seven Sizes

From 15 Inches Single Geared to 26 Inches Back Geared

BEFORE BUYING A CRANK SHAPER

Send for our catalog and compare the specifications of the

KELLY CRANK SHAPER

with any other crank shaper on the market. We invite this comparison because we are confident that, next to a tryout, it is the best way to demonstrate the superiority of the Kelly Crank Shaper.

Kelly Shapers are built strictly as per specifications.

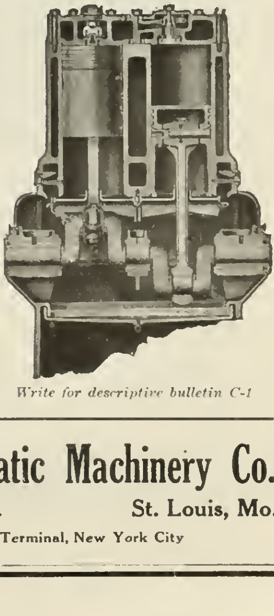
R. A. KELLY CO.
XENIA, OHIO, U. S. A.

The Curtis Compressor

Efficient Cooling Few Parts
Light Disk Valves, Small Clearances

No stuffing boxes, shoes, slides or guides, less friction and wear, lower maintenance. Will run 10 to 15 times as long with the same amount of oil as competing makes, yet will lubricate all parts properly and keep oil out of the discharge line.

Full Self-Oiling
Controlled Splash
Regulatable, Sight
Feed Cylinder Oiling



Write for descriptive bulletin C-1

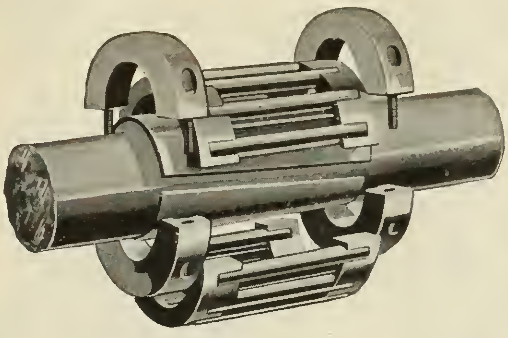
Curtis Pneumatic Machinery Co.
1568 Kienlen Ave. St. Louis, Mo.
530 G Hudson Terminal, New York City

HANNA
RIVETERS, SAND SIFTERS, LUBRICATORS

MUMFORD
SQUEEZERS, JOLT RAMMERS, VIBRATORS

QMS
METAL SAWS, HOISTS, CRANES, HAMMERS

VULCAN ENGINEERING SALES COMPANY
General Agent
1763 ELSTON AVENUE CHICAGO, U. S. A.



A letter is interesting to the extent that it either says something worth while or reflects personality—the personality of the writer.

A piece of machinery is serviceable to the extent to which it does something well—and is the embodiment of the character of the maker.

Conscientious workmanship and sound materials, as well as a regard for performance, efficiency and upkeep, are reflected in "Sells" Roller Bearings.

Take one point at a time—say the rollers. There is a lot of good judgment in the selection of rollers instead of balls. The greater bearing surface of the rollers will reduce the friction, lessen the amount of attention and lubrication required, and greatly decrease the wear on the shafting. Ball bearings wear grooves in the retainers, rollers do not, but as a further protection against wear in Sells Roller Bearings, there is a hard metal sleeve to protect the shaft.

These are the simple devices that help reduce the friction from 25 to 50 per cent over ordinary bearings. Just look at the picture. Did you ever see a better combination of common sense and mechanical simplicity?

Call me up or write to me and I'll explain the "Sells" principles as fully as you wish.

Yours for less friction,

John D. Sells

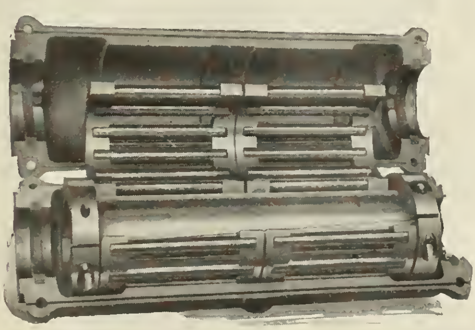
Manager.

Royersford Foundry & Machine Co.

54 North Fifth Street Philadelphia, Pa.

"Sells" Line Shaft Bearings, "Sells" Commercial Roller Bearings, Babbitted Ring Oil Bearings, Shaft Hangers, Collars and Couplings, Punches and Dies, Punching and Shearing Machines, Sensitive Drill Presses, Foot Presses, Grinding and Polishing Machines, Tumbling Barrels, "Rollerine"—the ball and roller bearing lubricant.

Old Reliable "Sells"



"NORMA" BALL BEARINGS

(Patented)

Bearing failure means machine failure. Resultant losses lie not alone in the cost of repairs, but in the interrupted service, the loss of output—and the loss of your prestige as a manufacturer of a dependable machine. Can you afford to risk these losses by using any but bearings of proved reliability?

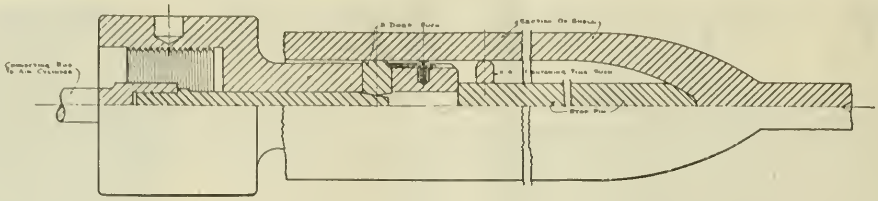
We will welcome an opportunity to explain to you the factors which lie at the root of "NORMA" dependability — the open type and separable construction — the rigid mounting of both races—the unequaled precision — the silent-running, vibrationless qualities. We can probably help you to better bearing service, higher bearing serviceability. Then—

Let it be said of your machine, "It is "NORMA" equipped."

THE NORMA COMPANY OF AMERICA

1790 BROADWAY NEW YORK

Ball, Roller, Thrust, Combination Bearings



AMERICAN SHELLS

ARE NOW BEING MADE BY

M. E. C.

Short Expanding Mandrels

AIR-OPERATED

Shown in Illustration

Manufacturers Equipment Co.

175-179 N. Jefferson St., Chicago, U. S. A.

AGENT FOR CENTRAL AND EASTERN STATES AND CANADA: J. R. Stone Tool & Supply Co., Goebel Bldg., Detroit, Mich.

FOREIGN AGENTS: Burton, Griffiths & Co., Ltd., Ludgate, Ludgate, Square, London, England.

Hundreds of makers of American shells have found M.E.C. Mandrels reliable, durable and efficient. They are particularly adapted for rough and finish turning. Compensating mandrel furnished for cutting rough shell forgings to length and for centering.

In the past three years M.E.C. Chucks and Mandrels have been extensively and profitably used not only in munition work, but in automobile and gas engine manufactories as well.

If you are in the market for labor-saving devices of this kind, by all means get in touch with us. Tell us your problems. We know we can help you. Write today for our latest catalog describing M.E.C. Labor Saving Devices.

Again the Woodstock Tapping Chuck "Brings Home the Bacon"

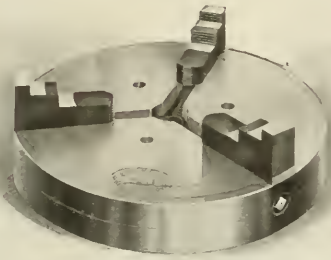
The Philadelphia Scoop Co. never knew trouble-proof tapping until they tried the "Woodstock." Now any tapping job is plain sailing, with broken taps as scarce as they formerly were numerous. Tapping scale pans is the job, the operator using a ¼ inch and a ⅜ inch chuck for the work. The "Woodstock" is a fixture in this plant because of its speed, accuracy and economy—and we could tell you of hundreds of other shops where this same experience applies. The shop that uses the Woodstock Tapping Chuck knows tapping satisfaction. Why not yours?

Try one for 30 days free and see what it can do.

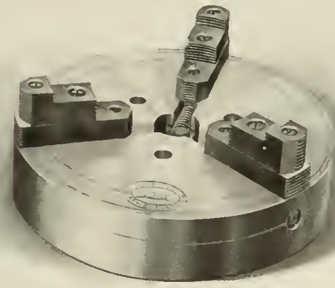
PETER BROTHERS MFG. CO., 135 Railroad Ave., Algonquin, Ill.

UNION

Makers of a Complete Line of Chucks



OUTSIDE JAWS



REVERSIBLE JAWS

Combination Lathe Chucks

PINION SCREW TYPE

UNIVERSAL
INDEPENDENT
ECCENTRIC
CONCENTRIC

The Union Combination Chuck as illustrated is made with solid or reversible jaws, also with four jaws. This type (Pinion Screw) of chuck makes a very accurate and quick acting chuck. Especially adapted for tool room, fine manufacturing, or experimental work.

UNION MANUFACTURING CO.
NEW BRITAIN CONN., U. S. A.
NEW YORK OFFICE: 26 CORTLANDT STREET

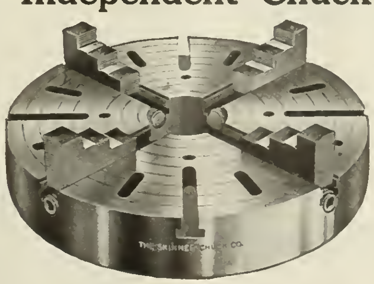
ROGERS TOOLS

Reamers,
Measuring Standards
Adjustable Hollow Mills
Mandrels, Etc.

The John M. Rogers Works, Inc.
Gloucester City, N. J., U. S. A. 1865-1917

Skinner Independent Chuck

Iron Body
(Figure 900)
Steel Body
(Figure 1900)
The most popular chuck on the market.
Contains all the latest improvements.



Want Catalog?

THE SKINNER CHUCK COMPANY
Factory and Main Office: NEW BRITAIN, CONN.
San Francisco Office: Rialto Building. New York Office: 94 Reade St.
London Office: 149 Queen Victoria St.

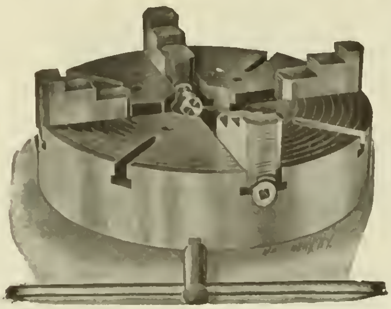
For Rapid Grinding Use "D & W" Magnetic Chucks

In fact, for planing, shaping and milling as well; the "D & W" Magnetic Chuck lends itself most profitably to a wide range of uses. No clamping or bolting—place the work in position, throw on the switch and go ahead. When the job is finished, another turn of the switch releases the work.

Ask for Bulletin 10-M

D & W FUSE COMPANY
PROVIDENCE, R. I.

THE RIGHT CHUCK FOR HEAVY TURNING

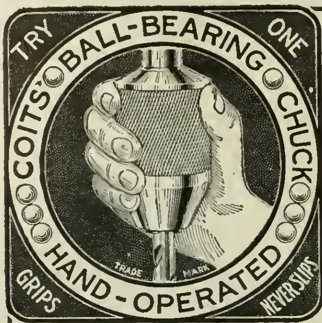


This Horton All-Steel Heavy Duty Chuck, made with extra large screw, double thrust bearings and long, wide jaws, possesses strength, power and endurance equal to the heaviest demands. In its thoroughness of construction it's a typical example of Horton standards and a true representative of a specialized line that provides a chuck for *every* purpose. Use Hortons in your plant and you'll be sure of chuck service par excellence.

Catalog lists entire line.

THE E. HORTON & SON CO.
WINDSOR LOCKS CONNECTICUT

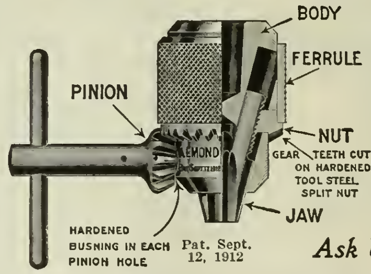
Makers of the Tool with the Tool-Steel Bearing



The Chuck That Never Slips.
The More You Crowd it,
The Tighter It Grips.

NARRAGANSETT MACHINE CO.
PROVIDENCE, R. I., U. S. A.

ALMOND CHUCKS



POWERFUL ACCURATE DURABLE

COST LESS TO MAINTAIN

Ask Us Why

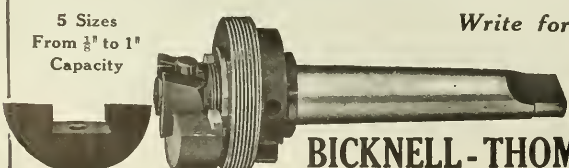
T. R. ALMOND MANUFACTURING CO.
2 MAPLE AVENUE ASHBURNHAM, MASS.
LONDON OFFICE: 8 White Street, Moorfields, London, E. C.

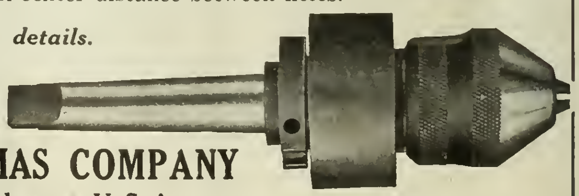
TIME TO LOOSEN UP

A chuck must grip tight, up to the limit of its driving capacity; but when the tool binds or strikes bottom is the time to loosen up. The Bicknell-Thomas Friction Chuck does this automatically—that is why there are no broken taps where Bicknell-Thomas Chucks are used. It is especially adapted for blind tapping and on machines having relatively small center distance between holes.

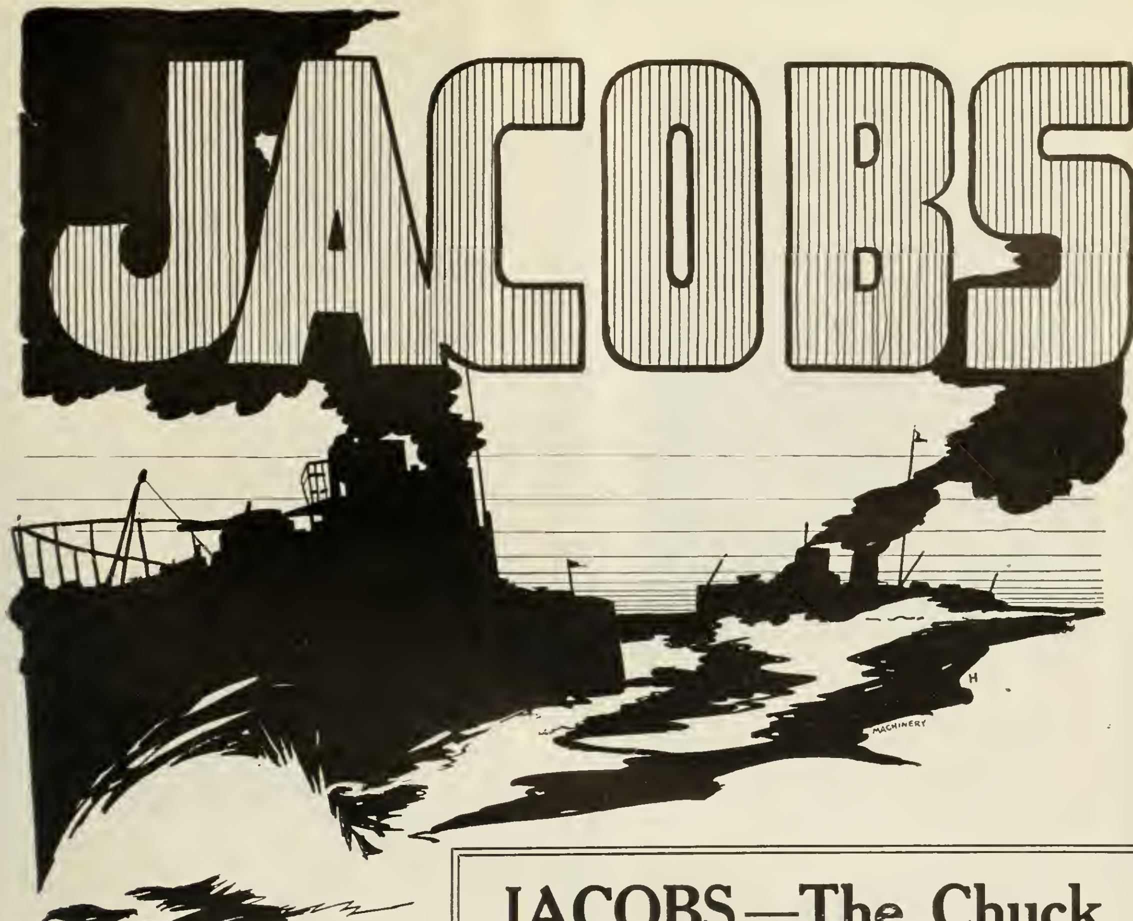
5 Sizes From $\frac{1}{8}$" to 1" Capacity

Write for details.





BICKNELL-THOMAS COMPANY
Greenfield, Massachusetts, U. S. A.



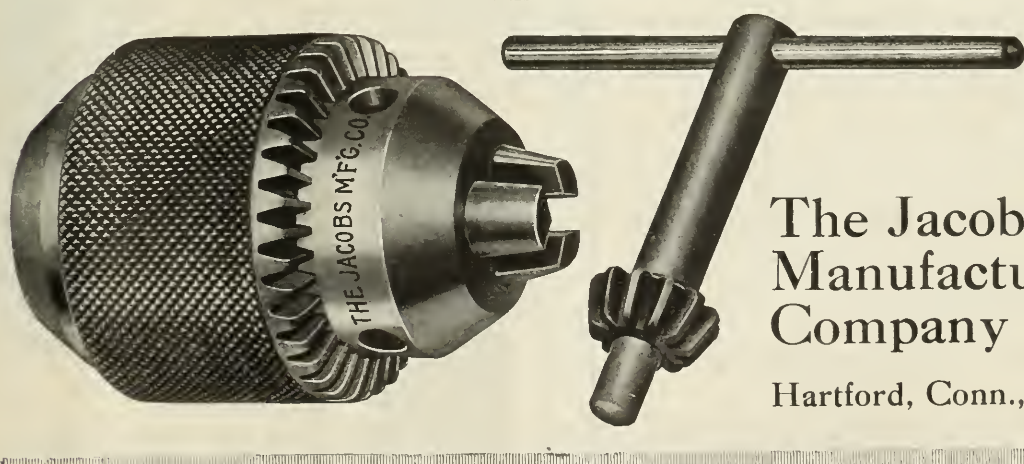
JACOBS—The Chuck

Ever since the Jacobs Improved Drill Chuck was first marketed, in 1902, it has held its place as the leader in this field. Thousands have been sold—all over the world. And this chuck is more popular today—selling in greater numbers—than ever before.

The Jacobs Improved Chuck combines convenience, efficiency, accuracy and durability. What more can you ask ?

FIVE SIZES

No. 1—0 to 13-64"
No. 2—0 to 21-64"
No. 3—0 to 17-32"
No. 4—1-16" to 3-4"
No. 5—3-8" to 1"



The Jacobs Manufacturing Company

Hartford, Conn., U.S.A.

National Counting Machine at the Plant of Stewart-Warner Speedometer Corporation, Chicago, Ill.

Instead of a Handful Count a Thousand

THAT is what it means to have your counting done with a

NATIONAL
COUNTING MACHINE

IT gives you a mechanically accurate count—not a brain-wearied result which may or may not be right—usually not.

The human brain cannot compete either in speed or accuracy with the National Counting Machine, because the machine doesn't get tired—the brain does.

The National Counting Machine will handle any kind of like unit raw material or finished stores in 50 to 90 per cent less time than it takes to hand count. On an inventory it often saves days of labor.

Illustrated Catalog MA on Request

National Counting Machine Co.

Distributors for the National Scale Co.

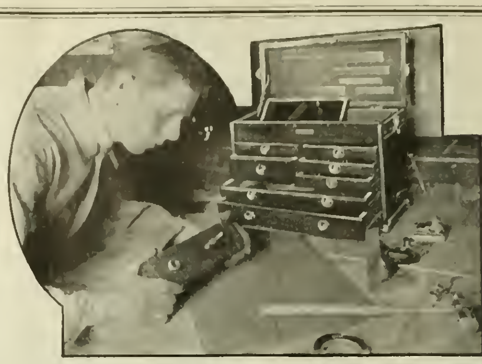
8 Mechanic Street, Chicopee Falls, Mass.

Also Builders of

NATIONAL-CHAPMAN ELEVATING TRUCKS

FOREIGN REPRESENTATIVES

S. Haug Ellingsen & Co., Christiania, Norway. Burton, Griffiths & Co., Ltd., London, England. H. Brenneisen & Co., 5 Jules Ferry Boulevard, Paris, France.



A Progressive Mechanic

has a place for every tool. He knows immediately if any tool is gone, misplaced or borrowed. He should have a

UNION TOOL CHEST

Compact, durable, perfectly designed. Keeps tools clean, safe, free from bangs, knocks and moisture. Saves time because tools can be so arranged that you only need open the drawer and pick out the tool wanted.

Made of plain or quartered oak or leatherette covered. Highly finished. Specially designed drawers, strong and perfectly fitted, some with felt. Drawer pulls—specially designed, practical and efficient. Space saving flush-ring. Every chest *guaranteed* to give perfect satisfaction to meet with your entire approval or money back.

Write for our Catalog and Prices of Nineteen Styles and Sizes. If there isn't a "Union" Dealer near you, get our Special Offer.

Style A

UNION TOOL CHEST WORKS

10 Railroad St., Rochester, N.Y.

Adjustable to fit any face

WILLSON SAFETY GLASSES

Can be worn over other glasses

For all munition workers

Send for illustrated price list

T. A. WILLSON & CO., INC.

Factory and Main Offices, Reading, Pa.

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K & E

Drawing Materials, Mathematical and Surveying Instruments, Measuring Tapes.

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KEUFFEL & ESSER COMPANY

127 Fulton Street - NEW YORK

General Office and Factories: HOBOKEN, N. J.

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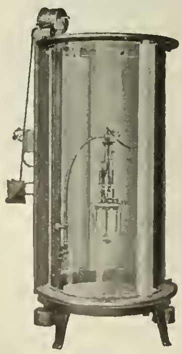

Electric Blue Printing Machines

Shipped on 30 days' trial

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Buckeye Engine Co.

Salem, Ohio

NEW PROCESS GEARS

Use Them Anywhere

When you want gears that are absolutely dependable, that are uniformly good, that will stand up to severe service without fail, choose NEW PROCESS GEARS and you can't go wrong.

We make them in all styles—spur, bevel and spiral, in steel, iron or brass, large or small—and will supply any quantity, one gear or ten thousand.

Send us your blueprints for quotation, and you'll wonder why you have been cutting your own gears for so long.

NEW PROCESS GEAR CORPORATION
SYRACUSE, N.Y

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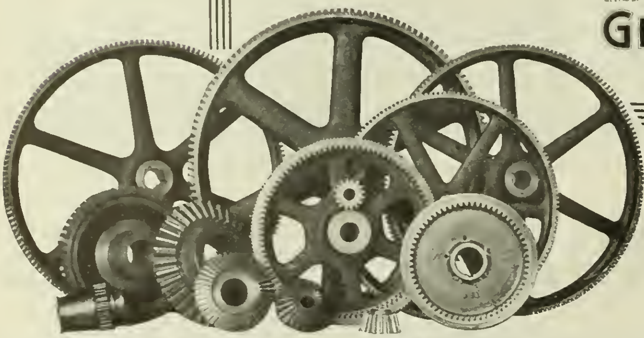
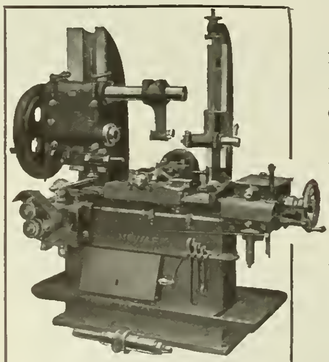


We not only make good gears, but we make good gears at low cost. One trial order is all we ask.

NEWARK

Gear Cutting Machines

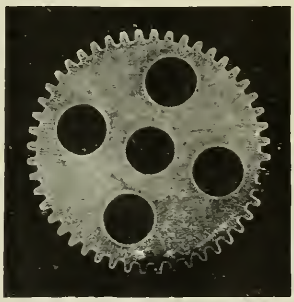


Our No. 3—36" Spur Gear Cutting Machine

Accurate, productive, durable machines; built by skilled labor; materials carefully selected; automatic in operation.

Buy them for gear cutting, for cutting sprockets, ratchet wheels, circular saw teeth and other similar work. Write for Catalog.

NEWARK GEAR CUTTING MACHINE CO.
Gear Specialists
69 Prospect St. NEWARK, N. J.



GENERATED
in our
Gear Cutting Department
(Cut is full size)

Let Us Quote You

MEISSELBACH-CATUCCI MFG. COMPANY
27 CONGRESS STREET NEWARK, N. J.

ACCURATE CUT GEARS

of every description in any material
SPUR, SPIRAL, HELICAL, INTERNAL, WORM
We Specialize in
MICARTA BAKELITE GEARS
BRAUN GEAR WORKS 1321 GATES AVE. BROOKLYN, N.Y.

The Simonds Mfg. Company
Pittsburgh Pa.
U.S.A.

Cut Gears, Racks, Worms, Worm Gears, Special Machinery, Motor Gears and Pinions

BARKER

Wrenchless Chucks Increase Output on Any Work, Any Machine, Under Any Condition

A big claim to make for any chuck; but the "Barker" has proved its case by what it has actually done and is doing.

Barker Chucks have been skeptically received in more than one plant where they have later been retained as regular equipment. A Barker Chuck increased average daily output on differential cages from 45 to 64 for a motor car company that thought 45 per day remarkably good. In a plant where brass ties were turned out at the rate of 375 per day, another "Barker" ran the figures up to 625 per day—a 66.6 per cent increase. So it goes through a long list.

The Barker Chuck is a self-contained unit, practical in design, accurately constructed, a universally efficient and economical chuck.

Complete description on request.

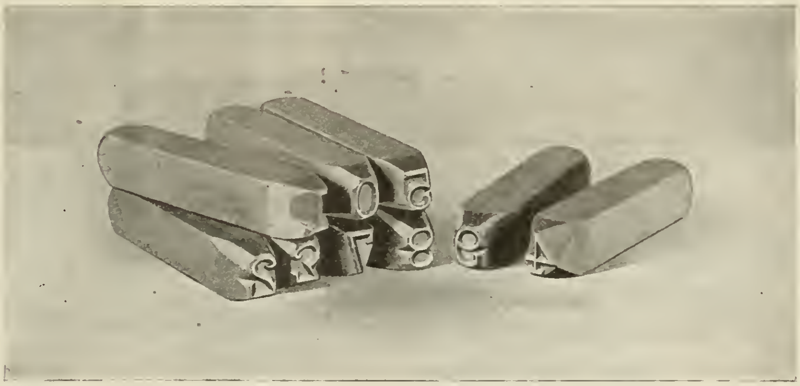
We'll be glad to tell in detail the special advantages of Barker Chuck construction. Write us.

Thomas Elevator Company

22 SOUTH HOYNE AVE.
CHICAGO ILLINOIS

For Clear Markings and Long Service

PANNIER
BEVEL STAMPS



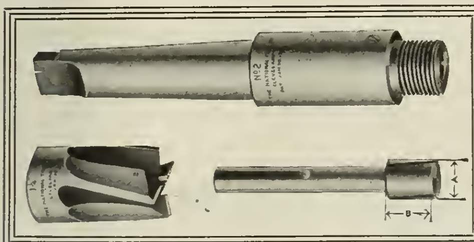
Prompt Shipments

Pannier Steel Bevel Stamps are designed by men who know the exact mathematical degree of balance between maximum efficiency and maximum wear—who turn out stamps that cut a clean, deep impression, and are still strong enough to stand up under hard work. Pannier Stamps are made of best grade tool steel, from blanks sawed from cold bars just as they come from the mill. They receive only *one heating*—that in the tempering furnace. Grinding, cutting, tempering are done by expert steel workers.

We guarantee every Pannier Stamp against defect in material or workmanship

Our Advisory and Consulting Service are yours for the asking. Catalogue on Request.

PANNIER BROS. STAMP CO., Inc.
PITTSBURGH, U. S. A.



Reducing Your Tool Bill with the NATIONAL Counterbore

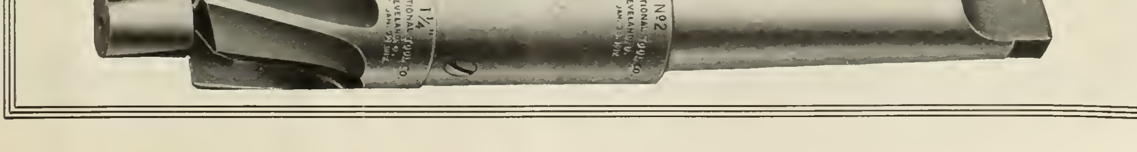
The price of tool steel is soaring—there's no telling where it will stop. You can't do without it—the best you can do is to use no more than you need.

THE NATIONAL PATENT INTERCHANGEABLE COUNTERBORE demonstrates the value of this practice applied to tool making. Of the three interchangeable parts, only the cutter is high speed steel. The pilot and shank are made of strong, durable, but less expensive steel—saving No. 1. The cutter is always the part that wears. If it's a "National," *only* the cutter need be renewed—saving No. 2.

If you are interested in reducing your tool bill, write for circular.

MANUFACTURED BY

THE NATIONAL TOOL CO., Cleveland, Ohio



A Cold Drink for the Industrial Army

There's a great deal of sympathy extended to the men in the trenches who suffer from thirst; but little if any goes to the men in the rank and file of manufacturing—the trench workers of the nation's industries. Shop work is hot and tiresome—a cold drink now and then sets a man up amazingly.

"Meeco" Bubbling Ice Water Fountains are as necessary to maintain uniform production in your plant as your lighting, ventilating and transportation systems. Take care of your men and they will take care of the work.

For attachment to municipal water supply. Holds 75 pounds of ice. 15½ coils of ½" seamless brass tubing. Serves 150 persons.

Our Lines Include: Sanitary Wash Bowls (in Batteries), Bubbling Fountains (Plain and Ice Cooled), Metal Lockers, Metal Stock and Pattern Storage Racks, Metal Shelving, Metal Cabinets, Vault Fixtures, Soda Kettles (10 and 60 Gallons), Metal Stools and Chairs, Water Mixers, Work Benches, Bench Legs, Full Line of Plumbing Fixtures, Etc.

Manufacturing Equipment & Engineering Company

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Office and Showrooms:
BOSTON, MASS.

Send for Complete Catalog of "Meeco" Specialties.

StueBing LIFT TRUCKS

"THE CHOICE OF THE GREATEST INDUSTRIES"

THE STUEBING TRUCK CO.

CINCINNATI OHIO, U. S. A.

Men Who Plan and Design Must Preserve Their Physical Endurance. Avoid Unsteady Tables, Haphazard Filing and Use the Economy Way.

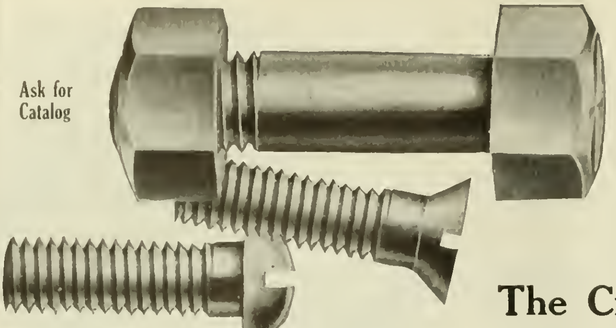
Economy is Harmony

Standard Sizes:
26 x 38—32 x 44 Inches

ECONOMY DRAWING TABLE CO.

Drawing Tables and Filing Cases in Steel and Wood

TOLEDO : : : OHIO



Screw Machine Products for Twenty Years

We make any kind of screw machine product—any metal—any size up to 4 inches in diameter.

We carry in stock a full line of standard screws, studs, bolts and nuts; also a full line of Ford accessories.

We solicit specifications from which we are prompt in furnishing estimates and making deliveries.

All screws U. S. S. thread unless otherwise specified.

The Cincinnati Screw Company
TWIGHTWEE (Cincinnati Suburb) OHIO

HIGH ON SPEED

Trade Mark

SHIP your high-speed steel scrap to us. We'll grade it; remelt it; forge it to the size bars you need—adding any Tungsten or other material needed to raise it to the high standard of

ONONDAGA PROCESS

High Speed Steel. Every bar trade marked as above; the best high speed steel you ever used.

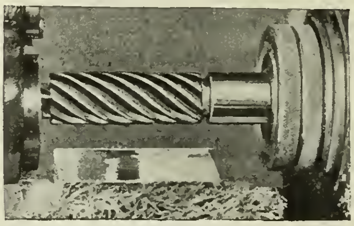
Write for more information.

ONONDAGA STEEL COMPANY INC.
SYRACUSE, N.Y.

STEEL BEARING BALLS

THE ABBOTT BALL CO.
Elmwood Hartford, Conn.

For Heavy Cuts in Tough Stock



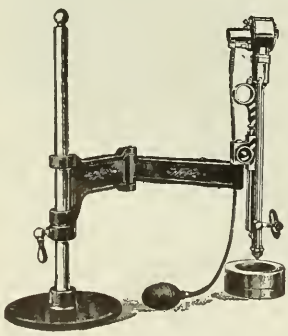
you can be sure of tool stamina if you use service-guaranteed

Windau Tools

The line includes High Speed Spiral Milling Cutters, Form Milling Cutters, Circular Tools and Special Small Tools.

Write for Quotations.

WINDAU TOOL COMPANY
1318 ADDISON ROAD CLEVELAND, OHIO



Testing a die for Hardness (Scleroscope on Swing Arm)

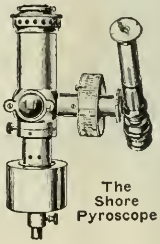
Have You a Scleroscope to Test Your Metals?

For Softness, Hardness or Strength

Can be operated by non-technical help. The majority of manufacturers are thus ordering their material to specifications, as to quality and fitness, meaning that the minority who have not a scleroscope to inspect their material may have to accept the discard of their more up-to-date competitors. It shows if you are getting what you pay for out of your tool steels. Send for our 80-page booklet. Free.

THE PYROSCOPE OPTICAL PYROMETER

If your heat troubles are still unsolved, investigate the pyroscope, the one common-sense instrument that makes straight for results without fuss. Extreme simplicity — constancy — always ready. Pamphlet on request.



The Shore Pyroscope

SHORE INSTRUMENT & MFG. CO., Inc., 555-557 W. 22nd St., New York

FOREIGN AGENTS: Agent for Great Britain and Colonies, Coats Mch. Tool Co., Ltd., Caxton House, London, S. W.; Glasgow; Newcastle-on-Tyne. Schuchardt & Schutte, Tokyo, Japan. Iznosskoff & Co., Petrograd, Russia. Aux Forges de Vulcain, Paris, France. R. S. Stokvis & Zonen, Ltd., Belgium and Holland.

"MULTI-UNIT" SECTIONAL STEEL SHELVING

"A Place For Everything And Everything In Its Place"

On Board U.S.S. MELVILLE

THIS vessel, which has served as Headquarters for Vice Admiral Sims and Mother Ship of the Destroyer Fleet now operating in European waters as submarine chasers, went abroad equipped with "Multi-Unit" Steel Shelving for the storage of repair materials, etc., needed by the fleet.

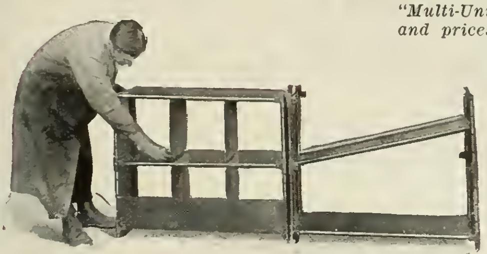
SUPER-STRENGTH, standardized steel units which can be quickly assembled into stacks of plain shelves or bin compartments of various dimensions.

Construction:—Extra heavy sheet steel with strengthening tubular edges of pleasing design.

Finish:—Furnished in plain steel for rough storage or in olive green, dark green or black enamels for offices, stores, warerooms or storerooms where handsome appearance is a factor.

First cost is the last cost. "Multi-Unit" is the economical, efficient shelving.

"Multi-Unit" Bulletin MD and prices sent on request.



Showing the Method of Assembling Units

NATIONAL SCALE CO.

(Standard Steel Shelving Division)

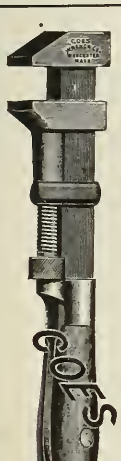
8 Mechanic St., Chicopee Falls, Mass.

Manufacturers of National Counting Machines and National-Chapman Elevating Tracks

FOREIGN REPRESENTATIVES: S. Haug Ellingsen & Co., Christiania, Norway. Burton, Griffiths Co., Ltd., London, England. H. Brenneisen & Co., 5 Jules Ferry Boulevard, Paris, France.

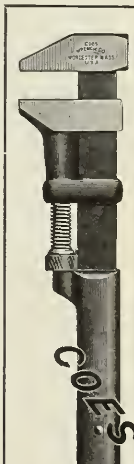
Not Bric-a-brac. Built for hard service. Use it like a ladder to reach the top-most bin.

Don't Experiment with Wrenches—Buy "Coes"



A "Coes" Wrench never slips—never rounds the corners of a nut—never jams the thread. You can depend on a "Coes"; it is stronger by 30 per cent than any similar wrench on the market; it is the choice of experienced mechanics all over the world.

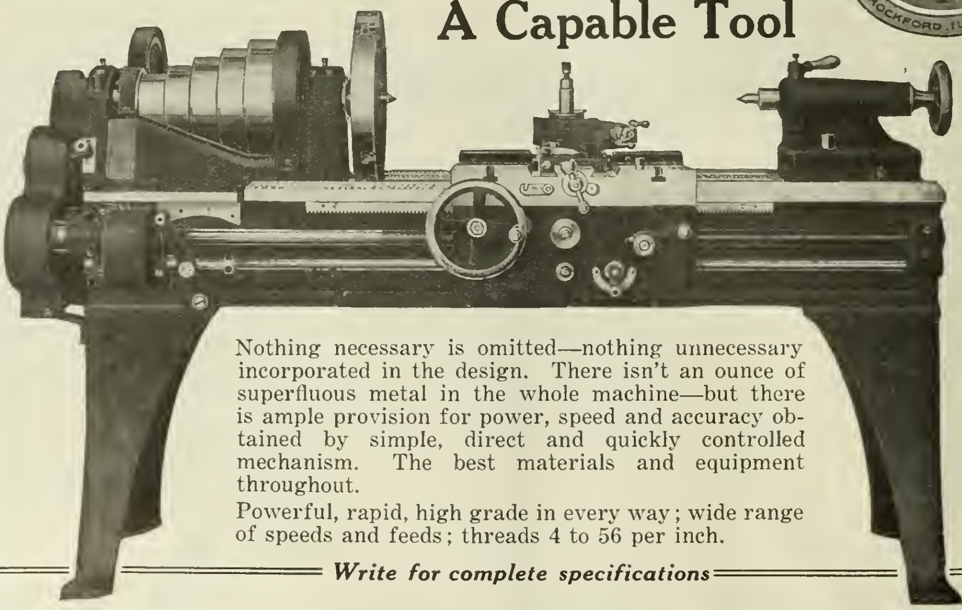
"Coes" Wrenches are made in five styles and a wide range of sizes—order by name from your dealer. "Coes" Steel Handle Model, 4″ to 21″ sizes; Knife Handle, the general utility "Coes," 6″ to 21″ sizes; Key Model "Coes," 28″, 36″, 48″ and 72″ sizes.

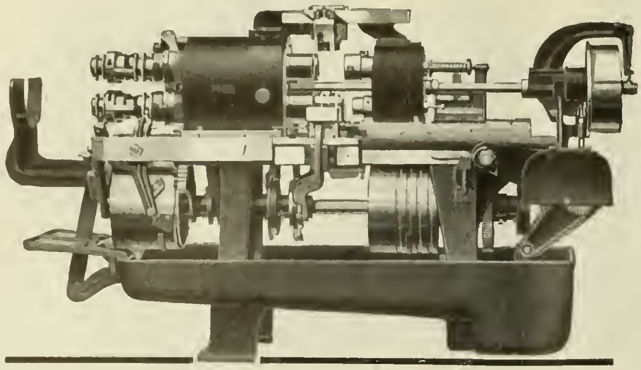


COES WRENCH COMPANY, Worcester, Mass., U. S. A.

AGENTS: J. C. McCARTY & CO., 29 Murray Street, New York. 438 Market Street, San Francisco, Cal. 1515 Lorimer Street, Denver, Colo.

AGENTS: JOHN H. GRAHAM & CO., 113 Chambers Street, New York. London, E. C., 118-122 Holborn, for Great Britain and Continental Europe.





Meeting Requirements

Users of screw machines are putting more and more stress upon Production and the Accuracy of it.

Today there are many manufacturers of screw products who look to Acme Automatics for an output that will meet their requirements.

Eight regular tool positions permit distributing heavy cuts over two or three tools.

All the tools at once gives a constant output at the rate of one piece in the time of a single operation.

The Acme patented shaving tool insures better finish and uniformity of output.

There's an Acme for every kind of screw cutting work up to 3¾" diameter.

Catalog Acme Method "B"?

THE NATIONAL ACME COMPANY

CLEVELAND, OHIO

NEW ENGLAND PLANT, WINDSOR, VERMONT
CANADIAN PLANT, MONTREAL, P. Q.

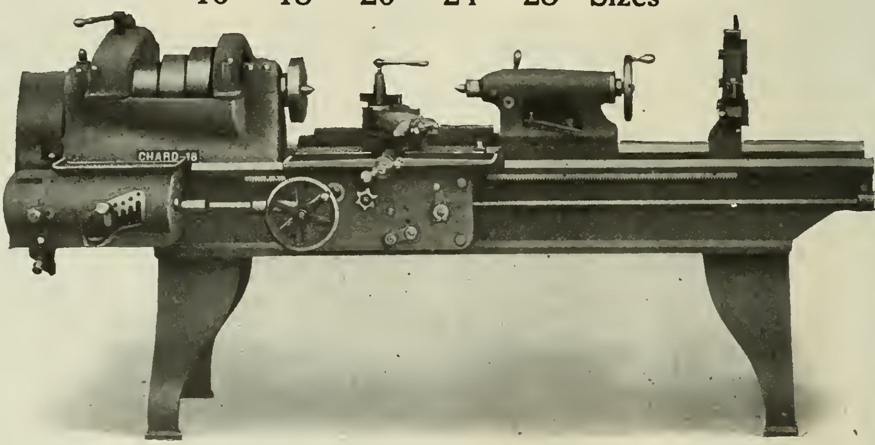
BRANCH OFFICES—NEW YORK BOSTON CHICAGO DETROIT
ATLANTA SAN FRANCISCO. REPRESENTATIVES IN FOREIGN COUNTRIES

Makers of Gridley Single and Multiple Spindle Automatics at Windsor, Vermont; and Acme Automatics, Threading Dies, and Screw Machine Products at Cleveland, Ohio

The Chard

Exceptional Lathe Value

16"—18"—20"—24"—28" Sizes



A Chard Lathe is 100 per cent quality. For an example of its thoroughness of construction, study the value put into the spindle. This is made of a special analysis steel, machined from forgings which are hammered down from 6-inch billets. The steel is thoroughly annealed, reheated to between 1525 degrees and 1550 degrees F., quenched, then reannealed at a temperature of from 1225 to 1250 degrees F. Every detail of construction is just as highly specialized—with factors for convenience and safety worked out to a perfect balance.

Write for complete description

CHARD LATHE COMPANY, Newcastle, Ind., U.S.A.

AGENTS: Vonnegut Machinery Co., Indianapolis, Ind. English and Miller Machinery Co., Detroit, Mich. The W. M. Pattison Supply Co., Cleveland, Ohio. Hill, Clarke & Co., Chicago, Ill. Odgen R. Adams, Rochester, N. Y. The F. O. Stallman Supply Co., San Francisco, Cal. J. S. Miller Machinery Company, Pittsburgh, Pa. Monarch Machinery Company, Philadelphia, Pa. Patterson Tool & Supply Company, Dayton, Ohio.

BICKETT EFFICIENCY

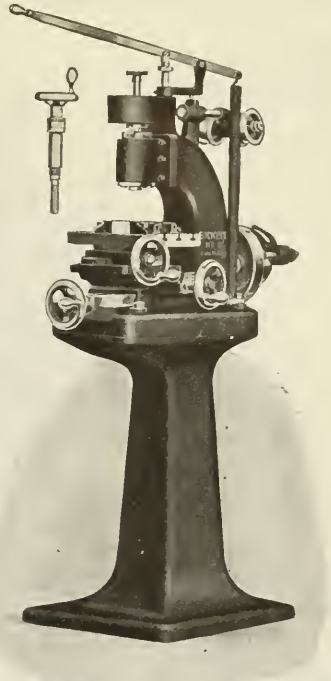
If you have a BICKETT MILLER in your factory you know it is always in use.
If you have not as yet bought one you are minus a good tool.
Not CHEAP, but ECONOMICAL.
Not EXPENSIVE, but EFFICIENT.
Fifteen different styles and sizes, both horizontal and vertical.

This illustration shows

The BICKETT No. 0 Vertical Milling and Profiling Machine

with spring lever attachment.

Particularly useful for profiling, routing, and letter cutting.
This machine can also be furnished with foot treadle attachment.



THE BICKETT MACHINE & MFG. COMPANY
1118 Richmond Street **CINCINNATI, OHIO, U. S. A.**
EUROPEAN AGENTS: The Selson Engineering Co., 83-85 Queen Victoria St., London, England.

Gray's Sheet Metal Cutter Saves a Lot of Metal

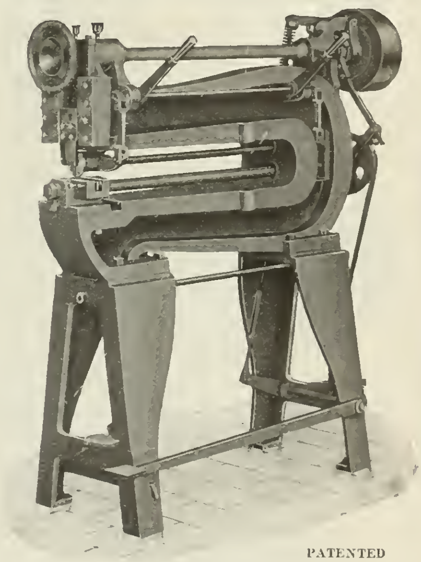
Steel is high and going higher—so is your scrap heap unless you are using a Gray Metal Cutting Machine for cutting gauge blanks, templates, gaskets, gear covers, jigs, etc.

Designs may be laid out close together on a large sheet—conserving every ounce of metal. The Gray Machine cuts a clean, smooth, accurate slot—without the spring and buckled edges of the shearing cut. This is double economy.

Capacity includes metal 3/16 inch thick in which 30 inches a minute can be accurately cut—the stock is automatically fed in by rollers above and below while the operator follows the design and controls the cutter.

Steel Plate, 10" x 18", 3/16" thick, finished by the Gray in 10½ minutes.

Complete description in Bulletin. Write for it.

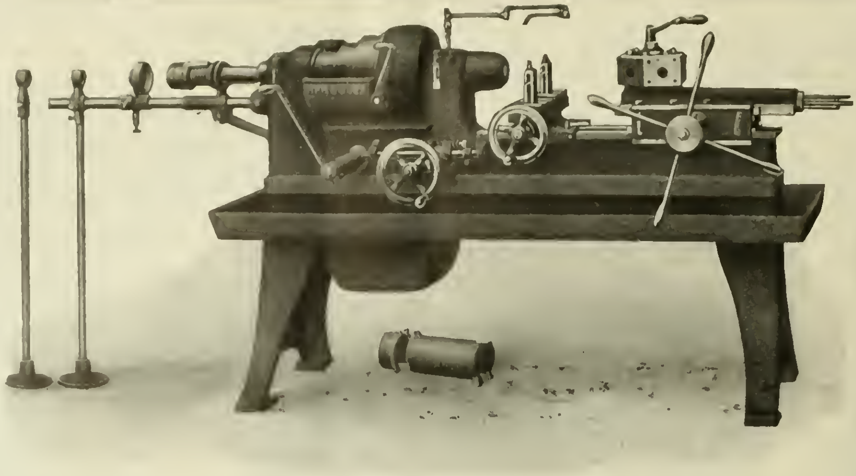


PATENTED

W. J. SAVAGE COMPANY, Inc.
KNOXVILLE **TENN., U. S. A.**

Hercules

Turret Lathe AND Screw Machine



Glad to Send Detailed Description on Request.

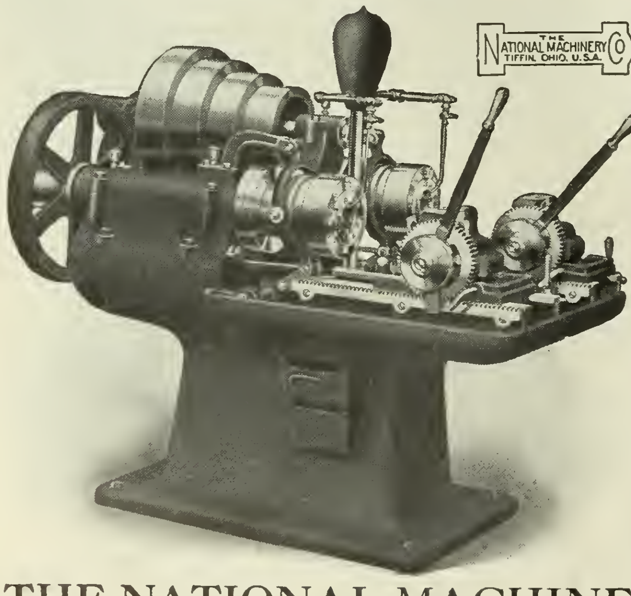
THIS machine is designed for working bar stock, for producing work that requires turning and threading at one setting, and for machining castings, forgings and second operation work. It is strong and rigid; bed is well braced; head and bed in one-piece; bearings all of phosphor bronze and lubricated automatically by a chain-oiling system. Machine is regularly equipped with automatic chuck and bar feed; but can be furnished without these attachments if desired. It is an accurate worker, operates smoothly, has provision for taking up wear.

Himoff Machine Co.
45 Mills St., ASTORIA
In the City of New York

Sales Office:
50 Church St., New York

A National Bolt Cutter

For Good Threads and Big Productions



THE NATIONAL MACHINERY CO. TIFFIN, OHIO, U.S.A.

About 70 per cent of all screw threads are cut on Bolt Cutters and a large percentage of this production is turned out by "Nationals." No matter what the threading problem, there is a "National" to meet it, which will give you accurate threads, along with the largest possible production.

The National Die Head has a positive lock which makes it as rigid as a solid die, and insures absolute accuracy in threading. This accuracy continues throughout the life of the machine, as there is no friction or wear that can affect the threading.

The National Die Head is simple, hence easy to adjust and operate; and can be run at the highest cutting speeds.

Tell us your threading problems and let us give you our recommendation.

THE NATIONAL MACHINERY CO., Tiffin, Ohio
Originators of Modern Bolt, Nut and Forging Machinery

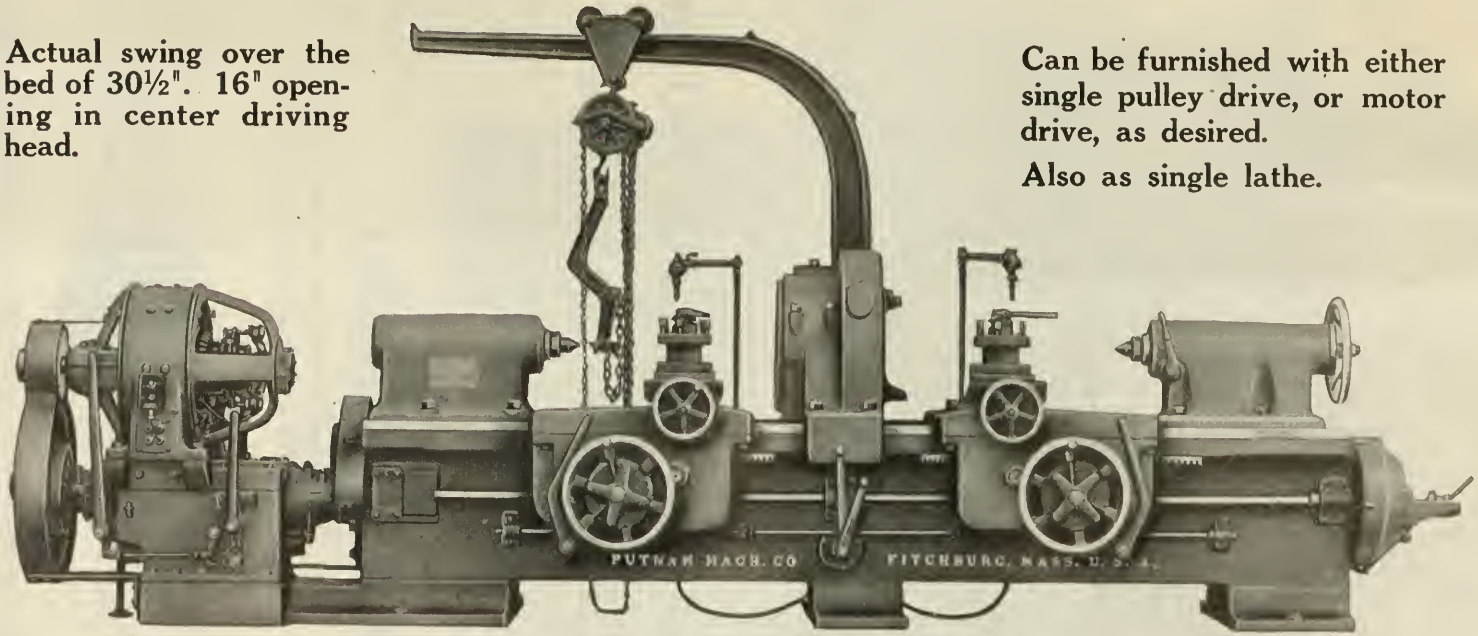
Putnam Heavy Double Axle Lathe

Built for maximum duty, and proportioned throughout to successfully absorb all strains and vibrations incident to heavy cutting.

Actual swing over the bed of 30½". 16" opening in center driving head.

Can be furnished with either single pulley drive, or motor drive, as desired.

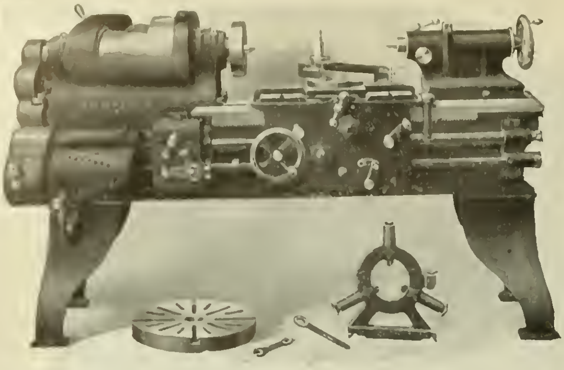
Also as single lathe.



Machine Shop and Foundry Equipment of Every Description.

MANNING, MAXWELL & MOORE, Inc., 119 West 40th Street, NEW YORK

BOSTON, BUFFALO, CHICAGO, CINCINNATI, CLEVELAND, DETROIT, MILWAUKEE
NEW HAVEN, PHILADELPHIA, PITTSBURGH, SEATTLE, ST. LOUIS, SAN FRANCISCO, YOKOHAMA, JAPAN



16" Lehmann Lathe Swings 18¼"

Built for Heavy Duty and Accuracy

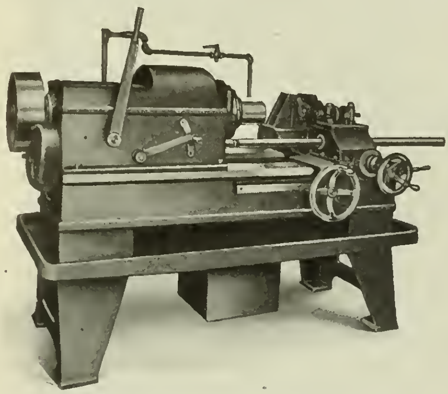
3-STEP CONE for 3" belt, DOUBLE BACK GEARS, CHILLED BED, HIGH CARBON STEEL SPINDLE, PHOSPHOR BRONZE BEARINGS, DOUBLE PLATE APRON, STEEL GEARING, BALL THRUST BEARING for lead screw, cuts threads 2 to 112 to the inch without change of gears, GEARED FEEDS from .007 to .4. 9' bed takes 5' between centers, net weight 3020 lbs.

Write for circular illustrating NEW and INTERESTING FEATURES of these lathes.

LEHMANN MACHINE CO.

606 to 612 South Broadway ST. LOUIS, MO.

Thurlow Waving and Undercutting Machine



Designed to cut, groove, undercut and wave shells simultaneously and at a single operation. Its adoption in any plant never fails to reduce costs and increase production, and in addition, it releases for other operations the lathes now tied up on this work. The Thurlow is made in three sizes to take shells from 3 inches to 9 inches; is strongly built and easy to operate.

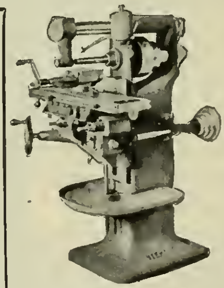
Full details on request.

Thurlow Steel Works, Inc.

1418 Walnut St. PHILADELPHIA, PA.

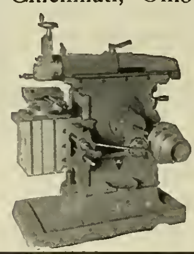
STEPTOE
Milling Machines and Shapers

Set Free Your Large Millers and Planers for Heavier Work



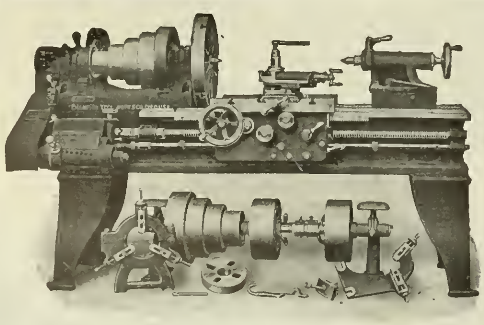
It is poor policy to put small work on large machines. A small milling machine can be handled much more quickly than a large milling machine. The same is true in regard to a shaper as compared to a heavy planer.

John Steptoe Co.
Brighton
Cincinnati, Ohio



Steptoe Milling Machines and Shapers will enable you to get economy and efficiency in production by the proper distribution of work.

The best possible evidence of their reliability, accuracy and economy is the fact that thousands of them are in world-wide use today.



Champion Lathes

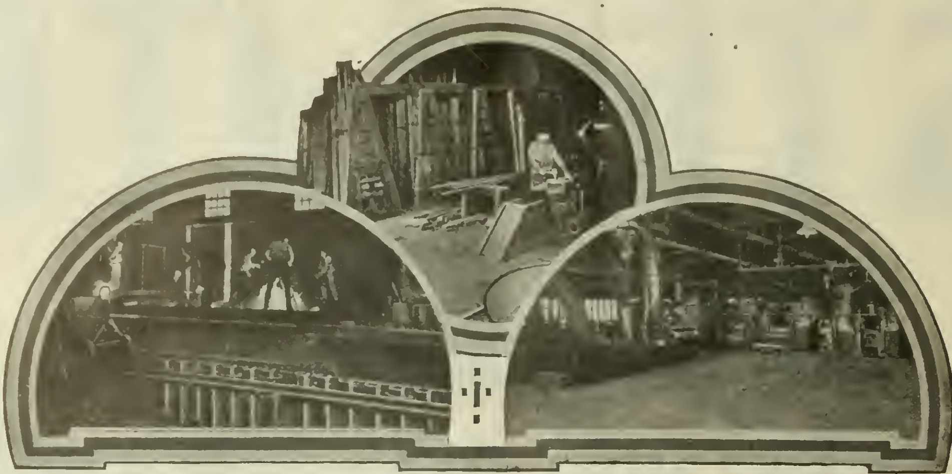
Built to Turn Out Accurate Work Fast

Champion Lathes are solidly constructed 12-, 14-, 16- and 18-inch machines. Metal is distributed to give each machine maximum rigidity and strength; power is provided to handle heaviest cuts within range; convenient arrangement of operating parts assures speed. The "Champion" is an A-1 tool room or manufacturing lathe. General Catalog on request.

CHAMPION TOOL WORKS CO.

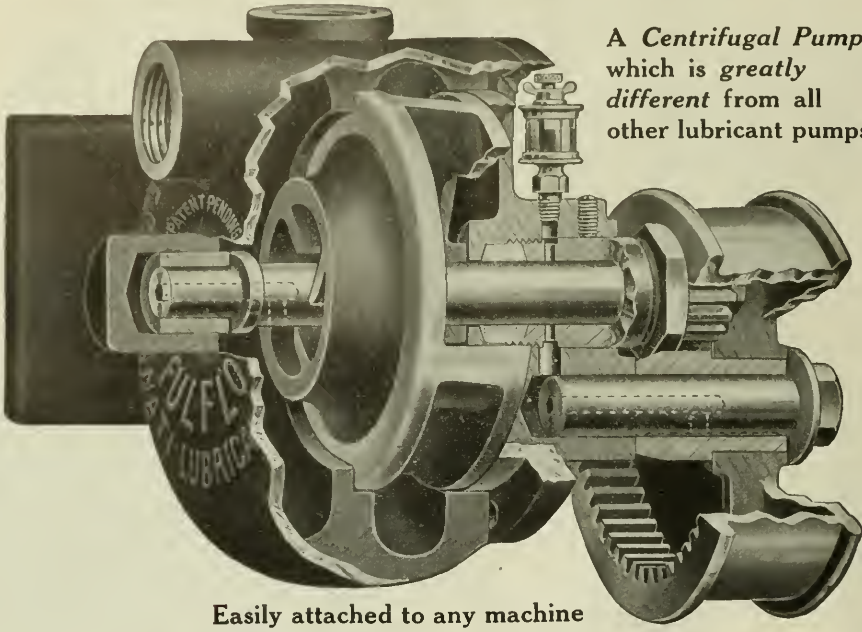
2422 SPRING GROVE AVE., CINCINNATI, OHIO, U. S. A.


Complicated Die Castings
BEST MADE BY
Stewart Process
Complicated and intricate parts require superior facilities, skillful designing of dies, and a vastly superior degree of technical and mechanical ingenuity to insure satisfactory die-castings.
The Stewart staff of engineers, diemakers, metallurgists and machine operators have had years of experience in the production of the most complicated parts ever designed.
That is why Stewart Process die-castings are acknowledged to be representative of the highest standard in die-casting engineering.
The Stewart Process is the solution of your die-casting problems.
STEWART MFG. COMPANY
Wells St. Bridge CHICAGO
Stewart
OFF
ON
ON
PRIMER
RICH
LEAN
CARBURETOR




The "Rocker-Joint"
Depends Upon Its Construction,
not Upon Lubricant,
for Its Life and Efficiency
POWER
TRANSMISSION
What does she know about it? Not a thing! But she knows that he knows, and that's the point. He is a long-time user of silent chains and what he says about them counts.
This is what he says: "There is only one silent Chain with a properly designed joint, and that is the MORSE. The 'ROCKER-JOINT,' the exclusive, patented feature of the MORSE, eliminates all power losses because it permits no destructive sliding friction, as do all other joints. There is only the simple movement of the rocking-chair."
Flexible Positive Efficient
MORSE CHAIN CO., Ithaca, N. Y.
Largest Manufacturers of Silent Chains in the World
MORSE
SILENT CHAINS

FULFLO The Lubricant Pump You've Looked For



A *Centrifugal Pump* which is *greatly different* from all other lubricant pumps

Price $10.00

Discount on Quantities

Easily attached to any machine

THE ONLY LUBRICANT PUMP FOR WHICH THESE CLAIMS CAN BE TRUTHFULLY MADE

"The Trouble-proof Pump"

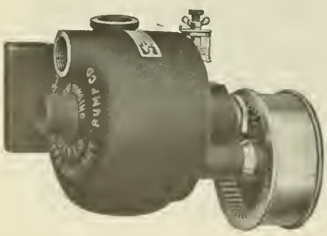
1 ***Greatest Capacity.*** 50 per cent more volume than any other pump its size. 1 to 20 gallons per minute, according to speed.

2 ***Cannot Lose Its Prime.*** Water has to run uphill before the Fulflo can lose its prime. All other pumps depend on valves to hold their prime.

3 ***Longest Life.*** There is but one pumping part—the impellor—and it touches nothing but the liquid, therefore retains its pumping efficiency indefinitely.

4 ***Won't Clog.*** Anything that can get in will go right through without injury to the pump. No passage smaller than intake, which is ¾ inch.

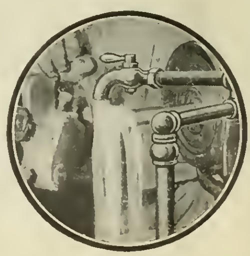
Are you going to continue to put up with lubricant pump troubles which have heretofore been necessary evils, or are you going to improve this feature of your manufacturing methods as you have all others, now that it is possible for you to do so?



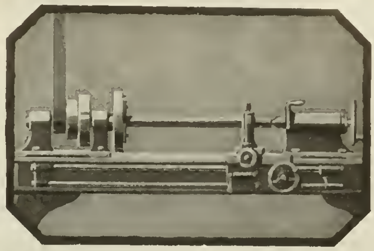
THE FULFLO PUMP COMPANY

129 Opera Place

CINCINNATI, OHIO, U.S.A.



The Machine Without a Man



ONE of the chief causes of delay in all forms of manufacturing is the machine without a man—the machine that is momentarily idle.

When a workman has to shut down his lathe to look for the bolt he is to turn, when he has to stop work to sharpen or find his tools, his machine is not producing and a decrease in output results.

Of all the causes which make it necessary for an operative to leave his machine, poor light is the most common— and the most unnecessary.

Even if the window to which a workman must step in order to adjust his micrometer or examine his calipers is but a few feet distant, a certain amount of time is lost. Insignificant as these seconds may seem in each individual instance, the total amount of time wasted by all operatives in similarly unproductive movements is far from negligible.

Every machine in your plant should be so well lighted that no workman need ever step away from it in order to see more clearly. The lamp that makes it unnecessary for him to walk to the window will soon pay for itself.

Adequate illumination will remove one of the chief causes of delay. It will enable you to speed up production by keeping your machine running all the time, and it will also improve the quality of your output.

By suggesting improvements and alterations to your lighting system our Engineering Department is ready to help you remove the most unnecessary cause of delay. This service is free and obligates you in no way.

"Increasing and Improving Production" is the title of a new book we have just published. The wide experience of the author, Mr. R. T. Kent, in industrial plant operation has enabled him to discuss the problems of factory management from the standpoint of practice rather than theory.

A copy of this book will be sent upon request to any industrial plant manager.

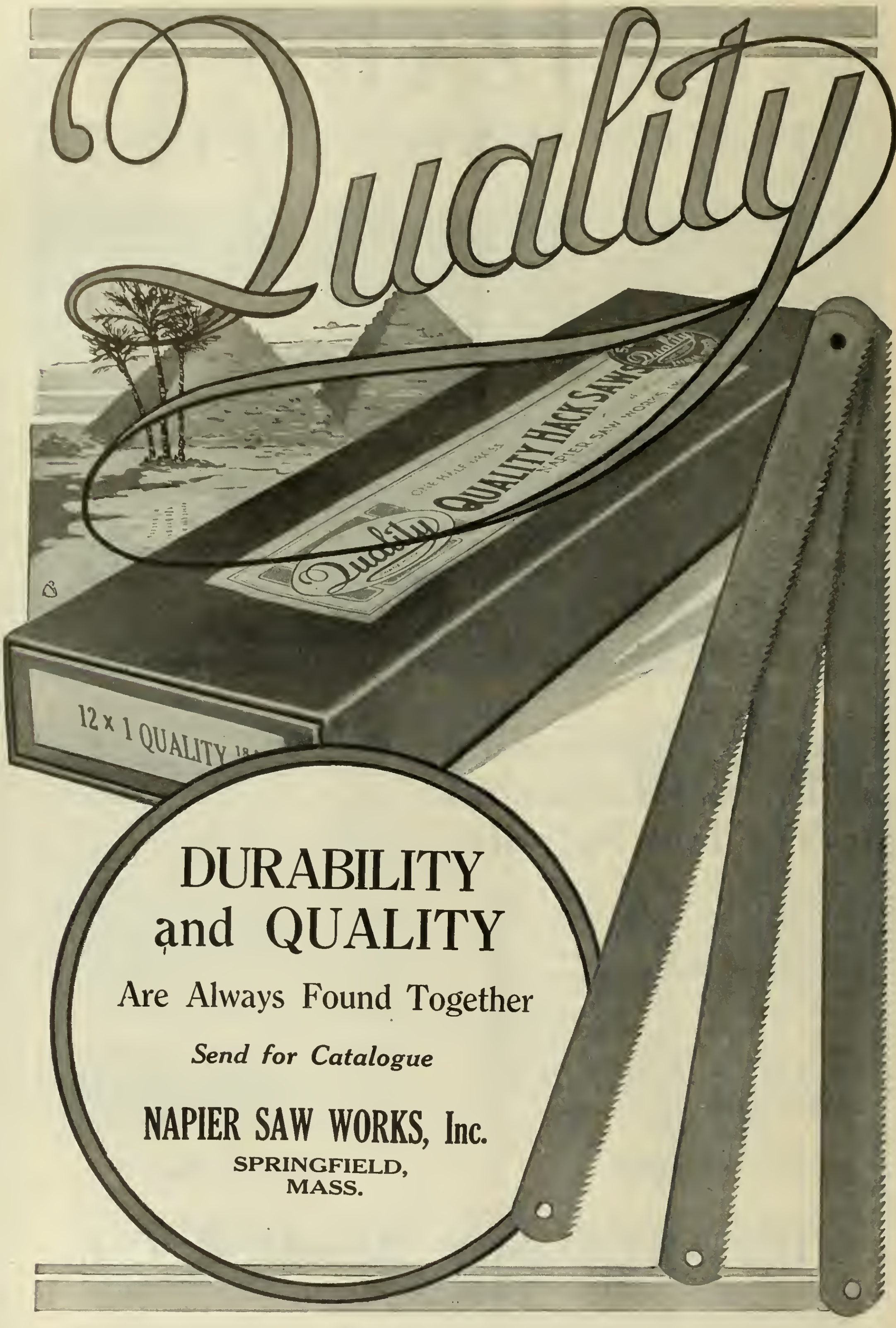
Westinghouse Lamp Company

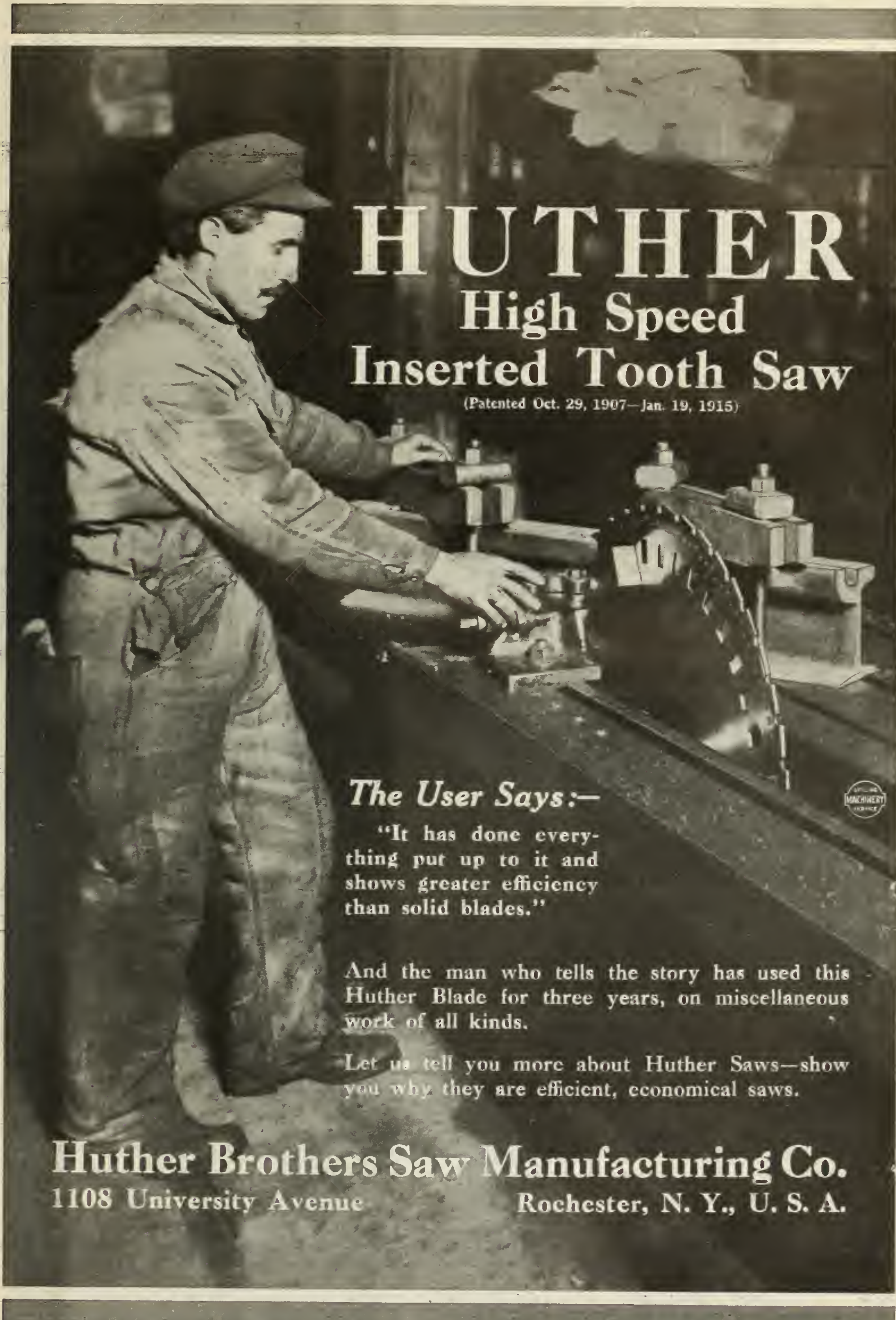
165 Broadway, New York

Sales Offices and Warehouses Throughout the Country

WESTINGHOUSE LAMP COMPANY TRADE MARK W U.S.A. WESTINGHOUSE MAZDA LAMPS

GUARANTEED BY THE NAME

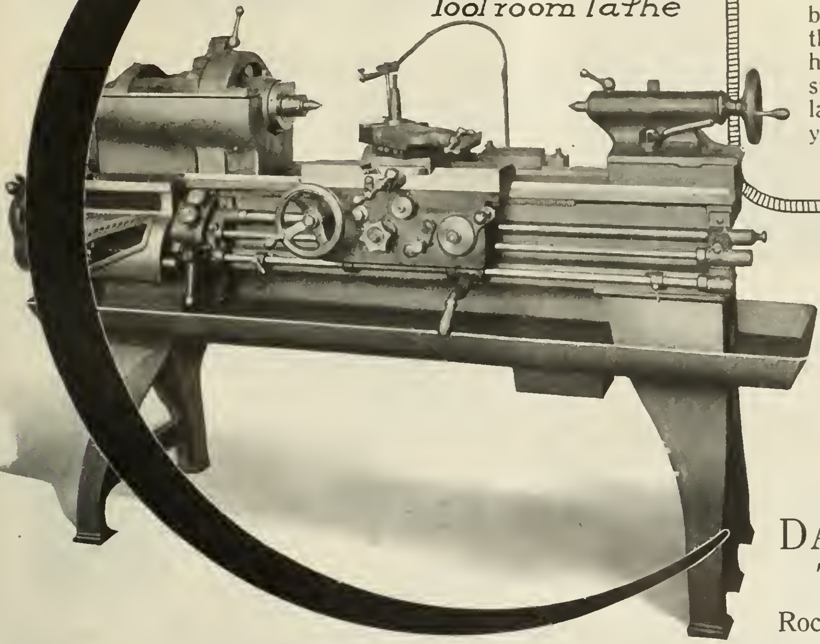

Quality
QUALITY HACK SAWS
12 x 1 QUALITY
DURABILITY
and QUALITY
Are Always Found Together
Send for Catalogue
NAPIER SAW WORKS, Inc.
SPRINGFIELD,
MASS.


HUTHER
High Speed
Inserted Tooth Saw
(Patented Oct. 29, 1907—Jan. 19, 1915)
The User Says:—
"It has done everything put up to it and shows greater efficiency than solid blades."
And the man who tells the story has used this Huther Blade for three years, on miscellaneous work of all kinds.
Let us tell you more about Huther Saws—show you why they are efficient, economical saws.
Huther Brothers Saw Manufacturing Co.
1108 University Avenue
Rochester, N. Y., U. S. A.

DAVIS

Close Coupled

Tool room lathe



MODERN demands have been fully met in our new "Close Coupled" tool room lathe. The spindle has taper bearings, and ball thrust. Add to these features generous housings, and 14¼" swing, and you have a lathe worthy of place in your tool room.

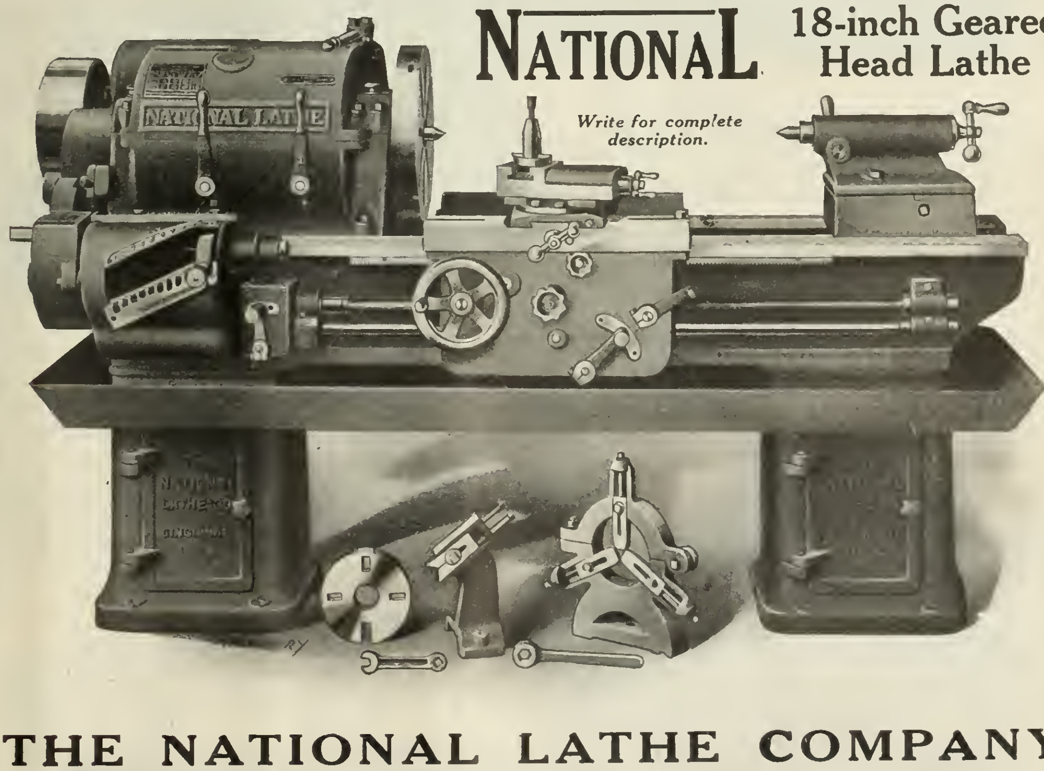
Complete description will be sent on request.

DAVIS MACHINE TOOL CO., Inc.
Rochester, N. Y. U. S. A.

NATIONAL

18-inch Geared Head Lathe

Write for complete description.



THE NATIONAL LATHE COMPANY

Established 1912 **15 West Second St., Cincinnati, Ohio, U. S. A.**

O. K. TAPS AND DIES

For Long and Faithful Service

Hammered from flat bar steel, specially heat treated, given ample chip clearance and means for lubrication, O. K. Taps and Dies are well adapted to survive a long period of active duty.

Accuracy and durability are standards that are never lost sight of in the manufacture of these tools. They are twin qualities that can be reckoned on by every user.

Complete list in Catalog 7A.

F. E. WELLS & SON COMPANY
GREENFIELD, MASSACHUSETTS

"Matthews" Helps with the Pay-Roll

The bother and expense of time checking and pay-roll distribution can be cut down considerably by the use of

Matthews' Identification Checks and Badges

They are clean-cut, easily read, not easily duplicated, and will last a life-time. Unusually prompt delivery on most styles.

Book of Checks, Badges and Name Plates on request

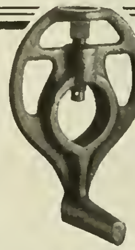
Jas. H. Matthews & Company

Manufacturers of Marking Devices Since 1850.

3946 Forbes Field
PITTSBURGH, PA.

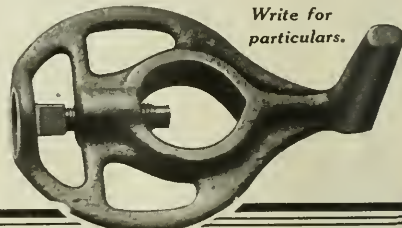
Protected Lathe Dogs

SAFE --- RELIABLE



We carry a full stock of standard crucible cast steel, protected lathe dogs—strong, durable, dependable lathe dogs. We are regularly supplying concerns whose policy is to surround their workers with the most reliable safeguards they can find. We shall be glad to go into the question of lathe dog equipment with you and explain why ours are the better kind.

Straight or Bent Tail Lathe Dogs, any size, any form.



Write for particulars.

The West Steel Casting Co.
CLEVELAND OHIO

You Can Now Solder Aluminum Successfully

WITH

Send for a Welded Sample

So-Luminum
The Aluminum Solder

Makes joints that are stronger than the metal. No flux required. Used with gasoline torch.

SAMPLE BAR $1.00

Used and endorsed by U. S. Army and navy, and leading automobile and aeroplane manufacturers. Send for booklet 200.

SO-LUMINUM MFG. CO., 1790 Broadway, New York

Oil Pan Logic

LATHE PANS
SPLASH GUARDS
GEAR GUARDS

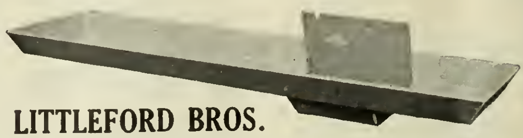
Sheet Steel Oil Pans weigh less, cost less and wear longer than any other kind and fulfill every requirement.

Incorporated when assembling or easily attached to machines already on the floor.

Littleford Sheet Steel Oil Pans

are the logical pans for your equipment.

Send for details, prices, etc.



LITTLEFORD BROS.
354 E. Pearl Street CINCINNATI, OHIO

NERY'S
PICTURE

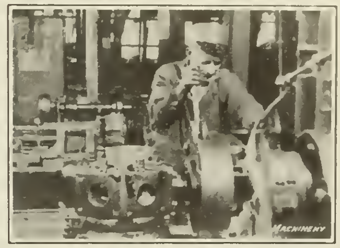
detail in the machining of a 9.2" Howitzer Shell

THE picture has been shown with great success at the Cincinnati Convention of the American Society of Mechanical Engineers and the National Machine Tool Builders' Association, and before Engineering Societies, Superintendents' and Foremen's Clubs, Employers' Associations, and other industrial gatherings in Cleveland, Buffalo, Rochester, Syracuse, Fitchburg, Worcester, and elsewhere.

MACHINERY is arranging an itinerary to show this interesting film in all the leading industrial centers and will be glad to hear from mechanical societies, engineering schools, manufacturers and others interested. This is not a money making proposition and there is no charge for showing the picture or for the use of the film. All that is necessary is to provide the auditorium and the simple facilities required. Mr. Lucas of MACHINERY'S Staff gives a concise explanation of the operations as they are shown. Total time required is about thirty minutes. It is a real picture of actual operations in logical order and was taken in the High-Explosive Shell Department of the A. P. Smith Mfg. Co., East Orange, N. J.

Write MACHINERY Now about your Dates for the Fall.

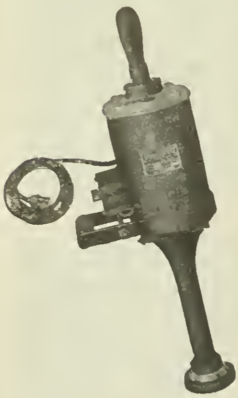
Lafayette St., New York



STANDARD PORTABLE TOOLS

PAY A GREATER RETURN THAN EVER BEFORE



Today is the day of intensive production—of crowding every hour full of productive activity. It's the day of the ever ready, easy to handle, universally useful, time-saving portable tool. Standard Portable "Electrics" are working where the drive is thickest—in machine tool and automobile plants, air-plane factories, railroad shops, etc., working hard and working profitably. They lead the field for accuracy, speed, power and endurance, and they are notably economical to use.

The list of Standard users reads like an industrial directory. It includes the U. S. Government and many of the largest manufacturers in the country.

We'll be glad to show you why your portable drills, reamers, grinders, etc., should be picked from the STANDARD Line.

Catalogue on request.

The

STANDARD ELECTRIC TOOL COMPANY

CINCINNATI OHIO, U. S. A.

New York Office
**Marbridge Bldg.
1328 Broadway**

Chicago Office
10 So. LaSalle Street


BROWN ELECTRIC PYROMETER
17800
DEGREES FAHRENHEIT
0 300 600 900 1200 1500 1800 2100 2400 2700 3000
RESISTANCE= 5.5 Ω
THE BROWN INSTRUMENT CO PHILADELPHIA PA
Put Your Heat-Treating Problems up to
The World's Standard Heat Meters
By far the majority of all firms using Pyrometers use Brown's. Baldwin's use 81 in their Eddystone Plants alone, Bethlehem use over 150. There are over 6000 other Brown users—each a Brown booster.
Let us send you the names of these in your territory so you can find out more about this success and what Brown's will save you.
Write to the Brown Instrument Co., Philadelphia, or one of their district offices in New York, Pittsburgh, Detroit, or Chicago for complete information now.
Brown Pyrometers

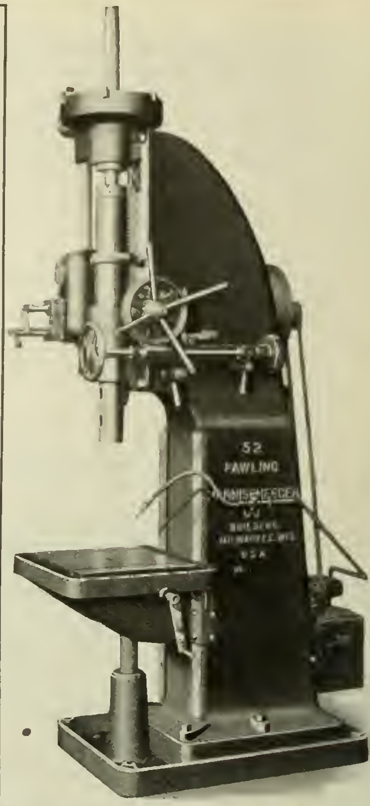
Pawling & Harnischfeger Co. No. 52 Heavy Duty Vertical Drill

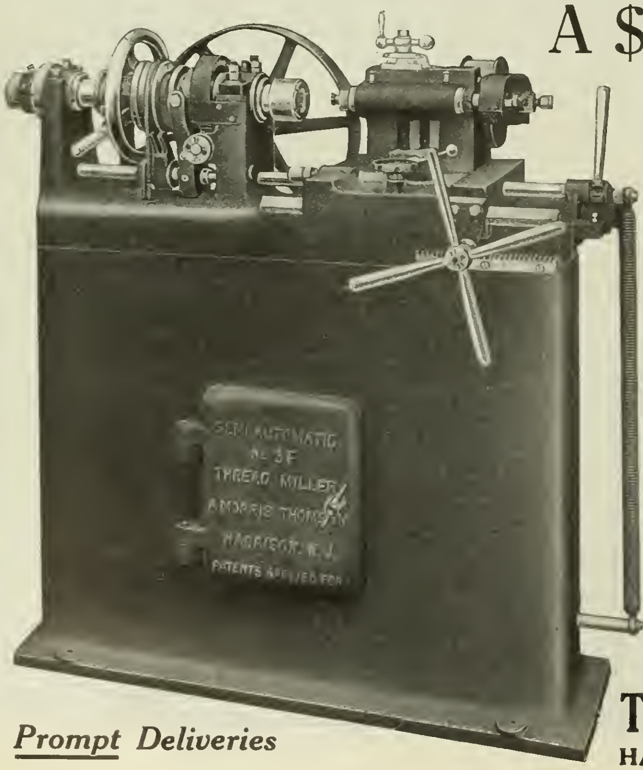
This P & H machine is of rugged construction throughout and is designed for the heaviest duty that may be required of a drill of this size.

A machine of this kind, which is master of its class, should surely have your attention long enough to convince you that it is an efficient and economical tool for your work.

Let us send complete description of the Drilling and Boring Machine suited to your work. Eleven sizes—all high grade, well built, wide-range machines.

DALE-BREWSTER MACHINERY CO., Inc.
545-547 West Washington Blvd., CHICAGO, ILLINOIS
30 Church St., NEW YORK

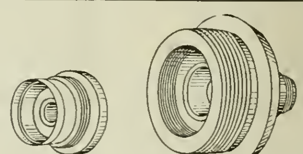




A $650. Thread Milling Machine

A simple machine—operator has absolutely no thinking to do—levers to pull, that's all. Semi-automatic in operation. Extremely accurate. A big producer. Capacity to 3½″ diameter, internal or external thread.

Let us send complete description.



BRONZE PRIMER
1″ diameter. 14 Threads cut at rate of 160 per hour.

BRONZE FUSE BODY
External Thread, 14 pitch; 2″ diam. Cut at rate of 160 per hour.

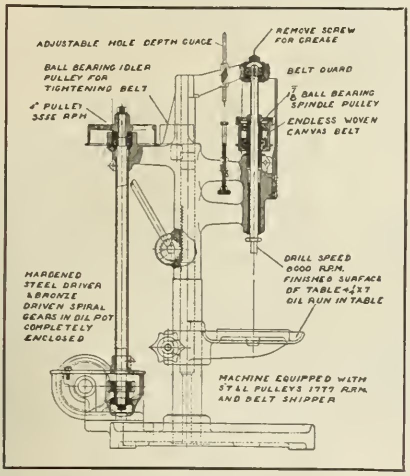
Prompt Deliveries

T.C.M. Manufacturing Co.
HARRISON NEW JERSEY

THE LANGELIER

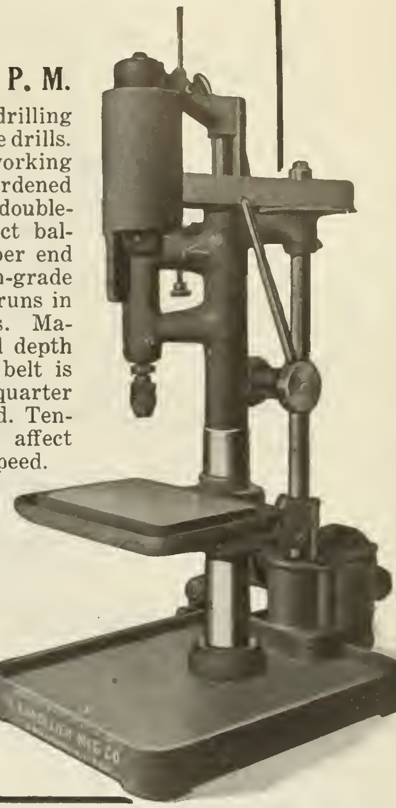
No. 1 High Speed Ball Bearing Drill, Eight Thousand R. P. M.

This high-speed ball bearing sensitive drill is built expressly for drilling holes up to 7/32″ diameter, developing full cutting efficiency of the drills. It takes up to 6″ in height and drills to 3″ from edge. Table working surface, 4¼″ by 7″. Total spindle feed 2″. The spindle is hardened steel ground to size; it is double-splined to provide perfect balance at high speed. Upper end runs in imported high-grade ball bearings; lower end runs in phosphor bronze bearings. Machines have fine threaded depth gauge. Spindle driving belt is endless and without quarter turns. Tightener provided. Tension of belt does not affect sensitiveness of spindle speed.

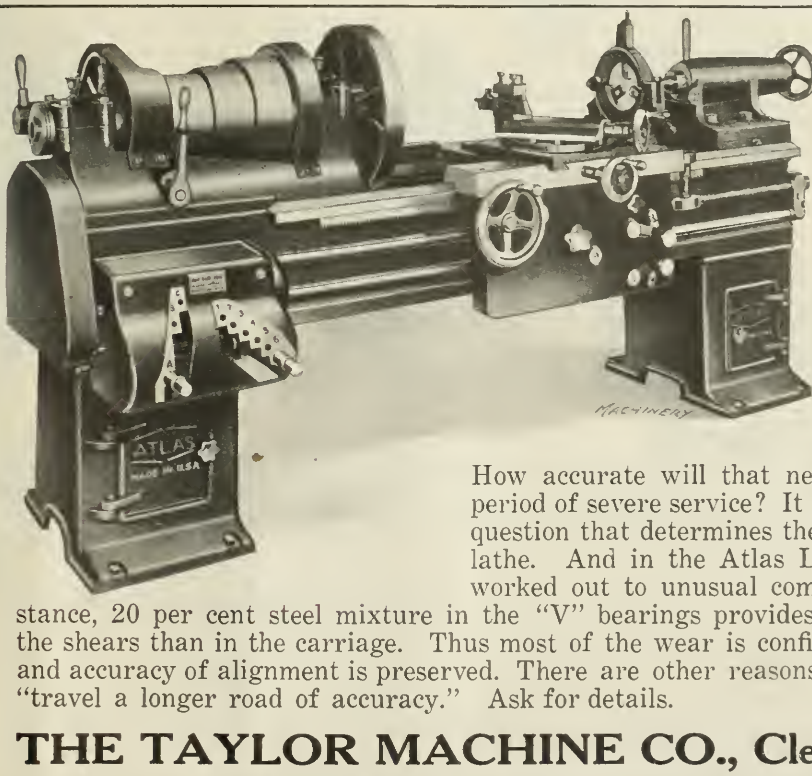


Machines also made in No. 2 size for drills up to ⅜″. Both sizes in bench or floor types and either in single spindle or gang models as desired.

These are remarkable tools — write us for more details. Quick deliveries.



LANGELIER MANUFACTURING COMPANY
PROVIDENCE, RHODE ISLAND



ATLAS Lathes

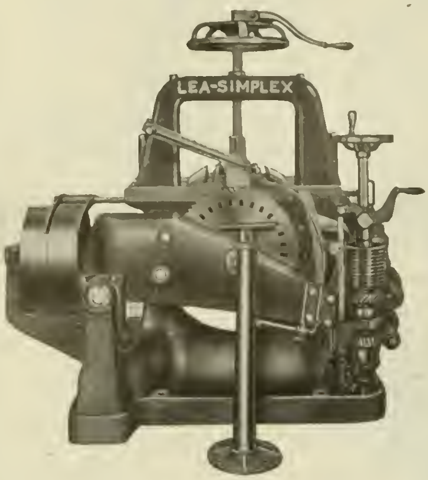
Travel a Longer Road of Accuracy

How accurate will that new lathe be after a period of severe service? It is the answer to this question that determines the real efficiency of a lathe. And in the Atlas Lathe the answer is worked out to unusual completeness. For instance, 20 per cent steel mixture in the "V" bearings provides a harder metal on the shears than in the carriage. Thus most of the wear is confined to the carriage and accuracy of alignment is preserved. There are other reasons why Atlas Lathes "travel a longer road of accuracy." Ask for details.

THE TAYLOR MACHINE CO., Cleveland, Ohio
Manufacturers of ATLAS Machine Tools

FOR SALE

No. 18 Lea-Simplex Cold Metal Saw



Price $450
F. O. B. DAYTON

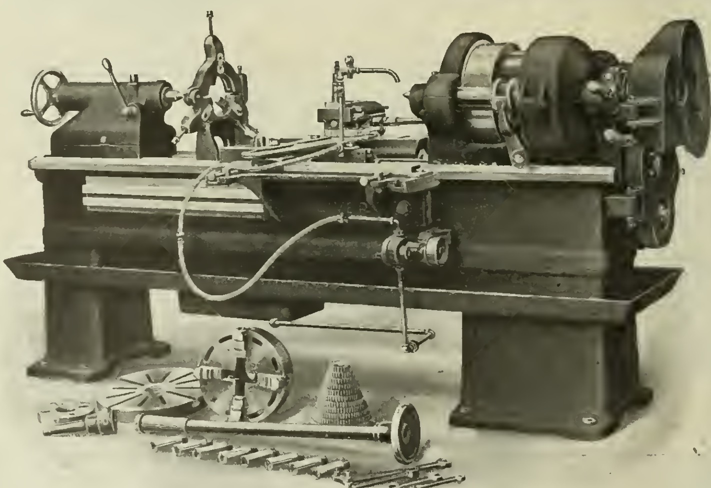
Manufactured by The Earle Gear and Machine Company, Philadelphia, Pa., complete with extra swivel block. Capacity 5″ to 7″ rounds and 6½″ squares; an extra circular saw, type "BB"; serial number 1-46-11; perfect working order, practically good as new; belt driven.

For Sale by

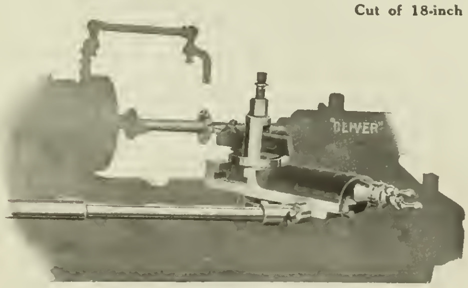
The Patterson Tool & Supply Co.
Dealers in Machinery, Tools and Supplies
DAYTON, OHIO, U. S. A.

OLIVER ENGINE LATHES

Built for your work, arranged with various Tool Room Attachments, Belt or Motor Drive, with or without Chip and Oil Pan Pump, etc. Any length of bed to suit your particular needs.



Cut of 18-inch Tool Room Lathe Equipped with Taper, Draw-in and Relieving Attachments



Relieving Attachment Doing Business

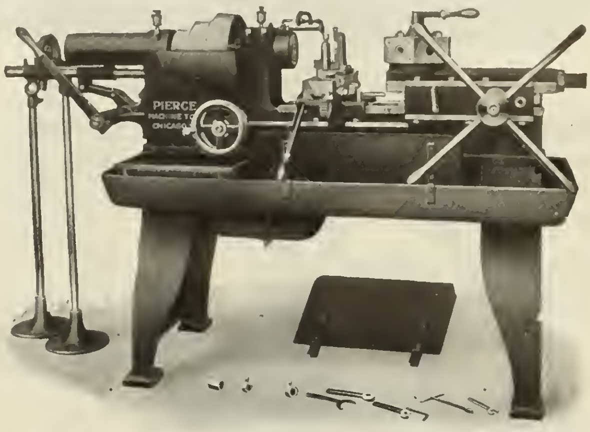
Engine Lathes—26-inch, 18-inch, 16-inch.
Turret Lathes—16-inch.
Screw Machines—2¼-inch.
Speed Lathes—12-inch.

OLIVER MACHINERY CO.
No 7 Coldbrook St. GRAND RAPIDS, MICH.

Accuracy, Speed, and Unusual Range

The Pierce Turret Screw Machine in operation is one of the speediest and most convenient machines of its kind on the market. We have made the "Pierce" rigid and strong, provided more power than is ever apt to be required, and made the machine a joy for the operator to handle. Spindle is carefully machined and hardened, has minimum overhang and is free from vibration regardless of speeds or class of work. Turret is rigidly constructed and automatically locked, directly under the cutting tool, when indexed.

Actual capacity is 1 1/16″ x 8″. In every important detail the "Pierce" is of greater dimensions than any other machine of similar capacity.

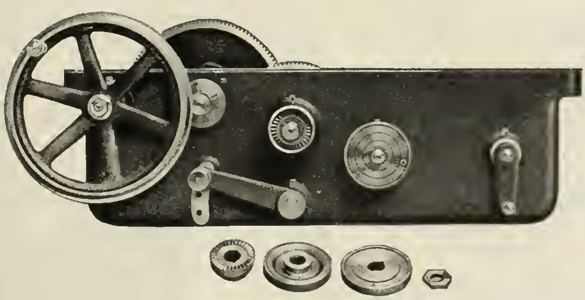


Actual Capacity 1 1/16″ x 8″

Complete description on request.

617 W. Jackson Blvd. **PIERCE MACHINE TOOL CO.** Chicago Ill., U. S. A.

HIGH GRADE TURRET MACHINERY



APRON POWER

to Feed the Carriage Against Heavy Cuts is Provided in Our Large Lathes

The above front view of apron partly dismantled shows construction of positive, toothed clutch (no frictions employed). The arrangement of the discs which carry the shearing pin is also shown. This shearing pin will break before the all-steel gearing will give way.

H-S-G TRADE MARK

LARGE SWING LATHES BUILT IN 30″, 36″ 42″, 48″, 54″ AND 60″ SIZES

THE HOUSTON, STANWOOD & GAMBLE COMPANY

CINCINNATI, U. S. A.

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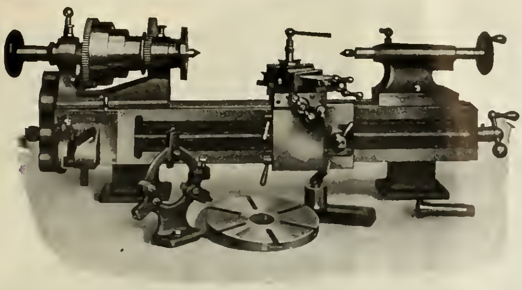


Wade 8" Precision Lathe

This lathe is designed for tool room, experimental and scientific work—for use wherever close accuracy is of prime importance. Nothing but the best in design and construction; only honest values go—for the Wade is built to take a permanent place in the machine tool field.

A strong feature is the quick change gear mechanism which provides for any thread from 12 to 120 per inch. Other features include a set of eleven spring chucks, two face plates, ground tool-steel bearings and draw-in type spindle, covered gears, etc.

Complete description on request

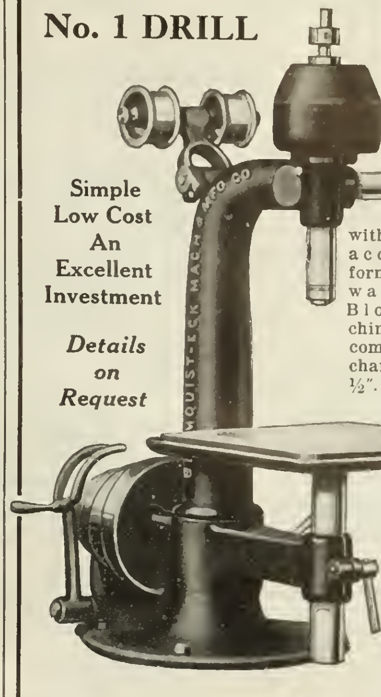
WALTER H. WADE

311 Atlantic Ave. Boston, Mass.

AGENTS: T. Crowther & Co., Boston, Mass. L. R. Meisenhelter Machinery Co., Philadelphia, Pa. E. A. Kinsey Co., Cincinnati, Ohio. International Commercial Co., New York, for Russia. Alfred Herbert, Ltd., Coventry, England. Charles Churchill & Co., Ltd., London, Eng.

BLOMQUIST-ECK

No. 1 DRILL



Simple
Low Cost
An
Excellent
Investment

Details on Request

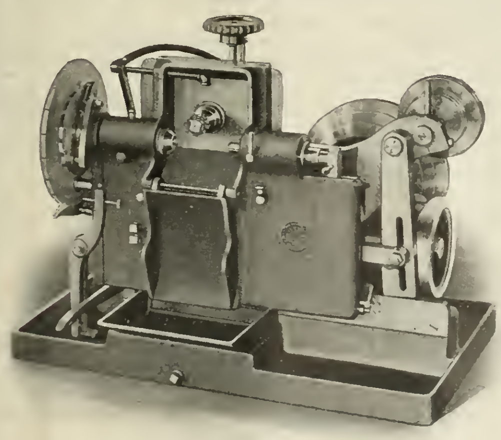
There's a place for this drilling machine in your shop if there is any quantity of bench drilling to perform. This drill answers requirements with the same speed, accuracy and uniformity that has always characterized Blomquist-Eck Machines. It is strong, compact, has two speed changes, drills up to ½".

The Blomquist-Eck Machine Company

**203 St. Clair Ave., N.E.
CLEVELAND, OHIO**

AGENTS: Northern Mchy. Co., Minneapolis, Minn. Strong, Carlisle & Hammond Co., Cleveland, Ohio. Essley Mchy. Co., Chicago, Ill.

The Waltham 4" Precision Gear Cutter



A profitable little machine for the shop that makes small gears and fine pitch pinions. The "Waltham" is automatic in operation, has all working parts protected and is a speedy producer of accurate work. When cutter slide is in cutting position and cut in progress, it is tightly clamped; clamp is released on return stroke so slide may be lifted for indexing.

Complete description on request.

Waltham Machine Works

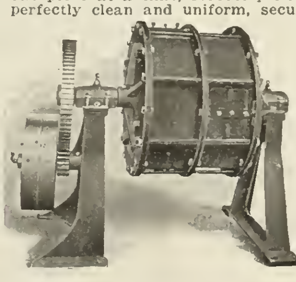
Newton Street WALTHAM, MASS.

Small Thread Millers, Gear Cutters and other small Automatic Machines

MACHINE TOOLS
THE
E·L·ESSLEY MACHINERY
CO
CHICAGO

Burnishing Up-to-Date

The modern idea of burnishing small metal parts—the most in the shortest time—is developed to the last notch by the Abbott Tumbling Barrel process. Hand polishing turns out one piece at a time, Abbott polishing—hundreds. Finish is perfectly clean and uniform, secured without injury to the work. And it's particularly cheap in labor—one operator handling four or five machines.



We'll gladly burnish samples of your work free and estimate on costs.

THE ABBOTT BALL COMPANY
(ELMWOOD)
HARTFORD CONN.

Second-Hand Machinery, Tools and Accessories

NEW, REBUILT AND USED MACHINERY

The Only Re-Manufacturing Plant in the World, 55,000 Sq. Ft. of floor space

TURRETS—Latest Models

25—21" Gisholts, 2-step, 5" belt, 3½" hole.
25—21" Gisholts, motor arrangement, 3½" hole.
15—24" Gisholts, 3-step, 4" belt, 4¼" hole.
40—24" Gisholts, 2-step, 6" belt, 6" hole.
42—24" Gisholts, motor arrangement, 6" hole.
4—3-A Warner & Swasey.

ENGINE LATHES—Latest Models

24—22" x 8' Hamilton, D.B.G., C.R., Semi-Q.C.G.
5—22" x 8' Hamilton, D.B.G., turret tool post.
7—22" x 10' Hamilton, D.B.G., C.R., Semi-Q.C.G.
2—22" x 10' Hamilton, D.B.G., turret tool post.
20—22" x 10' Davis, D.B.G., C.R., Q.C.G.
4—22" x 8' Davenport, D.B.G., turret tool post.
8—24" x 10' Lodge & Shipley, D.B.G., C.R., Q.C.G.
8—24" x 10' Lodge & Shipley, Selective Gd. Hd., C.R.
11—26" x 10' American, D.B.G., C.R., Q.C.G.
2—25" x 10' American, D.B.G., carriage turret.
19—26" x 12' Putnam, carriage turret, Semi-Q.C.G.
9—26" x 12' Putnam, C.R., Semi-Q.C.G.
2—26" x 12' Wickes, D.B.G., ,C.R. Semi-Q.C.
10—28" x 10' Niles, Bement, Pond, Q.C.G.
4—28" x 14' Lodge & Shipley, Select. Gd. Hd., C.R., carriage turret.
3—30" x 16' Lodge & Shipley, Select. Gd. Hd., C.R., carriage turret.
11—40" x 18' Pittsburgh Triple Geared, Q.C.G.

VERTICAL BORING MILLS

1—30" Baush.
1—32" Rogers.
2—34" Colburn.
1—36" Brown & Sharpe Chucking.
1—42" Colburn, 2 hds.
1—51" Baush, 2 hds.

RADIALS

3—2½' Fosdick.
2—2½' Mueller.
1—2½' Dreses.
1—3' Prentice.
1—3' Mueller.
1—3½' Gang.
1—4' Niles Full Universal.
3—5' Niles Semi-Universal.

PLANERS

1—22" x 22" x 5' Flather.
1—22" x 22" x 6' American.
1—24" x 24" x 4' Gray.
2—24" x 24" x 5' Gray.
1—24" x 24" x 6' Cincinnati.
1—24" x 24" x 10' Lodge & Davis.
1—26" x 26" x 6' American.
1—30" x 30" x 10' Powell, 4 hds.
1—32" x 32" x 8' Gray, 2 hds.
1—32" x 32" x 10' Gray, 2 hds.
1—76" x 48" x 18' Woodward & Powell, 4 hds.

PRESSES

1—No. 30 Perkins Inclinable.
1—No. 5 Niagara Geared.
1—No. 5 Consolidated.
1—No. 20-U Ryerson Punch.
3—No. 73½ Bliss S. S. Trimming.
1—No. 23½-B Niagara Toggle.
1—Long & Allstater Geared Punch.
1—No. 17 Williams & White Double End Punch.

MILLERS

1—No. 3 Brainard Plain.
1—No. 20 Oesterlein Universal.
1—No. 1½ Brown & Sharpe Universal.
1—No. 25 Becker Plain.
1—No. 2 Cincinnati Universal.
1—No. 5 Schuchardt & Schutte Plain.
1—No. 3 Hendey Plain.
1—60" x 48" x 8' Ingersoll Slab.
1—Beaman & Smith, 2 vert. hds., 1 horiz. hd.
1—No. 2 Beaman & Smith Combination.

GEAR CUTTERS

1—No. 1 S. & S. Hobber, spiral.
1—No. 12 B. & S., spur and bevel.
1—24" Fellows Gear Shaper.
2—No. 3-26" Cincinnati Spur.
1—36" Fellows.
1—36" Gleason Former, spur and bevel.
1—84"—96" Gleason Planer, spur and bevel.

ReMANUFACTURED -(ORIGINATED BY US)- MACHINE TOOLS

Our Guarantee:—Your money back, if you return machine within 30 days from date of shipment, freight prepaid. No excuses necessary.

Our new "Green List" just out, describes the above machines and hundreds of others. Write for one.

HILL, CLARKE & CO. of CHICAGO

625 Washington Blvd. CHICAGO, ILL., U. S. A.

NEW AND USED MACHINE TOOLS

IN STOCK FOR IMMEDIATE DELIVERY

RADIAL DRILLS (Used)
1—3′ Bickford Plain Radial, Gear Box Drive.

THREAD MILLER (Used)
1—No. 3 Lees-Bradner (used one month)

MILLING MACHINES (New)
1—No. 3 Rockford Hand Miller.
3—U. S. Plain Hand Millers (Whitney type).
2—Standard Hand Millers (Whitney type).

MILLING MACHINES (Used)
2—No. 2 Garvin Hand Millers, Lincoln type.
3—No. 1 Steptoe Hand Millers with vise and arbor.
1—No. 3 Cincinnati Plain Miller.

SHAPERS (Used)
1—20″ Queen City B.G. (like new).

SCREW MACHINES (New)
3—No. 0 Foster Plain Head, 9/16 wire feed capacity.
1—No. 2 Foster Plain Head, 1 1/16 wire feed capacity.
2—No. 4 Foster Geared Fr. Head, 1 9/16 wire feed capacity.
1—No. 6 Foster Geared Fr. Head, 2 1/16 wire feed capacity.
1—No. 140 Wells (7/8 capacity).
1—No. 2½ Garvin (1 7/16 capacity).

SCREW MACHINES (Used)
1—½ Pratt & Whitney Automatic Screw Machine.
1—Foster No. 4 Motor Driven Screw Machine.
1—No. 52 Acme 4-spindle, ¾″ capacity automatic.

GRINDERS (New)
1—Capital Internal Grinder, capacity 3/16″ to 2 x 2.
1—Greenfield Universal Grinder.
1—No. 1 Wilmarth & Morman Surface Grinder.
1—Wilmarth & Morman No. 2 Full Automatic Surface.
2—No. 190 Wells Tool and Cutter Grinder.
6—Dumore Portable Electric.

GRINDERS (Used)
1—No. 190 Wells.
1—No. 1 Landis Universal.

POWER SQUARING SHEAR (Used)
1—60″ Niagara Power Squaring Shear, capacity ⅛ stock.

BENCH LATHES (New)
2—No. 5½ Sloan & Chace, Comp. slide, 3 speed, c/s 10 col.
1—Ames Compound Slide, 3 speed, c/s 10 collets.

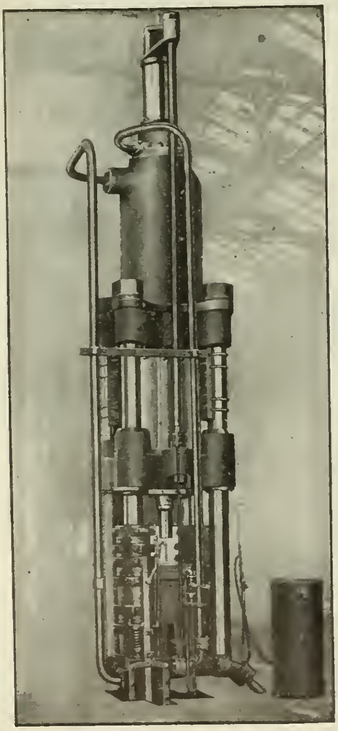
LATHES (New)
2—13 x 6 Worcester, P.C., C.R.
1—14 x 6 Hamilton, Q.C., C.R., Sgl. B.G.
3—16 x 8 Flather, Q.C., C.R., Dbl. B.G.
2—18 x 8 Hamilton, Q.C., C.R., Sgl. B.G.
1—20 x 6 Rahn-Larmon, Q.C., C.R., Dbl. B.G.
1—20 x 10 New Haven, P.C., C.R., Dbl. B.G.
1—26 x 10 Lodge & Shipley, Q.C., C.R., Dbl. B.G.

LATHES (Used)
1—12 x 5 Seneca Falls, P.C., C.R.
1—14 x 8 Davis, Q.C., C.R., with chuck.
1—18 x 8 Davis, Q.C., taper attachment, pan bed.
1—20 x 10 Jones & Lamson, P.C., C.R.
1—20 x 12 Greaves-Klusman, Q.C., C.R., taper attachment.
1—28 x 10 Hamilton, Q.C., C.R.
1—16 x 6 Lodge & Shipley Geared Head.

DRILL PRESSES (New)
6—10″ Sensitive Bench Drill Presses with chuck.
3—14″U. S. Sensitive Drills.
2—20″ Buffalo B.G. self-feed automatic stop.
2—20″ Barnes plain lever and worm feed.
2—20″ Barnes B.G., self-feed automatic stop.
3—20″ Champion B.G. self-feed automatic stop.
1—2-spindle No. 32 A Reed Sensitive.

DRILL PRESSES (Used)
1—Sgl. Spindle Sipp High Speed.
1—20″ Excelsior B.G. Auto. Feed.
1—25″ Hamilton B.G. Sliding Head.
3—23″ Snyder B.G. Automatic Feed.
1—24″ Barnes Sliding Head.

HOMER STRONG, Successor to Strong & Hery Company
309 STATE STREET ROCHESTER, N. Y., U. S. A.



FOR SALE

Two 350-Ton Vertical Hydraulic Presses

CAPACITY - - - UP to 6″ H. E. Shell Forgings
PRODUCTION - - - 5″ Forgings, 3,000 in 20 hours

Immediate Delivery

Including pumps, motors, accumulator, valves, underground and overhead piping, fittings, single and double holder die blocks, and all other accessories for complete units, ready for operation, except heating furnaces.

These units are two of four used for forging H. E. shell blanks. Operated less than six months. In first-class condition.

Also offer for sale complete units for machine finishing 4.5″, 5″ and 6″ H. E. shells.

For detailed description, price, terms, etc., address

THE UNION SWITCH & SIGNAL CO.
SWISSVALE PENNSYLVANIA, U. S. A.

Second Hand Machines

Four and one-half inch bar horizontal boring machine.
20" Prentice Bros. lever feed drill.
24" Sibley, sliding head drill, B.G., P.F.
20" Hoefer three-spindle gang, B.G., P.F.
20" Barnes four-spindle gang, one B.G., three P.F., one tapping.
No. 413 Baker Bros. heavy pattern four-spindle gang.
16" Brown & Sharpe spur and bevel gear cutter.
26" Brown & Sharpe spur gear cutter.
36" x 12" Gould & Eberhardt vertical cutting type spur gear cutter.
12" x 24" Modern plain grinder, self-contained, fine condition.
Landis universal grinder (small).
No. 1 Baker Bros. keyseater.
16" x 8' Bradford lathe, compound rest.
21" x 10' Bradford lathe, compound rest.
22" x 10' LeBlond lathe, compound rest, turret on carriage.
56" x 56" x 26' Bement planer, four heads.
1—½" x 9" Acme wire feed screw machine, power feed turret.
34" Lodge & Davis shaper.

Marshall & Huschart Machinery Co.
17 S. Jefferson St. CHICAGO, ILL. — 915 Chemical Bldg. ST. LOUIS, MO.

Immediate Delivery

24" x 10' Springfield Engine Lathe.
9" x 4' Star Engine Lathe.
No. ½ AVEY High-speed Ball-Bearing Sens. Drills.
No. 1 BAKER BROS. High-Speed Drill.
12" x 32" LANDIS Plain Grinder.
No. 3 GARVIN Cutter and Surface Grinder.
10" x 50" Norton Plain Grinder.
36" Bickford Plain Radial.
3" Stover Pipe Machine.
2¼" x 24" WARNER & SWASEY Hollow Hexagon Turret Lathe.
No. 6 Warner & Swasey Turret Screw Machines.
3½' Prentice Bros. Plain Radial.
4' Mueller Plain Radial.
7' OHL Bending Brake.
No. 2 BATH Universal Grinder, 9" x 20".
No. 2 COCHRANE-BLY Die Filing Machine.
⅞" FOSTER-KIMBALL Plain Head Screw Machine.
No. 1½ HIGLEY Cold Saw.
16" Barker Crank Shaper.
No. 3 Barber-Colman Gear Hobbing Machine.
⅝" CLEVELAND Automatic Screw Machines (2).

THE E. L. ESSLEY MACHINERY CO.
551-557 West Washington Boulevard
CHICAGO, ILLINOIS

Factory and Mill Supply Co.

137 Oliver Street, BOSTON, MASS.

One Baush Plain Radial Drill, 6' arm, cone driven.
One Bickford Radial Drill, with tapping attachment, 3' arm, single pulley drive.
Two Pratt & Whitney Plain Cylindrical Grinders, capacity 6"x 48", in excellent condition.
One Springfield Machine Tool Co., Cylindrical Grinder, capacity 12" x 96".
One Flather Automatic Spur Gear Cutter, capacity 26" x 8', excellent condition.
One Brown & Sharpe, ditto.
One 8" x 18" Modern Tool Co., Grinder, new.
One Diamond Machine Co., Roll Grinder, capacity 8" x 26".
One No. 5 Becker Vertical Milling Machine.
One Kempsmith No. 1 Universal Milling Machine.
One No. 3 Cincinnati Plain Milling Machine.
One 26" x 7' Niles Planer, parallel drive, one head.
One Wheeler Planer, 24" x 24" x 6' in excellent condition.
One Whitcomb Crank Planer, used less than two years, excellent condition.
One Hendey 28" Friction Shaper, motor driven, complete with motor, practically new.
One 2"x 24" Jones & Lamson Geared Head Turret Lathe, with bar and chucking equipment.
One 2" x 24" Jones & Lamson Geared Head Turret Lathe, flat, two spindle, with complete chucking equipment, latest model, in excellent condition.

We also carry a large line of Shapers, Turret Lathes, Hand Screw Machines, Engine Lathes, Upright Drills, etc. Send us your inquiries.

WANTED AT ONCE

the following machines for export to Japan. Must be in first-class condition and subject to acceptance after inspection:

10—Radial Drills, 5' or over. Give reach of arm.
6—Slotters over 18".
4—Horizontal Borers.
8—Planers 48 x 48 or over. Give length of bed.
30—Lathes, 48" or over. Give length of bed.
3—Lathes, 60" or over.
20—Upright Drills, 2" capacity.
5—Boring Mills over 7'.
1—Boring Mill, 10'.
1—Boring Mill, 12'.
1—Boring Mill, 42".
1—Bending Roll for 1-½" material 13' wide.
1—Bending Roll for 1-½" material 8' wide.
1—Straightening Roll for 1-½" material 8' wide.
1—Punch and Shear for punching 1-¾" hole in material, 1-½" thick, 36" gap.
1—Manhole Flanging Press for 1-½" material.
1—2000-ton Steam Hydraulic Press.
3—6' Universal Radial Drills.

PAYMENT CASH AGAINST SHIPPING DOCUMENTS—STATE FULLY MAKE, AGE AND CONDITION.
ALSO—6 Miles 40-lb. Rails and 5 Miles 30-lb. Rails, complete with splice bars and bolts. Second Hand; shipment in July.

BOX A138
Care MACHINERY, 148 Lafayette Street, N. Y.

ROUX & HEYBERGER

180 Rue Lafayette, Paris

Solicit Offers for

Seamless Steel Tubes.
Lap Welded Boiler and Steam Tubes.
MACHINE TOOLS
Draw Benches for Tubes. Presses.
Forging Machines for Nuts, Bolts and Rivets.
PUNCHING and SHEARING MACHINERY
Radial Drills. Steel and Iron Products.

MODERN GRINDER Plain Cylindrical, Self Contained 12" x 36"

Used less than 10 days. Same as brand new machine. No use for it here, so offer to help someone else. First come first gets it. A great bargain for quick sale.

W. B. MARVIN MFG. CO.
URBANA, OHIO

WANTED

Steam Driven Air Compressor

about 1,000 cu. ft., two stage. 90 to 100 pounds pressure, for 125 pounds boiler pressure. Non-condensing.

DRIVER-HARRIS CO.
NEWARK, N. J.

¾" GRIDLEY

Four Spindle Screw Machine, absolutely new —price $1500.

Nearly new Brass Tube Polishing Machine – price $500 for prompt acceptance.

STANDARD METAL MFG. CO.
NEWARK, N. J.

BOARD DROP HAMMERS

We offer subject to previous sale

2—Chambersburg 2000-lb. Model 20-BH
3—E. W. Bliss 800-lb. Model 1-2100
1—Billings & Spencer 400-lb. Model D

All are in good condition. B. & S. practically new. Space required for other equipment.

The Union Switch & Signal Co.
SWISSVALE, PA.

REBUILT TOOLS

GRINDERS: No. 1 Landis universal, 8" x 20".
Landis Crank Grinder, 16" x 66", with plain and crank heads.
TURRET LATHES: Jones & Lamson, 3" x 36", geared sliding head, bar equipment.
Pond 21" Rigid, geared head Hamilton, 20" x 8', engine turret, friction head, pan bed, p. f. turret on bed.
GEAR CUTTERS: 22" x 5" x 6 pitch, Gould & Eberhardt, spur and bevel.
Whiton, 24", spur gears only
MILLING MACHINES: No. 1-½ Grand Rapids, back geared, plain.
No. 13 Brown & Sharpe Manufacturing, plain.
No. 3 Aurora, plain, single back gear.
No. 1-½ American, universal, complete.
4-spindle Warner & Swasey Valve Miller.
PLANER: 42" x 42" x 10' Hewes & Phillips, one rail head, one side head, fine.

SEND FOR COMPLETE LIST

FEDERAL MACHINERY SALES CO.
14 N. Jefferson Street, CHICAGO

REBUILT MACHINES

PLANERS

1—Sellers 36 x 36 x 10' with 2 heads.
5—Sellers 25 x 25 x 6'.
2—Sellers 25 x 25 x 8'.
1—Putnam 24 x 24 x 8'6.
1—Putnam 25 x 25 x 10'.
1—Wheeler Heavy 30 x 30 x 8'6.
1—Lathe-Morse 24 x 24 x 5'6.
1—New Haven 24 x 24 x 7'.
1—Wood Light 30 x 30 x 8'.
1—Putnam 42 x 40 x 12'6.

GRINDERS

1—LeBlond Universal Tool & Cutter, power feed, same as new.
1—Bridgeport Plain Grinder, 16x36.
1—No. 1 Landis Universal Grinder.
1—No. 3 Landis Universal Grinder.
2—No. 6X Diamond Double Disc Grinders.
1—Ford-Smith Plain Grinder.

AUTOMATICS

1—1" National Acme Double Belt Type.
1—1⅝" National Acme Double Belt Type.
1—No. 55 National Acme.
1—1" National Acme four-spindle.
2—No. 54 National Acme four-spindle.
3—2" Cleveland.
1—2¼" Cleveland.
2—2¼" Gridley Single-spindle Motors.
1—3¼" Gridley Single-spindle Motor.

LATHES

1—32 x 12' Draper Lathe, C.R., H.S.
1—36 x 22' Fitchburg Lathe, C.R., P.C.F.
1—30 x 8' Fitchburg, C.R., P.C.F.
3—18 x 8' Putnam, C.R., taper.
6—18 x 8' Porter, C.R., semi-quick, taper.
2—18 x 8' Davis, C.R., pan, pump, taper.
10—16 x 8' Greaves-Klusman, C.R., pan, pump.
9—20 x 6' Perkins Plain Turning, pan, pump.
1—14 x 6' Porter, C.R.
1—20 x 8' LeBlond, C.R.
1—13 x 5' Seneca Falls, C.R., pan.
14—20 x 6' Perkins Lathes, pan bed, chuck, Fay & Scott turrets.

MISCELLANEOUS

1—No. 3 Kempsmith Plain Miller, same as new.
1—9" Industrial Works Slotter.
1—24" Aurora Sliding Head Back Geared Drill.
3—Prentice 24" Sliding Head Drills.
2—Industrial 40" Drills.
1—Western Hydraulic Banding Machine.
1—Jenckes Band Turning Lathe, with 3" Universal Chuck.
1—36" Aurora Drill.
1—12" Bement Travelling Head Shaper.
1—12" Juengst Crank Shaper.
1—90" Putnam Wheel Lathe, double quartering.
1—Sellers Slab Miller, 24 x 21 x 12'.
1—No. 21 Lea-Simplex Saw.
1—26 x 10 Cincinnati Gear Cutter.

This is only a Partial List—Send for Full List.

SIMMONS MACHINE CO., Inc.

New York: 1001 Singer Building
Telephone Cortlandt 6575

Albany, N. Y.: 987 Broadway
Telephone 4876 Main

Niles 42" Vertical Boring Mill. One Swivel Head. One Fixed Turret Head. Four Jaw Chuck Table. Self-contained.

Fellows 36" Gear Shaper.

Bardons & Oliver No. 5 Screw Machine.

Jones & Lamson 2" x 24" Flat Turret Lathe. Geared Head.

Warner & Swasey No. 2-A Hexagon Turret Lathe. Cone Drive.

Greenfield No. 1 Plain Grinder, 5" x 12". Hydraulic Table Feed. Landis No. 24 Plain Grinder, 12" x 66".

HILL, CLARKE & CO., Inc.

THE MACHINERY MERCHANTS

156 Oliver Street, BOSTON

136 Cedar Street, NEW YORK

List of Machinery for Disposal

On hand at Hudson Motor Car Plant

Prices are all f.o.b. Detroit—sale terms, one-third cash with order, balance to be paid against sight draft attached to bill of lading.

1—14" Fay Automatic Lathe, 14" swing over-shears and 10" under-carriage, turn to 10" in length, with equalizing drive face plate, self-contained taper attachment, oil pump, piping and change gears. (Practically new).

1—19" x 8' LeBlond Heavy Duty Lathe, complete with countershaft, etc. (Never been used).

7—19" x 6' LeBlond Heavy Duty Automobile Lathes, complete with turret tool posts. (Absolutely new.)

1—12-spindle Foote-Burt Valve Grinder. (Practically new.)

1—99 Defiance Bow Chucking Machine, complete with counter belt, shifting apparatus, 2 chucking heads, knives, guards, 1 cast iron master cam and necessary oil cups and wrenches. (Very little service.)

1—No. 598 Bow Shaping and Equalizing Machine, complete with all standard equipment. (Practically new.)

2—Bryant Chucking Grinders No. 6—one new and one used.

1—Bryant Chucking Grinder—double spindle. (New.)

1 Serial No. 16-249 Gisholt Lathe.
Diam. of chuck, 24".
Swing over ways, 24".
Swing over carriage, 13⅞".
Traverse of turret, 50¾".
Bore of spindle, 2½".
Diam. of holes in turret, 3".
Width of belt, 4".
Length overall, 11' 4".
Width overall, 3' 10".
Shipping weight (approx.) 8000 lb.
H. P. motor for main drive 4½.
H.P. motor, turret rapid traverse 1.

(This machine has been in use about a year and is in excellent condition.)

1—No. 6-K Disc Grinder, manufactured by Diamond Machine Co., Serial No. 5125. (Slightly used.)

1—No. 4 Gardner Disc Grinder. (Slightly used.)

1—2 x 8 Barnes Horizontal Drill, double spindle. (In excellent condition.)

HUDSON MOTOR CAR CO., Detroit, Mich.

M. J. WALSH MACHINERY CO.

141 Sycamore St., Milwaukee, Wisconsin

Second-Hand Machines

LATHES

1—18" x 10' Rahn-Meyers Lathe, 5-step cone, single back gear, compound and steady rest, hollow spindle, power cross feed, chuck fitted countershaft.
1—16" x 8' Porter Lathe, 4-step cone, single back gear, compound and steady rest, power cross feed, countershaft.
2—No. 6 Warner & Swasey Screw Machines geared friction head, power feed to the turret.
1—No. 2 A Warner & Swasey Lathe with bar equipment.
1—14 x 6 Hamilton Style A Lathe oil pan, taper attachment and relieving and tapping attachments.
1—11" x 5' Pratt & Whitney Lathe, 5-step cone, single back gear, plain rest, countershaft.
1—20" Porter Pattern Maker's Lathe, countershaft.
2—No. 6 Potter & Johnston Automatic Chucking Lathes, with all regular equipment regularly furnished for chucking..
1—3 x 36 All Geared Head Jones & Lamson Turret Lathe, with bar equipment, friction feed.

DRILLS

1—14"—4-Spindle Henry & Wright Ball Bearing Drill.
1—Small Knight Drilling Machine and for Milling.
1—20"—2-Spindle W. F. & J. Barnes Drill. One spindle arranged with wheel, lever and power feed. Other spindle with wheel, lever and power feed, back gears and tapping attachment. Both drills are the same.
1—24" All Geared Drive Barnes Drill

PUNCH PRESSES

1—No. 19 Bliss Open Back Inclined Press, with stationary legs, automatic feed, back geared.
1—No. 3 A Willard Open Back Inclined Press.
1—No. 1 Solid Back Heartley Press.
1—No. 472 Consolidated Double Crank Press, with 4 stroke.
1—Walsh Hand Screw Press.
1—Perkins Screw Press.

GRINDERS

1—16 x 60 Landis Plain Grinder with two sets of heads. One for plain cylindrical grinding. Other for crank grinding.
1—12 x 36 Cincinnati Plain Grinder Self Contained Counter.
1—No. 1 Landis Universal Grinder.
1—8 x 16 Ott Plain Grinder.

MISCELLANEOUS IRONWORKING MACHINES

1—No. 1½ Grand Rapids Back Geared Plain Mfg. Milling Machine.
1—Kempsmith Lincoln Type Milling Machine.
1—Four Spindle Warner & Swasey Valve Milling Machine, fitted with No. 2 M.E.C. valve milling air chuck, countershaft.
1—Racine Power Hack Saw No. 1.
1—Circle Shears.
1—62" Bertch Foot Power Gap Squaring Shears.
1—50" Peck, Stow & Wilcox Cornice Brake.
1—10' Dreis & Krump Bending Brake.
1—4' Peck Stow and Wilcox Roll, 4" diameter rolls.
1—7' Roll, 6½" Rolls.
1—20" Whiton Gear Cutter.
1—½" Acme Bolt Cutter.
1—American Oil Separator.
1—No. 94 Forbes Pipe Machine, for hand and power, cuts off and threads from 2½" to 6" inclusive.
1—No. 119 Bliss Thread Roller.
1—Peerless Combination Punch and Shear.
1—½" Shuster Riveter.
1—¼" Shuster Riveter.
1—Bliss Deep Throat Punch and Riveting Machine.

RIVERSIDE MACHINERY LIST

WE OWN EVERY TOOL OFFERED

ENGINE LATHES

1—28 x 10 Hamilton Standard Engine Lathe, with turret.
1—28 x 15 Putnam Standard Engine Lathe.
1—22 x 14 Putnam Standard Engine Lathe.
3—New 18 x 8 Springfield Engine Lathes.
1—New 16 x 8 Springfield Engine Lathe.
1—New 14 x 6 Springfield Engine Lathe.
1—18 x 6 Jones & Lamson Standard Engine Lathe.
1—16 x 8 Porter Standard Engine Lathe.
2—16 x 8 Reed Stud Lathes.
1—14 x 8 Sebastian Standard Engine Lathe.
1—14 x 6 Lodge & Shipley Engine Lathe.
1—14 x 6 Springfield Engine Lathe.
1—14 x 6 Prentiss Engine Lathe.
1—14 x 6 Sebastian Engine Lathe.
2—14 x 6 Van Werk Engine Lathes.
1—11 x 5 Seneca Falls Engine Lathe.
1—No. 3 Hardinge Bench Lathe.

TURRET AND SCREW MACHINES

1—$2\frac{1}{4}$ x 24 Jones & Lamson Flat Turret Lathe, S.G.H.
1—2 x 24 Jones & Lamson Flat Turret Lathe, cone head.
2—No. 6-A Potter & Johnson Automatic Lathes.
3—No. 4 Foster F.G. H. Hand Screw Machines.
2—No. 3 Foster F.G.H. Hand Screw Machines.
1—No. 5 Pierson F.G.H. Hand Screw Machine.
1—No. 4 Smurr & Kamen Hand Screw Machine.
4—New 14" Pierce Turret Lathes.
2—New 1 x 8 Pierce Hand Screw Machines.
2—2" Cleveland Automatic Screw Machines, jogger feed.

MILLING MACHINES AND GRINDERS

2—No. 3 Cincinnati Universal Cone Type.
5—No. $1\frac{1}{2}$ Knight Milling and Drilling Machines.
2—No. 13 Pratt & Whitney Lincoln Type Milling Machines.
1—No. 1 Cincinnati Plain Milling Machine.
1—No. $13\frac{1}{2}$ Garvin Plain Milling Machine.
1—No. 2 Hendey Plain Milling Machine.
3—Fox Hand Milling Machines.
1—Garvin Hand Miller.
1—No. $2\frac{1}{2}$ Bath Universal Grinder.
1—No. 170 Wells Cutter Grinder.
1—Mina Valley Universal Cutter Grinder.
4—No. 0 Burke Bench Mills. (New.)

DRILL PRESSES

1—3-spindle 8" Overhang Henry & Wright High Speed Drill.
3—12" Leland & Gifford High Speed Bench Drills.
5—20" Buffalo Plain Drill Presses.
4—6 spindle Fox High Speed Drill Presses.
2—4 spindle Fox High Speed Drill Presses.
1—3' Mueller Plain Radial Drill.
1—4' Bickford Radial Drill with T.A.
1—6' Mueller Plain Radial Drill.
1—16 spindle Natco Drill.

SHAPERS AND PLANERS

1—24" Ohio H.D. B.G. Crank Shaper.
1—24" New Barker Crank Shaper.
1—24" Lodge & Davis Geared Shaper.
1—18" Hendey Geared Shaper.
1—16" Hendey Geared Shaper.
1—16" Garvin Shaper.
2—16" New Springfield B.G. Crank Shapers.

PRESSES

1—Waterbury-Farrell Straight Sided Geared Press with double cam knock-out.
1—No. 10 Perkins Drawing Press.
5—No. 2-W Bliss Wiring Presses.
1—800-lb. B. & S. Roll Board Hammer.
1—800-lb. P. & W. Roll Board Hammer.
1—50-lb. Scranton Belt Hammer.
1—25-lb. Bradley Helve Hammer.

AIR COMPRESSORS

1—8 x 6 Westinghouse Steam Air Compressor.
1—16 x 18 x 12 Union Steam Pump Co., Steam Driven Air Compressor.
1—10 x 10 Ingersoll Sargent Belt Driven Air Compressor.
1—10 x 10 Clayton Belt Driven Air Compressor.
1—8 x 8 Fairbanks Morse Electrical Driven Air Compressor.
1—8 x 8 Gardner Single Belt Driven Air Compressor.
1—8 x 8 Union Steam Pump Co. Belt Driven Air Compressor.
1—$7\frac{1}{2}$ x 6 Chicago Pneumatic Tool Co. Belt Driven Air Compressor.
1—6 x 6 Chicago Pneumatic Tool Co. Belt Driven Air Compressor.

We also carry a large stock of Steam Engines, Steam Pumps and Electrical Equipment of all kinds.
We are in the market to purchase machine tools, both large and small.

RIVERSIDE MACHINERY DEPOT, 17-29 St. Aubin Ave., Detroit, Mich.

SECOND-HAND MACHINERY FOR SALE BY THE MOTCH & MERRYWEATHER MACHINERY COMPANY

711 Lakeside Ave., N.W. Cleveland, Ohio

Branch Offices: Detroit, Cincinnati, Pittsburgh.

AUTOMATICS

2" Cleveland.
No. 22 New Britain Chucking.
No. 23 New Britain Chucking.
No. 33 New Britain Chucking.

BROACHING MACHINES

No. 1 J. N. Lapointe.
No. 2 Lapointe Machine Tool Co.
No. 3 Lapointe Machine Tool Co.

DRILLING MACHINES

15" Barnes.
10' Burke Sensitive.
Four-spindle 26" Hoefer Gang.
Four-spindle No. $1\frac{1}{2}$ Foote-Burt Rail.
Four-spinde No. 2 Avey.
Two-spindle No. 2 Avey.

GRINDERS

6" x 32" Norton.
10" x 50" Norton.
10" x 30" Landis.
No. 1 Cincinnati Cutter.
No. 2 Brown & Sharpe, universal.
No. $2\frac{1}{2}$ Bath, universal.
No. 3 Oesterlein.
No. 12 Gardner, duplex disc.
24" Double Wet Tool.
20 x $1\frac{1}{2}$ Single Wet Tool.
No. 200 Heald, ring.

HAMMERS

35-lb. Williams & White, power tire welding.
No. 3 Standard 300-lb. belt drop.
1200-lb. Bell steam.

KEYSEATERS

No. 1 Davis.
No. 2 Mitts & Merrill.
18" x $1\frac{1}{2}$" Norton.

LATHES

14" x 6' Sebastian.
14" x 6' Reed Extra Heavy Stud.
16" x 6' Lodge & Shipley Patent Hd.
16" x 8' Walcott.
16" x 8' Reed Stud.
16" x 6' Harrington.
16" x 10' Rahn-Carpenter.
18" x 8' Lodge & Shipley.
Three step cone, D.B.G.
18" x 8' Lodge & Shipley, Pt. Hd.
18" x 8' LeBlond.
18" x 8' Bradford.
18" x 8' Walcott Q. C.
18" x 10' Monarch Q. C.
18" x 12' Monarch Q. C.
20" x 8' Walcott Q. C.
30" x 14' Lodge & Shipley.

MILLING MACHINES

No. 2 Oesterlein.
No. 7-H Becker, Lincoln Type.
No. 00 Brown & Sharpe.
No. 8 Pratt & Whitney, hand.
No. 10 Pratt & Whitney, hand.

PLANERS

24" x 24" x 5' Blaisdell, one head.
26" x 26" x 6' Pond.
36" x 36" x 10' Sellers, 4 heads.

PIPE MACHINES

12" Curtis & Curtis.

PRESSES

No. 2 Consolidated plain inclinable.
No. 5 Stiles & Parke Blanking Press.

SAWS

6" Atkins "Kwick-Kut."
7" High Duty Paragon.

SCREW MACHINES

$1\frac{1}{2}$" Foster, motor drive.
$1\frac{1}{2}$" Warner & Swasey.
$4\frac{1}{2}$" Bardons & Oliver.

SLOTTERS

12" Industrial.

TURRET LATHES

2" Jones & Lamson.
14" Warner & Swasey.
16" Bardons & Oliver.
21" Gisholt.
22" Libbey.
24" Gisholt.

MISCELLANEOUS

Flywheel balancing machine, Rockford.
Oil Separator, Curtis.

USED MACHINERY FOR SALE

SCREW MACHINES

4—No. 55 National Acme Automatics, 1⅝" capacity, 4-spindle, new within 6 months.
2—Universal Automatics, ¾" capacity, 5-spindle.
1—2" Cleveland Automatic.
1—1¾" Spencer Double End Automatic.
1—1" Pratt & Whitney Automatic.
1—Meridan Tool 2¼" Hand Screw Machine, wire feed and auto. chuck, back geared.

TURRET LATHES

1—Pratt & Whitney No. 3, 2" capacity with drawn collets, back geared, oil pump and pan, power feed turret.

MISCELLANEOUS TOOLS

1—Brainerd Plain Miller, No. 4½.
2—Geometric Threading Machines, fitted with self-opening heads, ¾" dies, new within 6 months.

THE PUFFER MFG. CO., Winchester, Mass.

34 to 42 INCH BORING MILLS

FOR PROMPT DELIVERY

to be used on War Department production. Urgently needed. Reply to

THE WEST STEEL CASTING CO., Cleveland, Ohio

FOR SALE

ENGINE LATHES

FOR IMMEDIATE DELIVERY

20—16" x 6', 8' and 10', full quick change gear.
8—20 x 10' Engine Lathes.
9—16 x 6' Toolroom Lathes with full equipment.

Prices right—act quickly—for further particulars and printed matter address

THE CLEVELAND MACHINERY & SUPPLY CO., Cleveland, O.

FOR SALE

Large quantity of cast iron, steel split, wood pulleys and hangers. All in good condition and can be inspected at any time. Address, Purchasing Dept.

ROBERT GAIR COMPANY, Brooklyn, N.Y.

20-Ton Forcing Press and Roller Jaw Drill Chucks

Manufactured by

WEAVER MANUFACTURING CO.
SPRINGFIELD, ILLINOIS

IDEAL!

Price $2.50
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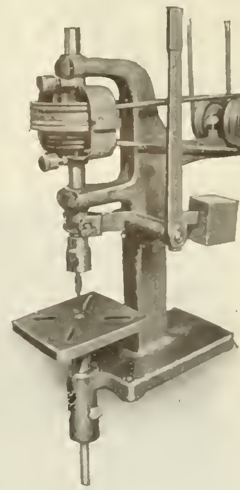

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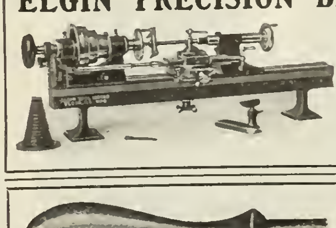

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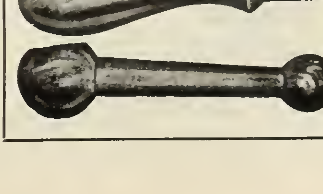

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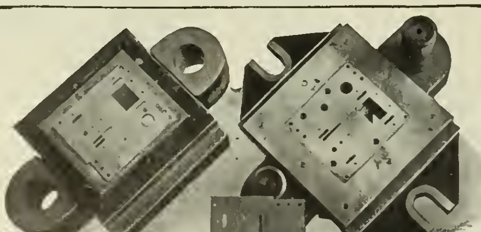

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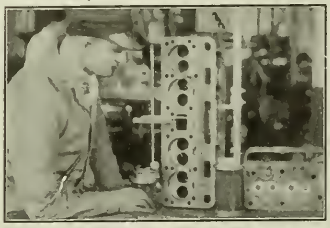

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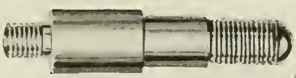

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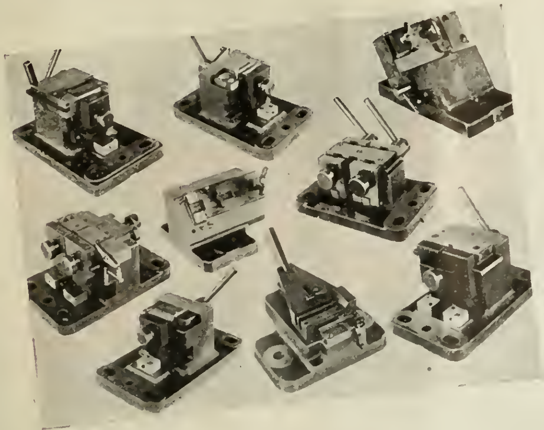

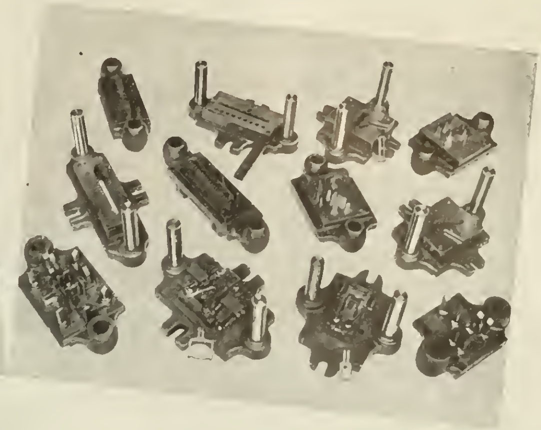

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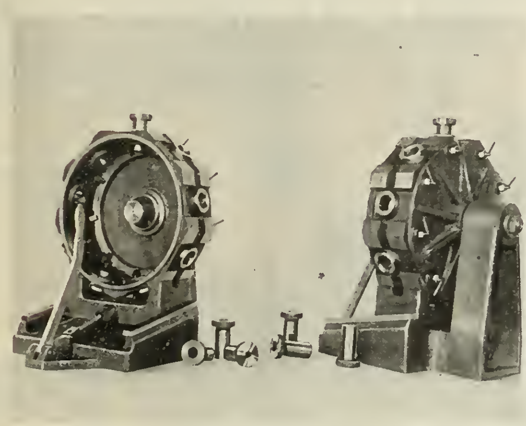

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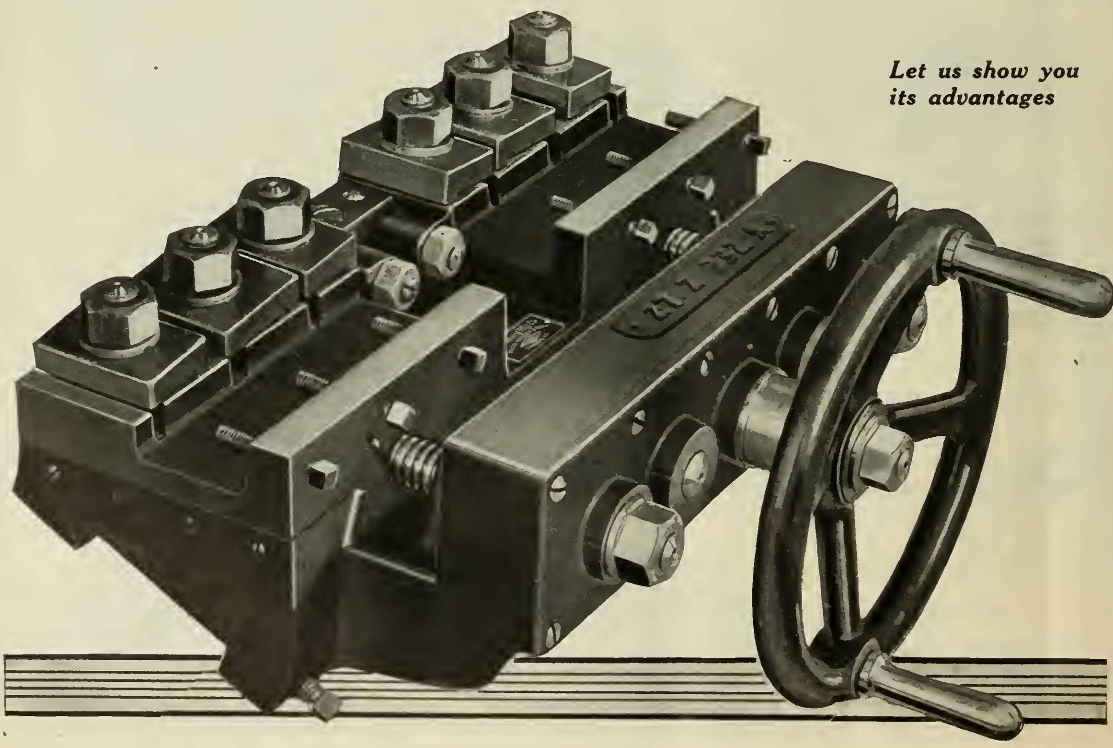

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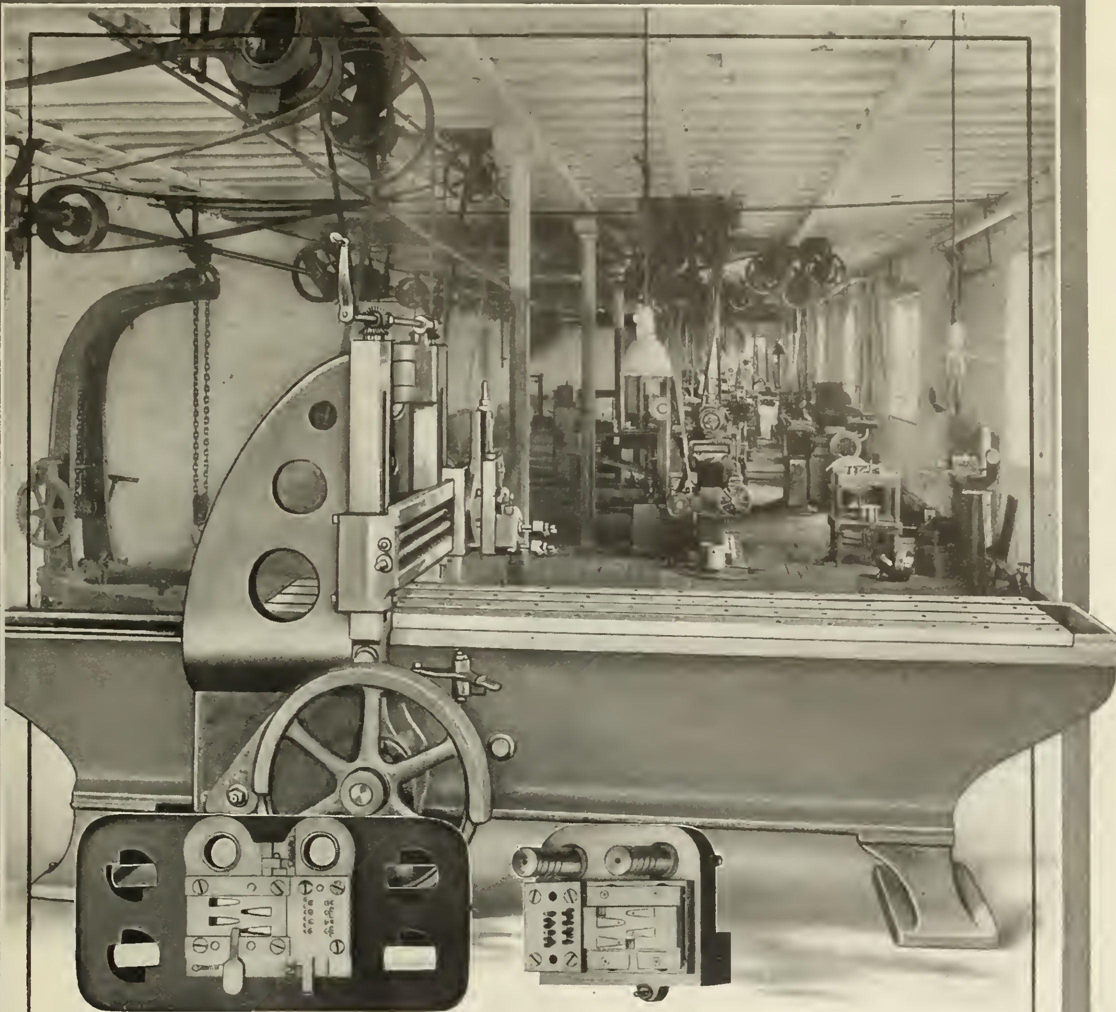

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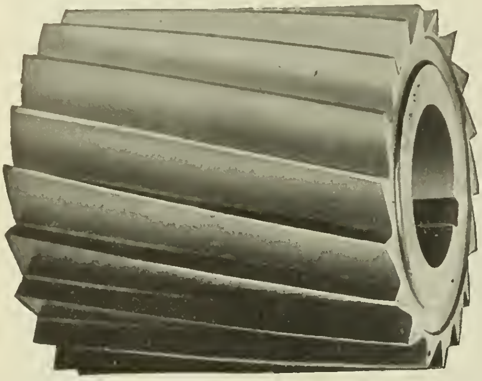

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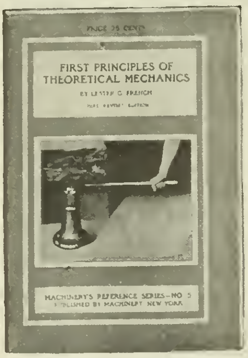

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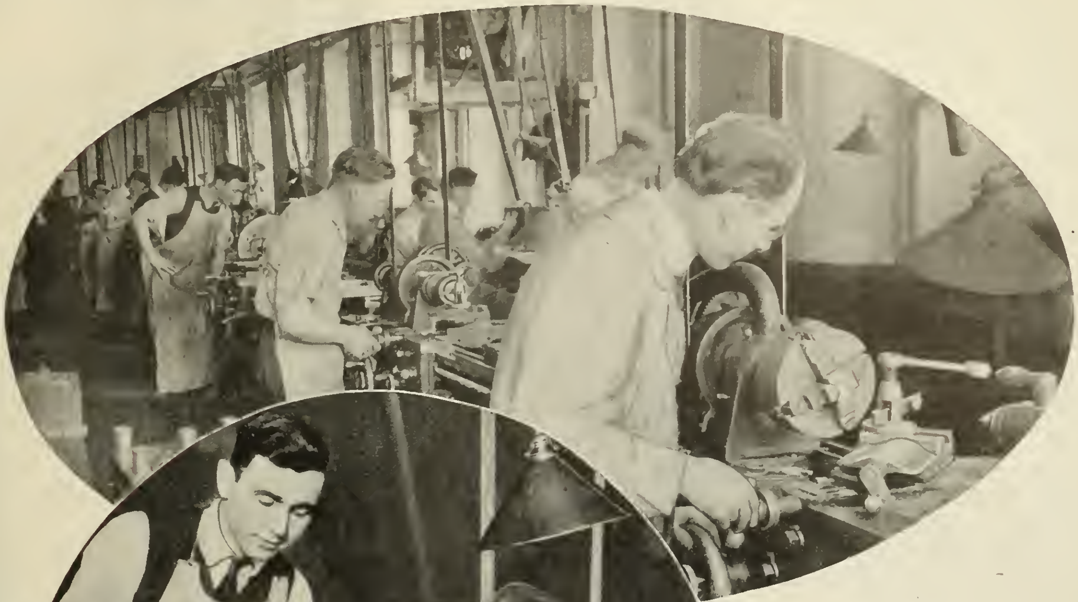

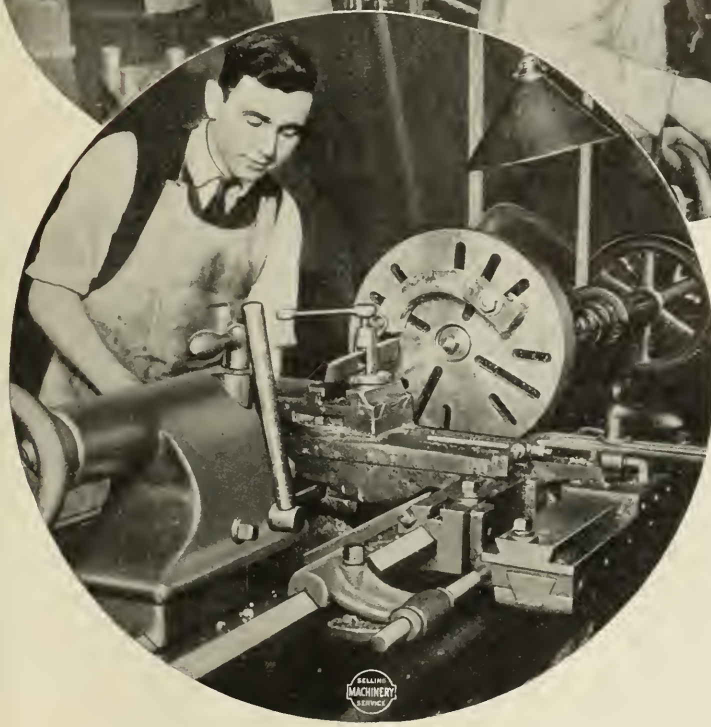

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See Boring Bars.

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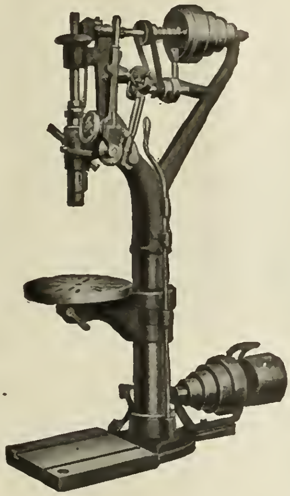

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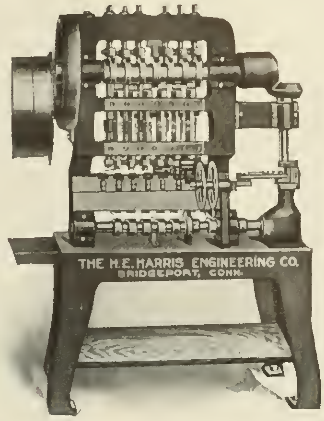

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Chucking Machines, Multiple Spindle, Automatic
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Newman Mfg. Co., Cincinnati, O.
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Millholland Mch. Co., W. K., Indianapolis, Ind.
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Hanna Engineering Works, 1763 Elston Ave., Chicago, Ill.
Harris Engineering Co., H. E., Bridgeport, Conn.
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Taylor Mch. Co., Cleveland, O.
Taylor-Shantz Co., Rochester, N. Y.
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Ulmer Co., J. C., Cleveland, O.
Urbana Tool & Die Co., Urbana, O.

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Onondaga Steel Co., Inc., Syracuse, N. Y.

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Curtis Pneumatic Mchy. Co., 1568 Kienlen Ave., St. Louis, Mo.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
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Niles-Bement-Pond Co., 111 Broadway, New York.
Northern Engineering Works, Detroit, Mich.
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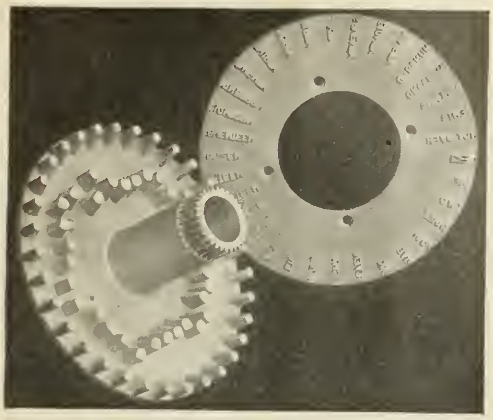

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Pratt & Whitney Co., Hartford, Conn.
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Maute & Sons, J., Buffalo, N. Y.
Noble & Westbrook Mfg. Co., Hartford, Conn.
Schwerdtle Stamp Co., Bridgeport, Conn.

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American Tool & Mfg. Co., Urbana, O.
Automat Tool Works, 252 Greenwich St., New York.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Cleveland Mch. & Mfg. Co., 4944 Hamilton Ave., Cleveland, O.
Columbus Die, Tool & Mch. Co., Columbus, O.
Ferracute Mch. Co., Bridgeton, N. J.
Goddard Tool Co., Chicago, Ill.
Harris Engineering Co., H. E., Bridgeport, Conn.
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Maute & Sons, J., Buffalo, N. Y.
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Michigan Tool Co., Detroit, Mich.
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Ulmer Co., J. C., Cleveland, O.
Urbana Tool & Die Co., Urbana, O.
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Roux & Heyberger, 108 Rue Lafayette, Paris, France.

Drawing Boards and Tables
Economy Drawing Table Co., Toledo, O.
Keuffel & Esser Co., Hoboken, N. J.
New Britain Mch. Co., New Britain, Conn.

Drawing Materials
Keuffel & Esser Co., Hoboken, N. J.

Dressers, Grinding Wheel
Abrasive Co., Bridesburg, Philadelphia, Pa.
American Emery Wheel Works, Providence, R. I.
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Calder, Geo. H., Lancaster, Pa.
Desmond-Stephan Mfg. Co., Urbana, O.
Hetherington-McCabe Co., Piqua, O.
Norton Co., Worcester, Mass.
Reed Mfg. Co., Erie, Pa.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Sterling Grinding Wheel Co., Tiffin, O.
Vitrified Wheel Co., Westfield, Mass.
Western Tool & Mfg. Co., Springfield, O.

Drill Heads, Multiple
Baush Mch. Tool Co., 200 Wason Ave., Springfield, Mass.
Covington Multiple Drill Co., Cincinnati, O.
Medina Mch. Co., Medina, O.
National Automatic Tool Co., Richmond, Ind.
Newman Mfg. Co., Cincinnati, O.
Rockford Drilling Mch. Co., Rockford, Ill.
Sellew Mch. Tool Co., Pawtucket, R. I.

Drill Sockets
Cleveland Twist Drill Co., Cleveland, O.
Detroit Twist Drill Co., Detroit, Mich.
Morse Twist Drill & Mch. Co., New Bedford, Mass.
National Twist Drill & Tool Co., Detroit, Mich.
Scully-Jones & Co., 647 Railway Exchange Bldg., Chicago, Ill.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.

Drill Speeders
Graham Mfg. Co., Providence, R. I.
Peter Bros. Mfg. Co., 135 Railroad Ave., Algonquin, Ill.

Drill Stands
Cleveland Twist Drill Co., Cleveland, O.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.

Drilling Machines, Automatic
Baker Bros., Toledo, O.

Drilling Machines, Bench
Ames Co., B. C., Waltham, Mass.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Blomquist-Eck Mch. Co., Cleveland, O.
Buffalo Forge Co., Buffalo, N. Y.
Canedy-Otto Mfg. Co., Chicago Heights, Ill.
Hisey-Wolf Mch. Co., Cincinnati, O.
Langelier Mfg. Co., Providence, R. I.
Leland-Gifford Co., Worcester, Mass.
National Automatic Tool Co., Richmond, Ind.
Pratt & Whitney Co., Hartford, Conn.
Reed Co., Francis, 43 Hammond St., Worcester, Mass.
Rockford Drilling Mch. Co., Rockford, Ill.
Taylor & Fenn Co., Hartford, Conn.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.

Drilling Machines, Boiler
Cincinnati Bickford Tool Co., Oakley, Cincinnati, O.
Foote-Burt Co., Cleveland, O.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Drilling Machines, Portable Electric
Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill.
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark Electric Co., Inc., Jas., Jr., Louisville, Ky.
Errington Mechanical Laboratory, 39 Cortlandt St., New York.
Hisey-Wolf Mch. Co., Cincinnati, O.
Independent Pneumatic Tool Co., Chicago, Ill.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Neil & Smith Elec. Tool Co., Cincinnati, O.
Standard Electric Tool Co., Cincinnati, O.
Stow Mfg. Co., Binghamton, N. Y.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.
Van Dorn Electric Tool Co., Cleveland, O.

Drilling Machines, Horizontal, Duplex
Garvin Mch. Co., Spring and Varick Sts., New York.
Langelier Mfg. Co., Providence, R. I.

Drilling Machines, Multiple Spindle, Adjustable
Baush Mch. Tool Co., 200 Wason Ave., Springfield, Mass.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Langelier Mfg. Co., Providence, R. I.
National Automatic Tool Co., Richmond, Ind.
Pratt & Whitney Co., Hartford, Conn.

Drilling Machines, Multiple Spindle, Horizontal
Baush Mch. Tool Co., 200 Wason Ave., Springfield, Mass.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Langelier Mfg. Co., Providence, R. I.
Moline Tool Co., Moline, Ill.
National Acme Co., Cleveland, O.

Drilling Machines, Multiple Spindle, Turret
Langelier Mfg. Co., Providence, R. I.
National Automatic Tool Co., Richmond, Ind.
Newman Mfg. Co., Cincinnati, O.
Quint, A. E., Hartford, Conn.
Turner Mch. Co., Danbury, Conn.

Drilling Machines, Multiple Spindle, Vertical
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Barnes Drill Co., Inc., 814 Chestnut St., Rockford, Ill.
Cincinnati Bickford Tool Co., Oakley, Cincinnati, O.
Cincinnati Pulley Mchy. Co., Cincinnati, O.
Clark Electric Co., Inc., Jas., Jr., Louisville, Ky.
Colburn Mch. Tool Co., Franklin, Pa.
Foote-Burt Co., Cleveland, O.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Langelier Mfg. Co., Providence, R. I.
Leland-Gifford Co., Worcester, Mass.
Medina Mch. Co., Medina, O.
Moline Tool Co., Moline, Ill.
National Automatic Tool Co., Richmond, Ind.
Newton Mch. Tool Wks., Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Pratt & Whitney Co., Hartford, Conn.
Quint, A. E., Hartford, Conn.
Reed Co., Francis, 43 Hammond St., Worcester, Mass.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Rockford Drilling Mch. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Silver Mfg. Co., Salem, O.
Sipp Mch. Co., Paterson, N. J.
Taylor & Fenn Co., Hartford, Conn.
Taylor Mch. Co., Cleveland, O.

Drilling Machines, Pneumatic
Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill.
Independent Pneumatic Tool Co., Chicago Ill.
Ingersoll-Rand Co., 11 Broadway, New York.

Drilling Machines, Radial
American Tool Works Co., Cincinnati, O.
Canedy-Otto Mfg. Co., Chicago Heights, Ill.
Carlton Mch. Tool Co., Cincinnati, O.
Cincinnati Bickford Tool Co., Oakley, Cincinnati, O.
Dreses Mch. Tool Co., Cincinnati, O.
Fosdick Mch. Tool Co., Cincinnati, O.
Hammond Mfg. Co., Cleveland, O.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Morris Mch. Tool Co., Cincinnati, O.
Mueller Mch. Tool Co., Cincinnati, O.
Niles-Bement-Pond Co., 111 Broadway, New York.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Roux & Heyberger, 108 Rue Lafayette, Paris, France.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Taylor & Fenn Co., Hartford, Conn.

Drilling Machines, Rail
Colburn Mch. Tool Co., Franklin, Pa.
Foote-Burt Co., Cleveland, O.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Moline Tool Co., Moline, Ill.
Newton Mch. Tool Wks., Inc., 23rd and Vine Sts., Philalelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Taylor & Fenn Co., Hartford, Conn.

Drilling Machines, Sensitive
Albany Hardware Specialty Mfg. Co., Albany, Wis.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Bilton Mch. Tool Co., Bridgeport, Conn.
Cincinnati Pulley Mchy. Co., Cincinnati, O.
De Mooy Mch. Co., Cleveland, O.
Gardam & Son, Inc., Wm., 108 Park Place, New York.
Hammond Mfg. Co., Cleveland, O.
Henry & Wright Mfg. Co., Hartford, Conn.
Johnson Mch. Tool Co., Gouverneur, N. Y.
Langelier Mfg. Co., Providence, R. I.
Leland-Gifford Co., Worcester, Mass.
Pratt & Whitney Co., Hartford, Conn.
Reed Co., Francis, 43 Hammond St., Worcester, Mass.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Royersford Foundry & Mch. Co., 54 N. 5th St., Philadelphia, Pa.
Sibley Mch. Co., 8 Tutt St., South Bend, Ind.
Sipp Machine Co., Paterson, N. J.
Taylor & Fenn Co., Hartford, Conn.

Drilling Machine Spacing Attachment, Universal
Medina Mch. Co., Medina, O.

Drilling Machines, Upright
Albany Hardware Specialty Mfg. Co., Albany, Wis.
Aurora Tool Works, Aurora, Ind.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.

Barnes Drill Co., Inc., 814 Chestnut St., Rockford, Ill.
Beaman & Smith Co., Providence, R. I.
Bilton Mch. Tool Co., Bridgeport, Conn.
Buffalo Forge Co., Buffalo, N. Y.
Canedy-Otto Mfg. Co., Chicago Heights, Ill.
Cincinnati Bickford Tool Co., Oakley, Cincinnati, O.
Cincinnati Pulley Mchy. Co., Cincinnati, O.
Colburn Mch. Tool Co., Franklin, Pa.
Davis Mch. Tool Co., Inc., Rochester, N. Y.
Foote-Burt Co., Cleveland, O.
Fosdick Mch. Tool Co., Cincinnati, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Knight Mchy. Co., W. B., 2019 Lucas Ave., St. Louis, Mo.
Langelier Mfg. Co., Providence, R. I.
Leland-Gifford Co., Worcester, Mass.
Lindgren Co., F. W., Rockford, Ill.
Minster Mch. Co., Minster, O.
Moline Tool Co., Moline, Ill.
Niles-Bement-Pond Co., 111 Broadway, New York.
Pratt & Whitney Co., Hartford, Conn.
Reed Co., Francis, 43 Hammond St., Worcester, Mass.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Rockford Drilling Mch. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Mch. Co., 8 Tutt St., South Bend, Ind.
Sipp Machine Co., Paterson, N. J.
Snyder & Son, J. E., Worcester, Mass.
Standard Mfg. Co., Bridgeport, Conn.
Taylor & Fenn Co., Hartford, Conn.

Drilling Machines, Wall Radial
Canedy-Otto Mfg. Co., Chicago Heights, Ill.

Drills, Center
Cleveland Twist Drill Co., Cleveland, O.
Detroit Twist Drill Co., Detroit, Mich.
Morse Twist Drill & Machine Co., New Bedford, Mass.
National Twist Drill & Tool Co., Detroit, Mich.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Providence, R. I.
Standard Tool Co., Cleveland, O.

Drills, Ratchet
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Detroit Twist Drill Co., Detroit, Mich.
Goodell-Pratt Co., Greenfield, Mass.
Greene, Tweed & Co., 109 Duane St., New York.
Millers Falls Co., Millers Falls, Mass.
National Twist Drill & Tool Co., Detroit, Mich.
Pratt & Whitney Co., Hartford, Conn.
Standard Tool Co., Cleveland, O.
Walworth Mfg. Co., Boston, Mass.
Whitman & Barnes Mfg. Co., 1000 West 120th St., Chicago, Ill.

Drills, Twist
Boker & Co., Inc., H., 101 Duane St., New York.
Clark Equipment Co., Buchanan, Mich.
Cleveland Twist Drill Co., Cleveland, O.
Detroit Twist Drill Co., Detroit, Mich.
Frasse & Co., Inc., Peter A., 417 Canal St., New York.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Montgomery & Co. Inc., 104 Fulton St., New York.
Morse Twist Drill & Machine Co., New Bedford, Mass.
National Twist Drill & Tool Co., Detroit, Mich.
Pratt & Whitney Co., Hartford, Conn.
Reliance Steel & Tool Co., Inc., 30 Church St., New York.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Whitman & Barnes Mfg. Co., 1000 West 120th St., Chicago, Ill.

Drinking Water Fountains and Systems
Allen Filter Co., Toledo, O.
Manufacturing Equipment & Eng. Co., Framingham, Mass.

Dynamos
Eck Dynamo & Motor Co., Belleville, N. J.
General Electric Co., Schenectady, N. Y.
Reliance Electric & Eng. Co., 1056 Ivanhoe Road, Cleveland, O.
Sprague Electric Works, 527 W. 34th St., New York.
Wagner Electric Mfg. Co., St. Louis, Mo.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Electrical Supplies
General Electric Co., Schenectady, N. Y.
Wagner Elec. Mfg. Co., St. Louis, Mo.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Elevators
Albro-Clem Elevator Co., 701 Glenwood Ave., Philadelphia, Pa.
Link-Belt Company, Chicago, Ill.

Emery Wheels
See Grinding Wheels.

Emery Wheel Dressers
See Dressers, Grinding Wheel.

Engines, Steam
Bethlehem Steel Co., South Bethlehem, Pa.
Buckeye Engine Co., Salem, O.
Buffalo Forge Co., Buffalo, N. Y.

Expanders, Tube
Nicholson & Co., W. H., 112 Oregon St., Wilkes-Barre, Pa.
Watson-Stillman Co., 192 Fulton St., New York.

Expansion Joints
Nuttall Co., R. D., Pittsburgh, Pa.

Eye Protectors
Willson & Co., Inc., T. A., 3rd and Washington Sts., Reading, Pa.

Fans, Exhaust, Electric, Ventilating
Buffalo Forge Co., Buffalo, N. Y.
Eck Dynamo & Motor Co., Belleville, N. J.
General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Ferro Tungsten
Vanadium-Alloys Steel Co., Pittsburgh, Pa.

File Handles
Hammacher Schlemmer & Co., 4th Ave. and 13th St., New York.
Osgood Tool Co., J. L., Buffalo, N. Y.

Files
American Swiss File & Tool Co., 21 John St., New York.
Barnett Co. G. & H., Philadelphia, Pa.
Delta File Works, Philadelphia, Pa.
Disston & Sons, Inc., Henry, Philadelphia, Pa.
Hammacher, Schlemmer & Co. 4th Ave. and 13th St., New York.
Montgomery & Co., Inc., 104 Fulton St., New York.
Nicholson File Co., Providence, R. I.
Reichhelm & Co., E. P., 24 John St., New York.
Simonds Mfg. Co., Fitchburg, Mass.
Walls Tool Co., T. P., 75 Walker St., New York.

Filing Machines, Die, Etc.
Ames Co., B. C., Waltham, Mass.
Cochrane-Bly Co., Rochester, N. Y.
Oliver Instrument Co., Adrian, Mich.
Rearwin, W. D., Grand Rapids, Mich.
Robinson Tool Works, Inc., Waterbury, Conn.
Waltham Machine Works, Waltham, Mass.

Fillet (Leather)
Graton & Knight Mfg. Co., Worcester, Mass.

Filters, Drinking Water
Allen Filter Co., Toledo, O.

Fittings, Steam, Hydraulic, Etc.
Dart Mfg. Co., E. M., Providence, R. I.
Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mt. Gilead, O.
Metalwood Mfg. Co., Detroit, Mich.
National Tube Co., Pittsburgh, Pa.
Walworth Mfg. Co., Boston, Mass.
Watson-Stillman Co., 192 Fulton St., New York.

Flexible Shafts
Chicago Flexible Shaft Co., 149 W. La Salle St., Chicago, Ill.
Oliver Instrument Co., Adrian, Mich.
Stow Mfg. Co., Binghamton, N. Y.

Flux, Welding
Gisholt Mch. Co., Madison, Wis.

Forges
Billings & Spencer Co., Hartford, Conn.
Buffalo Dental Mfg. Co., Buffalo, N. Y.
Buffalo Forge Co., Buffalo, N. Y.

Forging Machines
Acme Machinery Co., Cleveland, O.
Ajax Mfg. Co., Cleveland, O.
Beaudry & Co., Inc., Boston, Mass.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
National Machinery Co., Tiffin, O.
Roux & Heyberger, 108 Rue Lafayette, Paris, France.
Williams, White & Co., Moline Ill.

Forgings, Drop
Billings & Spencer Co., Hartford, Conn.
Johnston & Jennings Co., Addison Road and Lake Shore R. R. Tracks, Cleveland, O.
Whitman & Barnes Mfg. Co., 1000 West 120th St., Chicago, Ill.
Williams & Co., J. H., 61 Richards St., Brooklyn, N. Y.
Wyman-Gordon Co., Worcester, Mass.

Forgings, Iron and Steel
Camden Forge Co., Camden, N. J.
Cleveland Mch. & Mfg. Co., 4944 Hamilton Ave., Cleveland, O.
Cresson-Morris Co., Philadelphia, Pa.
Dyson & Sons, Jos., Cleveland, O.
Johnston & Jennings Co., Addison Road and Lake Shore R. R. Tracks, Cleveland, O.
Machinery Forging Co., Cleveland, O.

Forming and Bending Machines
Baird Mch. Co., Bridgeport, Conn.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Shuster Co., F. B., New Haven, Conn.

Foundry Equipment
Adams Co., Dubuque, Iowa.
Ingersoll-Rand Co., 11 Broadway, New York.
New Britain Mch. Co., New Britain, Conn.
Northern Engineering Works, Detroit, Mich.

Furnaces, Annealing, Hardening and Tempering
American Gas Furnace Co., 24 John St., New York.
Bellevue Industrial Furnace Co., Detroit, Mich.
Brown & Sharpe Mfg. Co., Providence, R. I.
Brown Instrument Co., Philadelphia, Pa.
Chicago Flexible Shaft Co., 149 W. La Salle St., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich.
Rockwell Co., W. S., 50 Church St., New York.
Strong, Carlisle & Hammond Co., Cleveland, O.

Furnaces, Case-hardening
American Gas Furnace Co., 24 John St., New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Chicago Flexible Shaft Co., 149 W. La Salle St., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Strong, Carlisle & Hammond Co., Cleveland, O.

Furnaces, Electric
General Electric Co., Schenectady, N. Y.
Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich.

Furnaces, Heating
Billings & Spencer Co., Hartford, Conn.

Furnaces, Melting
American Gas Furnace Co., 24 John St., New York.
Chicago Flexible Shaft Co., 149 W. La Salle St., Chicago, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.

Furniture, Shop and Drafting-room
Economy Drawing Table Co., Toledo, O.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Manufacturing Equipment & Eng. Co., Framingham, Mass.
New Britain Mch. Co., New Britain, Conn.
Western Tool & Mfg. Co., Springfield, O.

Gages, Ball
Atlas Ball Co., Glenwood Ave. at 4th St., Philadelphia, Pa.

Gages, Recording, Steam, Vacuum
Bristol Co., Waterbury, Conn.
Brown Instrument Co., Philadelphia, Pa.
Reliance Gauge Column Co., 6008 Carnegie Ave., Cleveland, O.

Gages, Surface, Depth, Dial, Snap, Etc.
Advance Tool Co., Cincinnati, O.
Ames Co., B. C., Waltham, Mass.
Automat Tool Works, 252 Greenwich St., New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Coats Mch. Tool Co., 30 Church St., New York.
Fraser Co., Warren F., Boston, Mass.
Gardam & Son., Inc., Wm., 108 Park Place New York.
Goddard Tool Co. Chicago, Ill.
Goodell-Pratt Co., Greenfield Mass.
Greenfield Tap & Die Corp., Greenfield, Mass.
Harris Eng. Co., H. E., Bridgeport, Conn.
Krasberg Mfg. Co., 412 Orleans St., Chicago, Ill.
La Precision Mecanique, 11 Rue Vergniaud, Paris, France
Marvin Mfg. Co., W. B., Urbana, O.
Mehl Mch. Tool & Die Co., Roselle, N. J.
Moore-Eastwood Mfg. Co., Dayton, O.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Inc., J. M., Gloucester City, N. J.
Slocomb Co., J. T., Providence, R. I.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York.
S-P Mfg. Co., Cleveland, O.
Starrett Co. L. S., Athol, Mass.
Swedish Gage, Co., Inc., 16 W. 61st So., New York.
Taft-Peirce Mfg. Co., Woonsocket, R. I.
Taylor-Shantz Co., Rochester, N. Y.
Ulmer Co., J. C., Cleveland, O.
Union Tool Co., Orange, Mass.
Vincent Steel Process Co., Detroit, Mich.

Gages, Universal Amplifying
North Side Tool Works, Dayton, O.

Galvanizing Machinery
Erie Foundry Co., Erie, Pa.

Gaskets
Graton & Knight Mfg. Co., Worcester, Mass.
Greene, Tweed & Co., 109 Duane St., New York.

Gear Blanks, Bronze
Bunting Brass & Bronez Co., 748 Spencer St., Toledo, Ohio.
Johnson Bronze Co., Newcastle, Pa.
Light Mfg. & Foundry Co., Pottstown, Pa.
Lumen Bearing Co., Buffalo, N. Y.
Titanium Alloy Mfg. Co., Buffalo, N. Y.

Gear Cutting Machines, Bevel (Generator and Templet Planer)
Bilgrim Mch. Works, 1231 Spring Garden St., Philadelphia, Pa.
Gleason Works, Rochester, N. Y.

Gear Cutting Machines, Bevel (Rotary Cutter)
Bilton Mch. Tool Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Flather Mfg. Co., E. J., Nashua, N. H.
Gould & Eberhardt, Newark, N. J.
Newark Gear Cutting Mch., Co., Newark, N. J.
Whiton Mch. Co., D. E., New London, Conn.

Gear Cutting Machines, Helical and Spur (Hob)
Adams Co., Dubuque, Iowa.
Barber-Colman Co., Rockford, Ill.
Boston Gear Works, Norfolk Downs, Mass.
Gould & Eberhardt, Newark N. J.
Himoff Mch. Co., 45 Mills St., Astoria, N. Y.
Lees-Bradner Co., Cleveland, O.
Meisselbach-Catucci Mfg. Co., 27 Congress St., Newark, N. J.
Newark Gear Cutting Mch. Co., Newark, N. J.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Reynolds Pattern & Mch. Co., Massillon, O.

Gear Cutting Machines, Helical and Spur (Shaper and Planer Type)
Bickett Mch. & Mfg. Co., Cincinnati, O.
Fellows Gear Shaper Co., Springfield, Vt.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.

Gear Cutting Machines, Spur (Rotary Cutter)
Bilton Mch. Tool Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Flather Mfg. Co., E. J., Nashua, N. H.
Gould & Eberhardt, Newark, N. J.
Newark Gear Cutting Mch. Co., Newark, N. J.
Newton Mch. Tool Wks., Inc., 23rd and Vine Sts., Philadelphia, Pa.
Waltham Mch. Works, Waltham, Mass.
Whiton Mch. Co., D. E., New London, Conn.

Gear Cutting Machines, Worms and Worm Wheels (Hob)
Adams Co., Dubuque, Iowa.
Barber-Colman Co., Rockford, Ill.
Bilton Mch. Tool Co., Bridgeport, Conn.
Boston Gear Works, Norfolk Downs, Mass.
Gould & Eberhardt, Newark, N. J.
Himoff Mch. Co., 45 Mills St., Astoria, N. Y.
Lees-Bradner Co., Cleveland, O.
Meisselbach-Catucci Mfg. Co., 27 Congress St., Newark, N. J.
Newark Gear Cutting Mch. Co., Newark, N. J.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Reynolds Pattern & Mch. Co., Massillon, O.

Gears, Cut
Acme Gear Works, Inc., 53 Mills St., Astoria, N. Y.
Adams Co., Dubuque, Iowa.
Albaugh-Dover Co., 2100 Marshall Blvd., Chicago, Ill.
Albro-Clem Elevator Co., 701 Glenwood Ave., Philadelphia, Pa.
Bilgram Mch. Works, 1231 Spring Garden St., Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Braun Gear Works, 1321 Gates Ave., Brooklyn, N. Y.
Brown Co., A. & F., 79 Barclay St., New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Caldwell & Son Co., H. W., 17th St. and Western Ave., Chicago, Ill.
Cincinnati Gear Co., Cincinnati, O.
Crofoot Gear Works, Inc., Cambridge A Branch, Boston, Mass.
Cullman Wheel Co., 1339 Altgeld St., Chicago, Ill.
Davis, Rodney, Philadelphia, Pa.
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.
Fawcus Machine Co., Pittsburgh, Pa.
Fellows Gear Shaper Co., Springfield, Vt.
Flather Mfg. Co., E. J., Nashua, N. H.
Foote Bros. Gear & Mch. Co., 210 N. Carpenter St., Chicago, Ill.

General Electric Co., Schenectady, N. Y.
Gleason Works, Rochester, N. Y.
Grant Gear Works, Inc., Boston, Mass.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Hindley Gear Co., Philadelphia, Pa.
Horsburgh & Scott Co., Cleveland, O.
Lees-Bradner Co., Cleveland, O.
Link-Belt Co., Chicago, Ill.
Meisel Press Mfg. Co., 948 Dorchester Ave., Boston, Mass.
Meisselbach-Catucci Mfg Co., 27 Congress St., Newark, N. J.
Newark Gear Cutting Mch. Co., Newark, N. J.
New Process Gear Corporation, Syracuse, N. Y.
Northern Engineering Works, Detroit, Mich.
Nuttall Co., R. D., Pittsburgh, Pa.
Philadelphia Gear Works, Vine and 11th Sts., Philadelphia, Pa.
Poole Engineering & Mch. Co., Baltimore, Md.
Simonds Mfg. Co., Pittsburgh, Pa.
Stahl Gear & Mch. Co., Cleveland, O.
T. C. M. Mfg. Co., Harrison, N. J.
Van Dorn & Dutton Co., Cleveland, O.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Woburn Gear Works, Woburn, Mass.

Gears, Double Helical Cut
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.
Fawcus Mch. Co., Pittsburgh, Pa.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.

Gears, Fabric, Rawhide, Bakelite, Etc.
Boston Gear Works, Norfolk Downs, Mass.
Brown Co., A. & F., 79 Barclay St., New York.
Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill.
Cresson-Morris Co., Philadelphia, Pa.
Crofoot Gear Works, Inc., Cambridge A Branch, Boston, Mass.
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.
Fawcus Mch. Co., Pittsburgh, Pa.
Foote Bros. Gear & Mch. Co., 210 N. Carpenter St., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Grant Gear Works, Inc., Boston, Mass.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Hosburgh & Scott Co., Cleveland, O.
Meisel Press Mfg. Co., 948 Dorchester Ave., Boston, Mass.
New Process Gear Corporation, Syracuse, N. Y.
Nuttall Co., R. D., Pittsburgh, Pa.
Philadelphia Gear Works, Vine and 11th Sts., Philadelphia, Pa.
Stahl Gear & Mch. Co., Cleveland, O.
Van Dorn & Dutton Co., Cleveland, O.

Gears, Molded
Brown Co., A. & F., 79 Barclay St., New York.
Caldwell & Son Co., H. W., 17th St. and Western Ave., Chicago, Ill.
Cresson-Morris Co., Philadelphia, Pa.
Crofoot Gear Works, Inc., Cambridge A Branch, Boston, Mass.
Franklin Mfg. Co., 738 Gifford St., Syracuse, N. Y.
Horsburgh & Scott Co., Cleveland, O.
Link-Belt Company, Chicago, Ill.
Philadelphia Gear Works, Vine and 11th Sts., Philadelphia, Pa.
Poole Engineering & Mch. Co., Baltimore, Md.
Stahl Gear & Mch. Co., Cleveland, O.
Van Dorn & Dutton Co., Cleveland, O.

Gears, Worm
Albaugh-Dover Co., 2100 Marshall Blvd., Chicago, Ill.
Albro-Clem Elevator Co., 701 Glenwood Ave., Philadelphia, Pa.
Bansh Mch. Tool Co., 200 Wason Ave., Springfield, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Brown Co., A. & F., 79 Barclay St., New York.
Cincinnati Gear Co., Cincinnati, O.
Crofoot Gear Works, Inc., Cambridge A Branch, Boston, Mass.
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.
Fawcus Mch. Co., Pittsburgh, Pa.
Foote Bros. Gear & Mch. Co., 210 N. Carpenter St., Chicago, Ill.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Hindley Gear Co., Philadelphia, Pa.
Horsburgh & Scott Co., Cleveland, O.
Link-Belt Company, Chicago, Ill.
Meisel Press Mfg. Co., 948 Dorchester Ave., Boston, Mass.
Newark Gear Cutting Mch. Co., Newark, N. J.
Nuttall Co., R. D., Pittsburgh, Pa.
Philadelphia Gear Works, Vine and 11th Sts., Philadelphia, Pa.
Poole Engineering & Mch. Co., Baltimore, Md.
Stahl Gear & Mch. Co., Cleveland, O.
Van Dorn & Dutton Co., Cleveland, O.
Woburn Gear Works, Woburn, Mass.

Gear Testing Machinery
Adams Co., Dubuque, Iowa.
Gisholt Mch. Co., Madison, Wis.
Gleason Works, Rochester, N. Y.
Morse Twist Drill & Machine Co., New Bedford, Mass.

Gear Tooth Rounders
Ingle Machine Co., Rochester, N. Y.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Walker, Chas. H., Detroit, Mich.

Generators, Electric
Eck Dynamo & Motor Co., Belleville, N. J.
General Electric Co., Schenectady, N. Y.
Reliance Elec. & Eng. Co., 1056 Ivanhoe Road, Cleveland, O.
Sprague Electric Works, 527 W. 34th St., New York.
Triumph Electric Co., Cincinnati, O.

Generators, Gas
American Gas Furnace Co., 24 John St., New York.

Gibs and Keys for Connecting Rods
Moltrup Steel Products Co., Beaver Falls, Pa.

Goggles, Safety
Hardy & Co., F. A., 10 S. Wabash Ave., Chicago, Ill.
Willson & Co., Inc., T. A., 3rd and Washington Sts., Reading, Pa.

Grinding Machines, Bench
Athol Mch. Co., Athol, Mass.
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Builders Iron Foundry, Providence, R. I.
C & C Electric & Mfg. Co., Garwood, N. J.
Cincinnati Elec. Tool Co., Cincinnati, O.
Diamond Mch. Co., Providence, R. I.
Forbes & Myers, 178 Union St., Worcester, Mass.
Goodell-Pratt Co., Greenfield, Mass.
Hardinge Bros., Inc., Berteau and Ravenswood Aves., Chicago, Ill.
Hisey-Wolf Mch. Co., Cincinnati, O.
New Britain Mch. Co., New Britain, Conn.
Ransom Mfg. Co., Oshkosh, Wis.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Safety Emery Wheel Co., Springfield, O.
Standard Electric Tool Co., Cincinnati, O.
Wells & Son Co., F. E., Greenfield, Mass.

Grinding Machines, Center
Cincinnati Elec. Tool Co., Cincinnati, O.
Diamond Mch. Co., Providence, R. I.
Standard Elec. Tool Co., Cincinnati, O.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.

Grinding Machines, Chucking
Bryant Chucking Grinder Co., Springfield, Vt.

Grinding Machines, Cutter
Becker Milling Mch. Co., Hyde Park, Mass.
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Mch. Co., Oakley, Cincinnati, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Gould & Eberhardt, Newark, N. J.
Grand Rapids Grinding Mch. Co., Grand Rapids, Mich.
Greenfield Mch. Co., Greenfield, Mass.
Harris Engineering Co., H. E., Bridgeport, Conn.
Ingersoll Milling Mch. Co., Rockford, Ill.
LeBlond Mch. Tool Co., R. K., Cincinnati, O
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Norton Grinding Co., Worcester, Mass.
Nutter & Barnes Co., Hinsdale, N. H.
Oesterlein Mch. Co., Cincinnati, O.
Pratt & Whitney Co., Hartford, Conn.
Simmons Mch. Co., 1001 Singer Bldg., New York.
Union Twist Drill Co., Athol, Mass.
United States Electrical Tool Co., 6th ave. and Mt. Hope St., Cincinnati, O.
Waltham Mch. Works, Waltham, Mass.
Wells & Son Co., F. E., Greenfield, Mass.
Wilmarth & Morman Co., 2180 Monroe Ave., N. W., Grand Rapids, Mich.

Grinding Machines, Cylindrical, Plain
Brown & Sharpe Mfg. Co., Providence, R. I.
Fitchburg Grinding Mch. Co., Fitchburg, Mass.
Greenfield Mch. Co., Greenfield, Mass.
Landis Tool Co., Waynesboro, Pa.
McDonough Mfg. Co., Eau Claire, Wis.
Middlesex Mch. Works, Middletown, Conn.
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Morse Twist Drill & Mch. Co., New Bedford, Mass.
Norton Grinding Co., Worcester, Mass.
Ott Grinder Co., Indianapolis, Ind.
Pratt & Whitney Co., Hartford, Conn.

Grinding Machines, Cylindrical, Universal
Brown & Sharpe Mfg. Co., Providence, R. I.
Fitchburg Grinding Mch. Co., Fitchburg, Mass.
Fraser Co., Warren F., Boston, Mass.
Grand Rapids Grinding Mch. Co., Grand Rapids, Mich.
Greenfield Mch. Co., Greenfield, Mass.
Landis Tool Co., Waynesboro, Pa.
McDonough Mfg. Co., Eau Claire, Wis.
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Ott Grinder Co., Indianapolis, Ind.
Pratt & Whitney Co., Hartford, Conn.
Thompson Grinder Co., Springfield, O.

Grinding Machines, Disc
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Bickford Mch. Co., Greenfield, Mass.
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Diamond Mch. Co., Providence, R. I.
Gardner Mch. Co., Beloit, Wis.
Ransom Mfg. Co., Oshkosh, Wis.
Rowbottom Mch. Co., Waterbury, Conn.
Safety Emery Wheel Co., Springfield, O.
Sellew Mch. Tool Co., Pawtucket, R. I.

Grinding Machines, Drill
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Grand Rapids Grinding Mch. Co., Grand Rapids, Mich.
Heald Machine Co., 20 New Bond St., Worcester, Mass.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
Sterling Grinding Wheel Co., Tiffin, O.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.
Wilmarth & Morman Co., 2180 Monroe Ave., N. W., Grand Rapids, Mich.

Grinding Machines, Portable Electric
Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill.
Cincinnati Elec. Tool Co., Cincinnati, O.
Clark Elec. Co., Inc., Jas. Jr., Louisville, Ky.
Diamond Mch. Co., Providence, R. I.
Dillon Electric Co., Canton, O.
Forbes & Myers, 178 Union St., Worcester, Mass.
General Electric Co., Schenectady, N. Y.
Hisey-Wolf Mch. Co., Cincinnati, O.
Independent Pneumatic Tool Co., Chicago, Ill.
Neil & Smith Elec. Tool Co., Cincinnati, O.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York.
Standard Electric Tool Co., Cincinnati, O.
Stow Mfg. Co., Binghamton, N. Y.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.
Van Dorn Electric Tool Co., Cleveland, O.
Wisconsin Elec. Co., Racine, Wis.

Grinding Machines, Gage
Steel Products Engineering Co., Springfield, O.

Grinding Machines, Internal
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Bryant Chucking Grinder Co., Springfield, Vt.
Cincinnati Elec. Tool Co., Cincinnati, O.
Fraser Co., Warren F., Boston, Mass.
Greenfield Machine Co., Greenfield, Mass.
Heald Machine Co., 20 New Bond St., Worcester, Mass.
Landis Tool Co., Waynesboro, Pa.
Lansing Stamping & Tool Co., Lansing, Mich.
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Ott Grinder Co., Indianapolis, Ind.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Schmidt Co., B. L., Davenport, Iowa.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.
Van Norman Machine Tool Co., Waltham Ave., Springfield, Mass.
Wood & Safford Mch. Wks., Great Falls, Montana.

Grinding Machines, Knife
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Diamond Mch. Co., Providence, R. I.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Safety Emery Wheel Co., Springfield, O.

Grinding Machines, Motor-Driven, Non-Portable
Dillon Electric Co., Canton, O.
Ransom Mfg. Co., Oshkosh, Wis.

Grinding Machines, Multiple Spindle
Bryant Chucking Grinder Co., Springfield, Vt.

Grinding Machines, Pipe Threading Die
Bignall & Keeler Mch. Works, Edwardsville, Ill.
Landis Mch. Co., Inc., Waynesboro, Pa.
National Mchy. Co., Tiffin, O.

Grinding Machines, Piston Ring
Heald Machine Co., 20 New Bond St., Worcester, Mass.
Pedrick Tool & Mch. Co., 3639 N. Lawrence St., Philadelphia, Pa.
Walker Co., O. S., Worcester, Mass.

Grinding Machines, Radial, Ball Race, Etc.
Rivett Lathe & Grinding Co., Brighton, Boston, Mass.
Van Norman Machine Tool Co., Waltham Ave., Springfield, Mass.

Grinding Machines, Rotary Surface
Heald Machine Co., 20 New Bond St., Worcester, Mass.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Persons-Arter Mch. Co., Worcester, Mass.

Grinding Machines, Surface
Blake & Johnson Co., Waterbury, Conn.
Blanchard Machine Co., 64 State St., Cambridge, Mass.
Boston Scale & Machine Co., Boston, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Diamond Machine Co., Providence, R. I.
Fraser Co., Warren F., Boston, Mass.
Garvin Mch. Co., Spring and Varick Sts., New York.
Heald Machine Co., 20 New Bond St., Worcester, Mass.
Middlesex Mch. Works, Middletown, Conn.
New Jersey Mchy. Exchange, Newark, N. J.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Norton Grinding Co., Worcester, Mass.
Pratt & Whitney Co., Hartford, Conn.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Rowbottom Machine Co., Waterbury, Conn.
Safety Emery Wheel Co., Springfield, O.
Walker Co., O. S., Worcester, Mass.
Walls Tool Co., T. P., 75 Walker St., New York.
Wilmarth & Morman Co., 2180 Monroe Ave., N. W., Grand Rapids, Mich.

Grinding Machines, Tool and Cutter
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.
Baird Mch. Co., Bridgeport, Conn.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Blake & Johnson Co. Waterbury, Conn.
Blount Co., J. G., Everett, Mass.
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Brown & Sharpe Mfg. Co. Providence, R. I.
Cincinnati Elec. Tool Co., Cincinnati, O.
Cincinnati Milling Mch. Co., Oakley, Cincinnati, O.
Diamond Mch. Co., Providence, R. I.
Factory & Mill Supply Co., Boston, Mass.
Forbes & Myers, 178 Union St., Worcester, Mass.
Gisholt Mch. Co., Madison, Wis.
Grand Rapids Grinding Mch. Co., Grand Rapids, Mich.
Greenfield Machine Co., Greenfield, Mass.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
McDonough Mfg. Co., Eau Claire, Wis.
Meisselbach-Catucci Mfg. Co., 27 Congress St., Newark, N. J.
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Newark Gear Cutting Mch. Co., Newark, N. J.
Norton Grinding Co., Worcester, Mass.
Nutter & Barnes Co., Hinsdale, N. H.
Oesterlein Mch. Co., Cincinnati, O.
Ott Grinder Co., Indianapolis, Ind.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Simmons Mch. Co., 1001 Singer Bldg., New York.
Standard Tool Co., Cleveland, O.
Taylor & Fenn Co., Hartford, Conn.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.
Vitrified Wheel Co., Westfield, Mass.
Walker Co., O. S., Worcester, Mass.
Wells & Son Co., F. E., Greenfield, Mass.
Whitney Mfg. Co., Hartford, Conn.
Wilmarth & Morman Co., 2180 Monroe Ave., N. W., Grand Rapids, Mich.
Wisconsin Elec. Co., Racine, Wis.

Grinding Machines, Universal, Lathe and Planer Tools
Gisholt Machine Co., Madison, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Grinding Wheels
Abrasive Co., Bridesburg, Philadelphia, Pa.
American Emery Wheel Works, Providence, R. I.
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Carborundum Co., Niagara Falls, N. Y.
Detroit Grinding Wheel Co., Detroit, Mich.
Norton Co., Worcester, Mass.
Safety Emery Wheel Co., Springfield, O.
Springfield Grinding Co., Chester, Mass.
Star Corundum Wheel Co., Detroit, Mich.
Sterling Grinding Wheel Co., Tiffin, O.
Vitrified Wheel Co., Westfield, Mass.

Hammers, Drop
Billings & Spencer Co., Hartford, Conn.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Erie Foundry Co., Erie, Pa.
Miner & Peck Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., 111 Broadway, New York.
Williams, White & Co., Moline, Ill.

Hammers, Pneumatic
Erie Foundry Co., Erie, Pa.
Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York.
Nazel Engineering Works, 4043 N 5th St., Philadelphia, Pa.

Hammers, Power
Beaudry & Co., Inc., Boston, Mass.
Bradley & Son., Inc., C. C., Syracuse, N. Y.
Buffalo Foundry & Mch. Co., 10 Winchester Ave., Buffalo, N. Y.
Dienelt & Eisenhardt, Inc., Philadelphia, Pa.
Erie Foundry Co., Erie, Pa.
Mayer Bros. Co., 131 Rock St., Mankato, Minn.
Nazel Engineering Works, 4013 N. 5th St., Philadelphia, Pa.
West Tire Setter Co., Rochester, N. Y.
Williams, White & Co., Moline, Ill.

Hammers, Steam
Buffalo Foundry & Mch. Co., 10 Winchester Ave., Buffalo, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Erie Foundry Co., Erie, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Handles, Machine
Cincinnati Ball Crank Co., Cincinnati, O.
Cincinnati Screw Co., Cincinnati, O.

Hangers, Shaft
Brown & Sharpe Mfg. Co., Providence, R. I.
Brown Co., A. & F., 79 Barclay St., New York.
Cresson-Morris Co., Philadelphia, Pa.
Fafnir Bearing Co., New Britain, Conn.
Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa.
Hyatt Roller Bearing Co., Newark, N. J.
Link-Belt Company, Chicago, Ill.
New Departure Mfg. Co., Bristol, Conn.
Royersford Fdry. & Mch. Co., 54 N. 5th St., Philadelphia, Pa.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
S K F Ball Bearing Co., Hartford, Conn.
Standard Pressed Steel Co., Philadelphia, Pa.
Wood Sons Co., T. B., Chambersburg, Pa.

Hardness Testing Instruments
Shore Instrument & Mfg. Co., Inc., 557 W. 22nd St., New York

Heating and Ventilating Apparatus
Buffalo Forge Co., Buffalo, N. Y.

Hobbing Machines
See Gear Cutting Machines, Helical and Spur (Hob) and Gear Cutting Machines, Worms and Worm Wheels (Hob).

Hobs
Adams Co., Dubuque, Iowa.
Barber-Colman Co., Rockford, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Goddard Tool Co., Chicago, Ill.
Gould & Eberhardt, Newark, N. J.
Illinois Tool Works, Chicago, Ill.
Lees-Bradner Co., Cleveland, O.
Meisselbach-Catucci Mfg. Co., 27 Congress St., Newark, N. J.
Michigan Tool Co., Detroit, Mich.
Union Twist Drill Co., Athol, Mass.

Hoisting and Conveying Machinery
Caldwell & Son, Co., H. W., 17th St. and Western Ave., Chicago, Ill.
Link-Belt Company, Chicago, Ill.
Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York.
Wright Mfg. Co., Lisbon, O.
Yale & Towne Mfg. Co., 9 E. 40th St., New York.

Hoists, Air
Ingersoll-Rand Co., 11 Broadway, New York.
Northern Engineering Works, Detroit, Mich.

Hoists, Chain, Etc.
Box & Co., Alfred, Philadelphia, Pa.
Ford Chain Block & Mfg. Co., Philadelphia, Pa.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Mason & Co., Inc., Volney W., Providence, R. I.
Wright Mfg. Co., Lisbon, O.
Yale & Towne Mfg. Co., 9 E. 40th St., New York.

Hoists, Electric
Box & Co., Alfred, Philadelphia, Pa.
Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Link-Belt Company, Chicago, Ill.
Northern Engineering Works, Detroit, Mich.
Sprague Electric Works, 527 W. 34th St., New York.
Thomas Elevator Co., 22 S. Hoyne Ave., Chicago, Ill.
Toledo Bridge & Crane Co., Toledo, O.
Yale & Towne Mfg. Co., 9 E. 40th St., New York.

Hoists, Pneumatic
Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill.
Curtis Pneumatic Mchy. Co., 1568 Kienlen Ave., St. Louis, Mo.
Ingersoll-Rand Co., 11 Broadway, New York.
Northern Engineering Works, Detroit, Mich.

Hoists, Portable
Brown Clutch Co., Sandusky, O.
Canton Foundry & Machine Co., Canton, O.

Horses, Steel
Frasse & Co., Inc., Peter A., 417 Canal St., New York.

Hydraulic Machinery and Tools
Bethlehem Steel Co., South Bethlehem, Pa.
Chambersburg Engineering Co., Chambersburg, Pa.
Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mt. Gilead, O.
Metalwood Mfg. Co., Detroit, Mich.
Watson-Stillman Co., 192 Fulton St., New York.
Williams, White & Co., Moline, Ill.

Indicators, Speed
Brown & Sharpe Mfg. Co., Providence, R. I.
Brown Instrument Co., Philadelphia, Pa.
Goodell-Pratt Co., Greenfield, Mass.
Greene, Tweed & Co., 109 Duane St., New York.
Johnson & Miller, 42 Murray St., New York.
Starrett Co., L. S., Athol, Mass.
Veeder Mfg. Co., 39 Sargeant St., Hartford, Conn.

Indicators, Test
Brown & Sharpe Mfg. Co., Providence, R. I.
Brown Instrument Co., Philadelphia, Pa.
Johnson & Miller, 42 Murray St., New York.
Norton Grinding Co., Worcester, Mass.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York
Starrett Co., L. S., Athol, Mass.

Injectors, Steam
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Walworth Mfg. Co., Boston, Mass.

Jacks, Hydraulic
Watson-Stillman Co., 192 Fulton St., New York.

Jacks, Planer
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.

Jigs and Fixtures
American Mch. & Foundry Co., 5520 2nd Ave., Brooklyn, N. Y.
American Tool & Mfg. Co., Urbana, O.
Automat Tool Works, 252 Greenwich St., New York.
Becker Milling Mch. Co., Hyde Park, Mass.
Columbus Die, Tool & Mch. Co., Columbus, O.
Fox Gun Co., A. H., Philadelphia, Pa.
Gardam & Son, Inc., Wm., 108 Park Place, New York.
Gisholt Mch. Co., Madison, Wis.
Goddard Tool Co., Chicago, Ill.
Harris Engineering Co., H. E., Bridgeport, Conn.
Krasberg Mfg. Co., 412 Orleans St., Chicago, Ill.
Lansing Stamping & Tool Co., Lansing, Mich.
Maute & Sons, J., Buffalo, N. Y.
Mehl Mch. Tool & Die Co., Roselle, N. J.
Michigan Tool Co., Detroit, Mich.
Middlesex Machine Works, Middletown, Conn.
Modern Tool, Die & Machine Co., Columbus, O.
Moore-Eastwood Mfg. Co., Dayton, O.
Nelson Tool Co., 781-783 E. 152nd St., New York.
North Side Tool Works, Dayton, O.
Off-Set Tool Co., Bridgeport, Conn.
Ohmer Fare Register Co., Dayton, O.
Reynolds Pattern & Mch. Co., Massillon, O.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York
Solar Metal Products Co., Inc., Columbus, O.
S-P Mfg. Co., Cleveland, O.
Steel Products Engineering Co., Springfield, O.
Steiner Bros., Lima, O.
Swedish Gage Co., Inc., 16 W. 61st St., New York.
Taft-Peirce Mfg. Co., Woonsocket, R. I.
Taylor-Shantz Co., Rochester, N. Y.
T. C. M. Mfg. Co., Harrison, N. J.
Ulmer Co., J. C., Cleveland, O.
Urbana Tool & Die Co., Urbana, O.
Windau Tool Co., Cleveland, O.

Kettles, Soda
Brown & Sharpe Mfg. Co., Providence, R. I.
Gray & Prior Mch. Co., 38 Suffield St., Hartford, Conn.
Niles-Bement-Pond Co., 111 Broadway, New York.

Keyseaters
Advance Tool Co., Cincinnati, O.
Baker Bros., Toledo, O.
Burr & Son, J. T., 429 Kent Ave., Brooklyn, N. Y.
Davis Mch. Tool Co., Inc., Rochester, N. Y.
Lapointe Mch. Tool Co., Hudson, Mass.
Mitts & Merrill, 843 Water St., Saginaw, Mich.
Morton Mfg. Co., Muskegon Heights, Mich.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.

Keys, Machine
Moltrup Steel Products Co., Beaver Falls, Pa.
Morton Mfg. Co., Muskegon Heights, Mich.
Standard Gauge Steel Co., Beaver Falls, Pa.
Whitney Mfg. Co., Hartford, Conn.
Williams & Co., J. H., 61 Richards St., Brooklyn, N. Y.

Knives, Machine
Coes Wrench Co., Worcester, Mass.
Simonds Mfg. Co., Fitchburg, Mass.

Knurl Holders
Graham Mfg. Co., Providence, R. I.
Pratt & Whitney Co., Hartford, Conn.

Knurling Tools
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
Pratt & Whitney Co., Hartford, Conn.
Wells & Son Co., F. E. Greenfield, Mass.
Williams & Co., J. H., 61 Richard St., Brooklyn, N. Y.

Lamp Brackets, Guards, Etc.
McCrosky Reamer Co., Meadville, Pa.
Newman Mfg. Co., Cincinnati, O.

Lamps, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Lamp Co., 165 Broadway, New York.

Lapping Machines, Power
Builders Iron Foundry, Providence, R. I.

Lathe Attachments
American Tool Works Co., Cincinnati, O.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Barnes Drill Co., Inc., 814 Chestnut St., Rockford, Ill.
Boye & Emmes Mch. Tool Co., Cincinnati, O.
Bradford Mch. Tool Co., Cincinnati, O.
Bridgeford Mch. Tool Works, 151 Winton Road, Rochester, N. Y.
Carroll-Jamieson Mch. Tool Co., 257 Davis St., Batavia, O.
Champion Tool Works Co., 2422 Spring Grove Ave., Cincinnati, O.
Chard Lathe Co., Newcastle, Ind.
Cincinnati Iron & Steel Co., Cincinnati, O.
Davis Machine Tool Co., Inc., Rochester, N. Y.
Diamond Machine Co., Providence, R. I.
Fitchburg Machine Works, Fitchburg, Mass.
Flather & Co., Inc., Nashua, N. H.
Garvin Mch. Co., Spring and Varick Sts., New York.
Greaves-Klusman Tool Co., Cincinnati, O.
Hendey Mch. Co., Torrington, Conn.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Lodge & Shipley Mch. Tool Co., Cincinnati, O.
Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York.
Monarch Mch. Tool Co., Sidney, O.
Mueller Mch. Tool Co., Cincinnati, O.
Newman Mfg. Co., Cincinnati, O.
Niles-Bement-Pond Co., 111 Broadway, New York.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Pratt & Whitney Co., Hartford, Conn.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Rockford Tool Co., Rockford, Ill.
Sebastian Lathe Co., Cincinnati, O.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York.
Springfield Mch. Tool Co., 631 Southern Ave., Springfield, O.
Vandyck Churchill Co., 149 Broadway, New York.
Willard Machine Tool Co., Cincinnati, O.
Wood & Safford Machine Works, Great Falls, Montana.

Lathe Dogs
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Ready Tool Co., Bridgeport, Conn.
Underwood & Co., H. B., Philadelphia, Pa.
Western Tool & Mfg. Co., Springfield, O.
West Steel Casting Co., Cleveland, O.
Williams & Co., J. H., 61 Richards St., Brooklyn, N. Y.

Lathe, Planer and Shaper Tools
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Chard Lathe Co., Newcastle, Ind.
Gisholt Machine Co., Madison, Wis.
McCrosky Reamer Co., Meadville, Pa.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.
Ready Tool Co., Bridgeport, Conn.
Sebastian Lathe Co., Cincinnati, O.
Thompson & Son Co., Henry G., New Haven, Conn.
West Haven Mfg. Co., New Haven, Conn.
Western Tool & Mfg. Co., Springfield, O.
Williams & Co., J. H., 61 Richards St., Brooklyn, N. Y.

Lathes, Automatic
Fitchburg Automatic Mch. Works, Fitchburg, Mass.
Gisholt Mch. Co., Madison, Wis.
Jones & Lamson Mch. Co., Springfield, Vt.
New Britain Mch. Co., New Britain, Conn.
Potter & Johnston Mch. Co., Pawtucket, R. I.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.

Lathes, Automatic Screw Threading
Automatic Machine Co., Bridgeport, Conn.

Lathes, Axle and Shaft
Bridgeford Mch. Tool Works, 151 Winton Road, Rochester, N. Y.
Fitchburg Machine Works, Fitchburg, Mass.
Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York
Niles-Bement-Pond Co., 111 Broadway, New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Lathes, Bench
Ames Co., B. C., Waltham, Mass.
Dalton Manufacturing Corporation, 1911 Park Ave., New York.
Diamond Mch. Co., Providence, R. I.
Elgin Tool Works, Elgin, Ill.
Hardinge Bros., Inc., Berteau and Ravenswood Aves., Chicago, Ill.
Hjorth Lathe & Tool Co., Boston, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.
Sloan & Chace Mfg. Co., Ltd., Newark, N. J.
Van Norman Mch. Tool Co., Springfield, O.
Wade, Walter H., Boston, Mass.
Waltham Mch. Works, Waltham, Mass.
Wells & Son Co., F. E., Greenfield, Mass.

Lathes, Boring
Gisholt Mch. Co., Madison, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Lathes, Brass Workers'
Acme Machine Tool Co., Cincinnati, O.
Bardons & Oliver, Cleveland, O.
Dreses Mch. Tool Co., Cincinnati, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Pierce Mch. Tool Co., 617 W. Jackson Blvd., Chicago, Ill.
Springfield Mch. Tool Co., 631 Southern Ave., Springfield, O.
Warner & Swasey Co., Cleveland, O.
Wood Turret Mch. Co., Brazil, Ind.

Lathes, Car Wheel
Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York.
Niles-Bement-Pond Co., 111 Broadway, New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Lathes, Crankshaft
American Tool Works Co., Cincinnati, O.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Lodge & Shipley Mch. Tool Co., Cincinnati, O.
Niles-Bement-Pond Co., 111 Broadway, New York.

Lathes, Engine
American Tool Works Co., Cincinnati, O. 14" to 24", inclusive.
Axelson Mch. Co., Los Angeles, Cal. 16" and 18".
Barnes Co., W. F. & John, Rockford, Ill. 9" to 18", inclusive.
Barnes Drill Co., Inc., Rockford, Ill. 14-24" and 22-36" gap.
Bosworth, W. H., Cleveland, O. 16".
Boye & Emmes Mch. Tool Co., Cincinnati, O. 18" to 48", inclusive.
Bradford Mch. Tool Co., Cincinnati, O. 14" to 42", inclusive.
Bridgeford Mch. Tool Works, 151 Winton Road, Rochester, N. Y., 26" to 48", inclusive.
Carroll-Jamieson Mch. Tool Co., 257 Davis St., Batavia, O., 13" and 14".
Champion Tool Works Co., 2422 Spring Grove Ave., Cincinnati, O. 12" to 18", inclusive.
Chard Lathe Co., Newcastle, Ind. 16" to 28", incl.
Cincinnati Iron & Steel Co., Cincinnati, O. 14" to 24", inclusive.
Cincinnati Lathe & Tool Co., Oakley, Cincinnati, O., 16" to 22", incl.
Dalton Manufacturing Corporation, 1911 Park Ave., New York, 6" to 18" inclusive.
Davis Mch. Tool Co., Inc., Rochester, N. Y. 12" to 42", inclusive.
Earle Gear & Mch. Co., Philadelphia, Pa. 14" and 18".
Flather & Co., Inc., Nashua, N. H., 13" to 28", incl.
Gisholt Mch. Co. Madison, Wis., 16" and 25".
Greaves-Klusman Tool Co., Cincinnati, O., 16" to 30".
Hamilton Mch. Tool Co., Hamilton, O. 14" to 24".
Hendey Mch. Co., Torrington, Conn. 12" to 24".
Hill, Clark & Co., Inc., Boston, Mass. 18" to 30" iclusive.
Himoff Mch. Co., 45 Mills St., Astoria, N. Y. 11" to 21", inclusive.
Houston, Stanwood & Gamble Co., Cincinnati, O. 30" to 60", inclusive
LeBlond Mch. Tool Co., R. K., Cincinnati, O., 12" to 36".
Lehmann Mch. Co., St. Louis, Mo. 16".
Lodge & Shipley Mch. Tool Co., Cincinnati, O. 14" to 48", inclusive.
Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York. 12" to 84", inclusive.
Master Mch. Tool Co., 110 W. 40th St., New York 12".

Monarch Mch. Tool Co., Sidney, O. 14" to 20", incl.
Morris Mch. Tool Co., Cincinnati, O. 16" to 21" incl.
Mueller Mch. Tool Co., Cincinnati, O. 18".
National Lathe Co., Cincinnati, O. 17" and 18".
Niles-Bement-Pond Co., 111 Broadway, New York. 20" to 100", inclusive.
Oliver Mchy. Co., 7 Coldbrook St., Grand Rapids, Mich. 16" to 20", inclusive.
Porter-Cable Mch. Co., Syracuse, N. Y. 12".
Pratt & Whitney Co., Hartford, Conn. 10" to 16", inclusive.
Rahn-Larmon Co., Cincinnati, O. 16" to 32" incl.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept. Worcester, Mass. 12" to 27", incl.
Rockford Tool Co., Rockford, Ill. 15" and 16".
Sebastian Lathe Co., Cincinnati, O. 13", 14" and 15".
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y. 9" to 16", inclusive.
Sidney Tool Co., Sidney, O. 17" and 19".
Simplex Mch. Tool Co., Hamilton, O. 16" to 32", incl.
Smith Mfg. Co., Philip, Sidney, O. 13".
South Bend Lathe Works, South Bend, Ind. 13" to 24" inclusive.
Springfield Mch Tool Co., Springfield, O. 14" to 36", inclusive.
Taylor Mch. Co., Cleveland, O. 20".
United States Lathe & Mch. Co., Cincinnati, O. 20" to 24", inclusive.
Universal Mchy. Co., Milwaukee, Wis. 12" to 24", inclusive.
Walcott Lathe Co., Jackson, Mich. 14" to 28", incl.
Whitcomb-Blaisdell Mch. Tool. Co., Worcester, Mass. 14" to 30", inclusive.
Wickes Bros., Saginaw, Mich. 17" to 30" inclusive.
Willard Mch. Tool Co., Cincinnati, O. 13".
Worcester Lathe Co., Worcester, Mass. 11", 13" and 16".

Lathes, Extension, Bed and Gap
Barnes Drill Co., Inc., 814 Chestnut St., Rockford, Ill.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Manning, Maxwell & Moore, Inc., 119 W. 40th St., N. Y.
Rahn-Larmon Co., Cincinnati, O.
Sebastian Lathe Co., Cincinnati, O.

Lathes, Foot Power
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.

Lathes, Patternmakers'
Blount Co., J. G., Everett, Mass.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Wells & Son Co., F. E., Greenfield, Mass.

Lathes, Pulley
Cincinnati Pulley Mchy. Co., Cincinnati, O.

Lathes, Shell
Thurlow Steel Works, Inc., Philadelphia, Pa.

Lathes, Speed
Blount Co., J. G., Everett, Mass.
Diamond Mch. Co., Providence, R. I.
Himoff Mch. Co., 45 Mills St., Astoria, N. Y.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.
Wells & Son Co., F. E., Greenfield, Mass.

Lathes, Turret
See also Chucking Machines.
Acme Mch. Tool Co., Cincinnati, O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Bullard Mch. Tool Co., Bridgeport, Conn.
Davis Mch. Tool Co., Inc., Rochester, N. Y.
Dreses Mch. Tool Co., Cincinnati, O.
Foster Mch. Co., Elkhart, Ind.
Garvin Mch. Co., Spring and Varick Sts., New York.
Gisholt Mch. Co., Madison, Wis.
Greaves-Klusman Tool Co., Cincinnati, O.
Himoff Mch. Co., 45 Mills St., Astoria, N. Y.
International Mch. Tool Co., Indianapolis, Ind.
Jones & Lamson Mch. Co., Springfield, Vt.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Lodge & Shipley Mch. Tool Co., Cincinnati, O.
Morris Mch. Tool Co., Cincinnati, O.
New Britain Mch. Co., New Britain, Conn.
Niles-Bement-Pond Co., 111 Broadway, New York.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Pierce Mch. Tool Co., 617 W. Jackson Blvd., Chicago, Ill.
Pratt & Whitney Co., Hartford, Conn.
Rahn-Larmon Co., Cincinnati, O.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Springfield Mch. Tool Co., 631 Southern Ave., Springfield, O.
Warner & Swasey Co., Cleveland, O.
Wells & Son Co., F. E., Greenfield, Mass.
Wood Turret Mch. Co., Brazil, Ind.

Lathes, Wood Workers'
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.

Leather Belting, Round
Schieren Co., Chas. A., 73 Ferry St., New York.

Levels
Goodell-Pratt Co., Greenfield, Mass.
Keuffel & Esser Co., Hoboken, N. J.
Starrett Co., L. S., Athol, Mass.

Lockers, Metal
Manufacturing Equipment & Eng. Co., Framingham, Mass.

Lubricants
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Cataract Refining & Mfg. Co., Buffalo, N. Y.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Fiske Bros. Refining Co., 24 State St., New York.
Haws, Inc., Geo. A., 135 Front St., New York.
Hosmer Co., G. A., Buffalo, N. Y.
Lumen Bearing Co., Buffalo, N. Y.
Oakley Chemical Co., 26 Thames St., New York.
Royersford Foundry & Mch. Co., 54 N. 5th St., Philadelphia, Pa.
S K F Ball Bearing Co., Hartford, Conn.
Stuart & Co., Inc., D. A., 29 La Salle St., Chicago, Ill.
Swan & Finch Co., 165 Broadway, New York.

Lubricators
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Greene, Tweed & Co., 109 Duane St., New York.
Inter-State Mch. Products Co., Inc., Rochester, N. Y.

Machinery Dealers
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Brownell Mchy. Co. Providence, R. I.
Coats Mch. Tool Co., Inc., 30 Church St., New York.
Davis Mch. Tool Co., W. F., 32 N. Clinton St., Chicago, Ill.
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.
Easley Mchy. Co., E. L., Chicago, Ill.
Garvin Mch. Co., Spring and Varick Sts., New York.
Hill, Clarke & Co., Inc., Boston, Mass.
Hill, Clarke & Co., of Chicago, 625 Washington Blvd., Chicago, Ill.
Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York.
Marshall & Huschart Mchy. Co., 17 S. Jefferson St., Chicago, Ill.
McDonough Mfg. Co., Eau Claire, Wis.
Motch & Merryweather Mchy. Co., Cleveland, O.
Niles-Bement-Pond Co., 111 Broadway, New York.
Osgood Tool Co., J. L., Buffalo, N. Y.
Patterson Tool & Supply Co., Dayton, O.
Simmons Mch. Co., 1001 Singer Bldg., New York.
Vandyck Churchill Co., 149 Broadway, New York.
Walls Tool Co., T. P., 75 Walker St., New York.
Young, Corley & Dolan, Inc., 115 Broadway, New York.

Machinists' Small Tools
See Calipers, Hammers, Wrenches, Drills, Taps, etc.

Mallets, Rawhide
Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill.

Mandrels, Expanding and Solid
See Arbors and Mandrels, Expanding and Solid.

Marking Machines
Bickford Machine Co., Greenfield, Mass.
Grant Mfg. & Mch. Co., N. W. Station, Bridgeport, Conn.
Martin Mch. Co., Greenfield, Mass.
Noble & Westbrook Mfg. Co., Hartford, Conn.

Measuring Machines, Precision
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Inc., J. M., Gloucester City, N. J.
Swedish Gage Co., Inc., 16 W. 61st St., New York.

Metals, Bearing
See Bearings, Bronze, Babbitt, etc., and Bushings, Brass, Bronze, etc.

Milling and Drilling Machines, Upright
Knight Mchy Co., W. B., 2019 Lucas Ave., St. Louis, Mo.

Milling Attachments
Adams Co., Dubuque, Iowa.
Becker Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Oakley, Cincinnati, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Hendey Machine Co., Torrington, Conn.
Ingersoll Milling Machine Co., Rockford, Ill.
Kearney & Trecker Co., Milwaukee, Wis.
Kempsmith Mfg. Co., Milwaukee, Wis.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Oesterlein Mch. Co., Cincinnati, O.
Porter-Cable Mch. Co., Syracuse, N. Y.
Pratt & Whitney Co., Hartford, Conn.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Rockford Milling Mch. Co., Rockford, Ill.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.
Whitney Mfg. Co., Hartford, Conn.

Milling Machines, Automatic
Pratt & Whitney Co., Hartford, Conn.

Milling Machines, Bench
Ames Co., B. C., Waltham, Mass.
Carter & Hakes Co., Sterling Place, Winsted, Conn.
Hardinge Bros., Inc., Berteau and Ravenswood Aves., Chicago, Ill.
Rockford Milling Mch. Co., Rockford, Ill.
Sloan & Chace Mfg. Co., Newark, N. J.
Van Norman Mch. Tool Co., Waltham Ave., Springfield, Mass.

Milling Machines, Circular, Continuous
Becker Milling Mch. Co., Hyde Park, Mass.
Gould & Eberhardt, Newark, N. J.

Milling Machines, Hand
Adams Co., Dubuque, Iowa.
Becker Milling Mch. Co., Hyde Park, Mass.
Bickett Mch. & Mfg. Co., Cincinnati, O.
Bickford Mch. Co., Greenfield, Mass.
Biggs-Watterson Co., Cleveland, O.
Carter & Hakes Co., Sterling Place, Winsted, Conn.
Cleveland Milling Mch. Co., Cleveland, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Pratt & Whitney Co., Hartford, Conn.
Rockford Milling Mch. Co., Rockford, Ill.
Steptoe Co., John, Brighton, Cincinnati, O.
Van Norman Mch. Tool Co., Waltham Ave., Springfield, Mass.
Whitney Mfg. Co., Hartford, Conn.

Milling Machines, Horizontal, Plain
Adams Co., Dubuque, Iowa.
Beaman & Smith Co., Providence, R. I.
Becker Milling Machine Co., Hyde Park, Mass.
Bilton Mch. Tool Co., Bridgeport, Conn.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Mch. Co., Oakley, Cincinnati, O.
Cleveland Milling Mch. Co., Cleveland, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Gooley & Edlund, Inc., Cortland, New York.
Hendey Machine Co., Torrington, Conn.
Ingersoll Milling Machine Co., Rockford, Ill.
Kearney & Trecker Co., Milwaukee, Wis.
Kempsmith Mfg. Co., Milwaukee, Wis.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Oesterlein Mch. Co., Cincinnati, O.
Pratt & Whitney Co., Hartford, Conn.
Rockford Milling Mch. Co., Rockford, Ill.

Milling Machines, Horizontal, Universal
Becker Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Mch. Co., Oakley, Cincinnati, O.
Cleveland Milling Machine Co., Cleveland, O.
Hendey Machine Co., Torrington, Conn.
Kearney & Trecker Co., Milwaukee, Wis.
Kempsmith Mfg. Co., Milwaukee, Wis.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Oesterlein Mch. Co., Cincinnati, O.
Rockford Milling Mch. Co., Rockford, Ill.
Rowbottom Mch. Co., Waterbury, Conn.
Van Norman Mch. Tool Co., Waltham Ave., Springfield, Mass.

Milling Machines, Lincoln Type
Beaman & Smith Co., Providence, R. I.
Becker Milling Mch. Co., Hyde Park, Mass.
Garvin Mch. Co., Spring and Varick Sts., New York.
Kempsmith Mfg. Co., Milwaukee, Wis.
Hendey Machine Co., Torrington, Conn.
Reynolds Pattern & Mch. Co., Massillon, O.
Van Norman Mch. Tool Co., Waltham Ave., Springfield, Mass.

Milling Machines, Portable
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Pedrick Tool & Mch. Co., 3639 N. Lawrence St., Philadelphia, Pa.
Underwood & Co., H. B., Philadelphia, Pa.

Milling Machines, Vertical
Adams Co., Dubuque, Iowa.
Beaman & Smith Co., Providence, R. I.
Becker Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Mch. Co., Oakley, Cincinnati, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Ingersoll Milling Mch. Co., Rockford, Ill.
Kearney & Trecker Co., Milwaukee, Wis.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Van Norman Mch. Tool Co., Waltham Ave., Springfield, Mass.

Milling Tools (Hollow Adjustable)
Geometric Tool Co., New Haven, Conn.
Rogers Works, Inc., J. M., Gloucester City, N. J.

Model and Experimental Work
See Special Machinery and Tools.

Molding Machines
Adams Co., Dubuque, Iowa.
Mumford Molding Mch. Co., 1763 Elston Ave., Chicago, Ill.

Motors, Electric
Eck Dynamo & Motor Co., Belleville, N. J.
General Electric Co., Schenectady, N. Y.
Reliance Elec. & Eng. Co., 1056 Ivanhoe Road, Cleveland, O.
Sprague Electric Works, 527 W. 34th St., New York.
Triumph Electric Co., Cincinnati, O.
Wagner Electric Mfg. Co., St. Louis, Mo.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Name Plates, Cast Bronze, Stamped and Etched
Matthews & Co., Jas. H., 3946 Forbes Field, Pittsburgh, Pa.
Newman Mfg. Co., Cincinnati, O.
Noble & Westbrook Mfg. Co., Hartford, Conn.
Schwerdtle Stamp Co., Bridgeport, Conn.

Nichrome Castings
Driver-Harris Co., Harrison, N. J.

Nipple Threading Machinery
Bignall & Keeler Mch. Works, Edwardsville, Ill.
Landis Mch. Co., Inc., Waynesboro, Pa.
Merrell Mfg. Co., 15 Curtis St., Detroit, Mich.
Murchey Mch. & Tool Co., 34 Porter St., Detroit, Mich.
Saunders' Sons, D., Yonkers, N. Y.
Standard Engineering Co., Ellwood City, Pa.

Nuts, Castellated, Etc.
Cincinnati Screw Co., Cincinnati, O.

Nut Tappers
See Bolt and Nut Machinery.

Odometers
Veeder Mfg. Co., 39 Sargeant St., Hartford, Conn.

Oil Cups
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Gits Bros. Mfg. Co., 551 Monroe St., Chicago, Ill.
Tucker, W. M. & C. F., Hartford, Conn.
Winkley Co., Detroit, Mich.

Oilers, Loose Pulley
Brown Engineering Co., 133 N. 3d Street, Reading, Pa.

Oil Hole Covers
Gits Bros. Mfg. Co., 551 Monroe St., Chicago, Ill.
Tucker, W. M. & C. F., Hartford, Conn.
Winkley Co., Detroit, Mich.

Oil Pans, Sheet Steel
Littleford Bros., Cincinnati, O.

Oils, Lubricating
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Cataract Refining & Mfg. Co., Buffalo, N. Y.
Fiske Bros. Refining Co., 24 State St., New York.
Haws, Inc., Geo. A., 135 Front St., New York.
Hosmer Co., G. A., Buffalo, N. Y.
Stuart & Co., Inc., D. A., 29 So. La Salle St., Chicago, Ill.
Swan & Finch Co., 165 Broadway, New York.

Oils, Quenching and Tempering
Cataract Refining & Mfg. Co., Buffalo, N. Y.
Fiske Bros. Refining Co., 24 State St., New York.
Haws, Inc., Geo. A., 135 Front St., New York.
Stuart & Co., Inc., D. A., 29 So. La Salle St., Chicago, Ill.
Swan & Finch Co., 165 Broadway, New York.

Ovens, Baking
American Gas Furnace Co., 24 John St., New York.
General Electric Co., Schenectady, N. Y.
Rockwell Co., W. S., 50 Church St., New York.

Ovens, Tempering
Boker & Co., Inc., H., 101 Duane St., New York.
General Electric Co., Schenectady, New York.

Oxygen
Linde Air Products Co., 42nd St. Bldg., New York.

Packings, Leather
Graton & Knight Mfg. Co., Worcester, Mass.
Swan & Finch Co., 165 Broadway, New York.

Pans, Shop and Lathe
New Britain Mch. Co., New Britain, Conn.

Parallels
Walker Co., O. S., Worcester, Mass.

Patents
Parker, C. L., Washington, D. C.

Pattern Shop Tools and Machinery
Crescent Mch. Co., 56 Main St., Leetonia, O.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.

Patterns, Wood and Metal
Grant Mfg. & Mch. Co., N. W. Station, Bridgeport, Conn.
Mehl Mch. Tool & Die Co., Roselle, N. J.
S-P Mfg. Co., Cleveland, O.

Pencils, Drawing
American Lead Pencil Co., 237 5th Ave., New York.
Dixon Crucible Co., Joseph, Jersey City, N. J.

Phosphor Bronze
See Bronze.

Pipe Bending Tools
Underwood & Co., H. B., Philadelphia, Pa.

Pipe Cutting and Threading Machines
Armstrong Mfg. C., 297 Knowlton St., Bridgeport, Conn.
Bignall & Keeler Mch. Works, Edwardsville, Ill.
Curtis & Curtis Co., 8 Garden St., Bridgeport, Conn.
Foote-Burt Co., Cleveland, O.
Greenfield Tap & Die Corp., Greenfield, Mass.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Hart Mfg. Co., E. 20th St. and Marion Ave., Cleveland, O.
Landis Mch. Co., Inc., Waynesboro, Pa.
Merrell Mfg. Co., 15 Curtis St., Toledo, O.
Murchey Mch. & Tool Co., 34 Porter St., Detroit, Mich.
Saunders' Sons, D., Yonkers, N. Y.
Standard Engineering Co., Ellwood City, Pa.
Treadwell Engineering Co., Easton Pa.
Trimont Mfg. Co., Roxbury, Mass.
Victor Tool Co., Waynesboro, Pa.
Walworth Mfg. Co., Boston, Mass.
Wells & Son Co., F. E., Greenfield, Mass.

Pipe and Pipe Fittings
National Tube Co., Pittsburgh. Pa.
Newman Mfg. Co., Cincinnati, O.
Walworth Mfg. Co., Boston, Mass.

Planer Attachments
Cincinnati Planer Co., Cincinnati, O.
Gray Co., G. A., Cincinnati, O.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.

Planers
American Tool Works Co., Cincinnati, O.
Cincinnati Planer Co., Cincinnati, O.
Cincinnati Shaper Co., Cincinnati, O.
Cleveland Planer Works, 3150-3152 Superior Ave., Cleveland, O.
Gray Co., G. A., Cincinnati, O.
Hamilton Machine Tool Co., Hamilton, O.
Morton Mfg. Co., Muskegon Heights, Mich.
Niles-Bement-Pond Co., 111 Broadway, New York.
Ohio Machine Tool Co., Kenton, O.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Whitcomb-Blaisdell Mch. Tool Co., Worcester, Mass.
Wilson Mch. Co., W. A., Rochester, N. Y.
Woodward & Powell Planer Co., Worcester, Mass.

Planers, Portable
Morton Mfg. Co., Muskegon Heights, Mich.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Underwood & Co., H. B., Philadelphia, Pa.

Planers, Rotary
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Pedrick Tool & Mch. Co., 3639 N. Lawrence St., Philadelphia, Pa.
Underwood & Co., H. B., Philadelphia, Pa.

Plate Rolls
Niles-Bement-Pond Co., 111 Broadway, New York.

Plates, Steel
Moltrup Steel Products Co., Beaver Falls, Pa.

Pneumatic Tools
Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York.
Keller Pneumatic Tool Co., Fond du Lac, Wis.
Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York.

Polishing Machines
Abbott Ball Co., Elmwood, Hartford, Conn.
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.
Brown & Sharpe Mfg. Co. Providence, R. I.
Builders Iron Foundry Co., Providence, R. I.
Diamond Machine Co., Providence, R. I.
Forbes & Myers, 178 Union St., Worcester, Mass.
Gardner Mch. Co., Beloit, Wis.
Goodell-Pratt Co., Greenfield, Mass.
Hisey-Wolf Mch. Co., Cincinnati, O.
New Britain Mch. Co., New Britain, Conn.
Ransom Mfg. Co., Oshkosh, Wis.
Royersford Fdry. & Mch. Co., 54 N. 5th St., Philadelphia, Pa.
Safety Emery Wheel Co., Springfield, O.
Sterling Grinding Wheel Co., Tiffin, O.
Stow Mfg. Co., Binghamton, N. Y.
United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, O.
Wells & Son Co., F. E., Greenfield, Mass.

Portable Tools, Repair, Railroad, Etc.
Newman Mfg. Co., Cincinnati, O.
Pedrick Tool & Mch. Co., 3639 N. Lawrence St., Philadelphia, Pa.
Underwood & Co., H. B., Philadelphia, Pa.

Presses, Arbor
Atlas Press Co., 323 N. Park St., Kalamazoo, Mich.
Lucas Mch. Tool Co., Cleveland, O.
Nicholson & Co., W. H., 112 Oregon St., Wilkes-Barre, Pa.

Presses, Broaching
Ams Mch. Co., Max, Bridgeport, Conn.
Atlas Press Co., 323 N. Park St., Kalamazoo, Mich.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Ferracute Mch. Co., Bridgeton, N. J.
Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mt. Gilead, O.
Metalwood Mfg. Co., Detroit, Mich.
Swaine Mfg. Co., F. J., St. Louis, Mo.
Toledo Mch. & Tool Co., Toledo, O.
Watson-Stillman Co., 192 Fulton St., New York.

Presses, Drop
See Hammers, Drop.

Presses, Foot and Screw
Baird Mch. Co., Bridgeport, Conn.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Etna Mch. Co., Toledo, O.
Ferracute Mch. Co., Bridgeton, N. J.
Niagara Mch. & Tool Works, Buffalo, N. Y.
Royersford Fdry. & Mch. Co., 54 N. 5th St., Philadelphia, Pa.
Shuster Co., F. B., New Haven, Conn.
Swaine Mfg. Co., F. J., St. Louis, Mo.
Taylor & Fenn Co., Hartford, Conn.
Toledo Mch. & Tool Co., Toledo, O.

Presses, Forging
Ams Mch. Co., Max, Bridgeport, Conn.
Bethlehem Steel Co., South Bethlehem, Pa.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Cleveland Mch. & Mfg. Co., 4944 Hamilton Ave., Cleveland, O.
Elmes Engineering Works, Chas. F., 222 N. Morgan St., Chicago, Ill.
Ferracute Mch. Co., Bridgeton, N. J.
Niagara Mch. & Tool Works, Buffalo, N. Y.
Swaine Mfg. Co., F. J., St. Louis, Mo.
Toledo Mch. & Tool Co., Toledo, O.
Treadwell Engineering Co., Easton, Pa.

Presses, Hydraulic
Chambersburg Engineering Co., Chambersburg, Pa.
Elmes Engineering Works, Chas. F., 222 N. Morgan St., Chicago, Ill.
Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mt. Gilead, O.
Metalwood Mfg. Co., Detroit, Mich.
Niles-Bement-Pond Co., 111 Broadway, New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Treadwell Engineering Co., Easton, Pa.
Watson-Stillman Co., 192 Fulton St., New York.

Presses, Power Forcing
Atlas Press Co., 323 N. Park St., Kalamazoo, Mich.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Elmes Engineering Works, Chas. F., 222 N. Morgan St., Chicago, Ill.
Lucas Mch. Tool Co., Cleveland, O.
Weaver Mfg. Co., Springfield, Ill.

Presses, Sheet Metal Working
Ams Mch. Co., Max, Bridgeport, Conn.
Automatic Mch. Co., Bridgeport, Conn.
Baird Mch. Co., Bridgeport, Conn.
Biggs-Watterson Co., Cleveland, O.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Buckeye Engine Co., Salem, O.
Cleveland Mch. & Mfg. Co., 4944 Hamilton Ave., Cleveland, O.
Ferracute Mch. Co., Bridgeton, N. J.
Niagara Mch. & Tool Works, Buffalo, N. Y.
Swaine Mfg. Co., F. J., St. Louis, Mo.
Toledo Mch. & Tool Co., Toledo, O.
Willard Mch. Tool Co., Cincinnati, O.

Presses, Shell Banding
West Tire Setter Co., Rochester, N. Y.

Presses, Straightening
Elmes Engineering Works, Chas. F., 222 N. Morgan St., Chicago, Ill.
Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mt. Gilead, O.
Metalwood Mfg. Co., Detroit, Mich.
Morse Twist Drill & Mch. Co., New Bedford, Mass.
Springfield Mch. Tool Co., 631 Southern Ave., Springfield, O.
Watson-Stillman Co., 192 Fulton St., New York.

Presses, Trimming
Billings & Spencer Co., Hartford, Conn.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Cleveland Mch. & Mfg. Co., 4944 Hamilton Ave., Cleveland, O.
Erie Foundry Co., Erie, Pa.
Ferracute Mch. Co., Bridgeton, N. J.
Toledo Mch. & Tool Co., Toledo, O.

Press Guards
Safety Engineering Co., Cleveland, O.

Profiling Machines
Becker Milling Mch. Co., Hyde Park, Mass.
Bickett Mch. & Mfg. Co., Cincinnati, O.
Biggs-Watterson Co., Cleveland, O.
Garvin Mch. Co., Spring and Varick Sts., New York.
Leland-Gifford Co., Worcester, Mass.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.

Pulleys, Friction, Cone, Etc.
American Pulley Co., 4208-60 Wissahickon Ave., Philadelphia, Pa.
Brown Co., A. & F., 79 Barclay St., New York.
Brown & Sharpe Mfg. Co., Providence, R. I.
Caldwell & Son Co., H. W., 17th St. and Western Ave., Chicago, Ill.
Conway & Co., Cincinnati, O.
Cresson-Morris Co., Philadelphia, Pa.
Link-Belt Co., Chicago, Ill.
Mason & Co., Inc., Volney W., Providence, R. I.
Moore & White Co., 2707-2737 N. 15th St., Philadelphia, Pa.
Poole Eng. & Mch. Co., Baltimore, Md.
Saginaw Mfg. Co., Saginaw, Mich.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Wood Sons Co., T. B., Chambersburg, Pa.

Pulley Blocks
Yale & Towne Mfg. Co., 9 E. 40th St., New York.

Pulley Turning and Boring Machines
American Tool Works Co., Cincinnati, O.
Niles-Bement-Pond Co., 111 Broadway, New York.

Pump Leathers
Graton & Knight Mfg. Co., Worcester, Mass.

Pumps, Hydraulic
Buffalo Forge Co., Buffalo, N. Y.
Chambersburg Engineering Co., Chambersburg, Pa.
Elmes Engineering Works, Chas. F., 222 N. Morgan St., Chicago, Ill.
Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mt. Gilead, O.
Metalwood Mfg. Co., Detroit, Mich.
Watson-Stillman Co., 192 Fulton St., New York.
Worthington Pump & Mchy. Corp., 115 Broadway, New York.

Pumps, Lubricant and Oil
Bickford Mch. Co., Greenfield, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Fulflo Pump Co., Cincinnati, O.
Inter-state Mch. Products Co., Inc., Rochester, N. Y.
Trahern Pump Co., Rockford, Ill.

Pumps, Pneumatic
Ingersoll-Rand Co., 11 Broadway, New York.
Worthington Pump & Mchy. Corp., 115 Broadway, New York.

Pumps, Power Driven
Bethlehem Steel Co., South Bethlehem, Pa.

Pumps, Rotary
Inter-State Mch. Products Co., Inc., Rochester, N. Y.
Trahern Pump Co., Rockford, Ill.

Pumps, Steam
Buffalo Forge Co., Buffalo, N. Y.
Ingersoll-Rand Co., 11 Broadway, New York.
Worthington Pump & Mchy. Corp., 115 Broadway, New York.

Pumps, Turbine Driven
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.

Pumps, Vacuum
Leiman Bros., 62 E. John St., New York.

Punches and Dies
American Mch. & Foundry Co., 5520 2nd Ave., Brooklyn, N. Y.
Ams Mch. Co., Max, Bridgeport, Conn.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Columbus Die, Tool & Mch. Co., Columbus, O.
Harris Engineering Co., H. E., Bridgeport, Conn.
Krasberg Mfg. Co., 412 Orleans St., Chicago, Ill.
Nelson Tool Co., Inc., 781-783 E. 142d St., New York.
Pratt & Whitney Co., Hartford, Conn.
Royersford Fdry. & Mch. Co., 54 N. 5th St., Philadelphia, Pa.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York.
Swaine Mfg. Co., F. J., St. Louis, Mo.
Taft-Peirce Mfg. Co., Woonsocket, R. I.
Taylor-Shantz Co., Rochester, N. Y.
Toledo Mch. & Tool Co., Toledo, O.
Ulmer Co., J. C., Cleveland, O.

Punches, Centering
Brown & Sharpe Mfg. Co., Providence, R. I.
Goodell-Pratt Co., Greenfield, Mass.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Slocomb Co., J. T., Providence, R. I.
Starrett Co., L. S., Athol, Mass.

Punching and Shearing Machinery
Beaudry & Co., Inc., Boston, Mass.
Bethlehem Steel Co., South Bethlehem, Pa.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Buckeye Engine Co., Salem, O.
Buffalo Forge Co., Buffalo, N. Y.
Canton Foundry & Machine Co., Canton, O.
Cleveland Mch. & Mfg. Co., 4944 Hamilton Ave., Cleveland, O.
Ferracute Mch. Co., Bridgeton, N. J.
Mitts & Merrill, 843 Water St., Saginaw, Mich.
Niagara Mch. & Tool Works, Buffalo, N. Y.
Niles-Bement-Pond Co., 111 Broadway, New York.
Royersford Fdry. & Mch. Co., 54 N. 5th St., Philadelphia, Pa.
Roux & Heyberger, 108 Rue Lafayette, Paris, France.
Toledo Mch. & Tool Co., Toledo, O.
Tucker, W. M. & C. F., Hartford, Conn.
Union Mfg. Co., New Britain, Conn.
Watson-Stillman Co., 192 Fulton St., New York.
Williams, White & Co., Moline, Ill.

Pyrometers
Bristol Co., Waterbury, Conn.
Brown Instrument Co., Philadelphia, Pa.
Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich.
Shore Instrument & Mfg. Co., Inc., 557 W. 22nd St., New York.
Wilson-Maeulen Co., Inc., 783 E. 142d St., New York.

Rack Cutting Machines and Attachments
Adams Co., Dubuque, Iowa.
Bickett Mch. & Mfg. Co., Cincinnati, O.
Gould & Eberhardt, Newark, N. J.
LeBlond Mch. Tool Co., R. K., Cincinnati, O.

Racks, Cut
Brown & Sharpe Mfg. Co., Providence, R. I.
Fawcus Mch. Co., Pittsburgh, Pa.
Fellows Gear Shaper Co., Springfield, Vt.
Horsburgh & Scott Co., Cleveland, O.
Meisel Press Mfg. Co., 948 Dorchester Ave., Boston, Mass.
Newark Gear Cutting Mch. Co., Newark, N. J.
Nuttall Co., R. D., Pittsburgh, Pa.
Philadelphia Gear Works, Vine and 11th Sts., Philadelphia, Pa.
Simonds Mfg. Co., Pittsburgh, Pa.
Stahl Gear & Mch. Co., Cleveland, O.
Standard Gauge Steel Co., Beaver Falls, Pa.

Racks, Tool
New Britain Machine Co., New Britain, Conn.
Western Tool & Mfg. Co., Springfield, O.

Radiators, Japanning Oven
American Gas Furnace Co., 24 John St., New York.

Reamers
Advance Tool Co., Cincinnati, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Brubaker & Bros., W. L., Millersburg, Pa.
Butterfield & Co., Derby Lane, Vt.
Card Mfg. Co., S. W., Mansfield, Mass.
Carpenter Tap & Die Co., J. M., Pawtucket, R. I.
Clark Equipment Co., Buchanan, Mich.
Cleveland Twist Drill Co., Cleveland, O.
Detroit Twist Drill Co., Detroit, Mich.
Greenfield Tap & Die Corp., Greenfield, Mass.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Kelly Reamer Co., Cleveland, O.
McCrosky Reamer Co., Meadville, Pa.
Morse Twist Drill & Machine Co., New Bedford, Mass.
National Twist Drill & Tool Co., Detroit, Mich.
Pratt & Whitney Co., Hartford, Conn.
Reiff & Nestor, Lykens, Pa.
Rogers Works, Inc., J. M., Gloucester City, N. J.
Schellenbach-Hunt Tool Co., Cincinnati, O.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., 1000 West 120th St., Chicago, Ill.

Reamers, Adjustable
Advance Tool Co., Cincinnati, O.
Cleveland Twist Drill Co., Cleveland, O.
Detroit Twist Drill Co., Detroit, Mich.
Gisholt Mch. Co., Madison, Wis.
Kelly Reamer Co., Cleveland, O.
McCrosky Reamer Co., Meadville, Pa.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Inc., J. M., Gloucester City, N. J.
Schellenbach-Hunt Tool Co., Cincinnati, O.

Reamers, Portable Electric
Cincinnati Elec. Tool Co., Cincinnati, O.
Standard Electric Tool Co., Cincinnati, O.
Van Dorn Electric Tool Co., Cleveland, O.

Recorders, Time
Gisholt Mch. Co., Madison, Wis.

Recording Instruments for Pressure, Temperature, Electricity, Speed and Time
Bristol Co., Waterbury, Conn.
Brown Instrument Co., Philadelphia, Pa.
General Electric Co., Schenectady, N. Y.
Gisholt Mch. Co., Madison, Wis.
Hoskins Mfg Co., 450 Lawton Ave., Detroit, Mich.

Re-Cutting Milling Cutters, Reamers, Saws, Etc.
Detroit Reamer Salvage Co., Detroit, Mich.
Sutherland Tool Co., Flint, Mich.

Relieving Machines
Cleveland Milling Machine Co., Cleveland, O.

Rheostats
General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Rifle Barrel Machinery
Baush Mch. Tool Co., 200 Wason Ave., Springfield, Mass.
Diamond Mch. Co., Providence, R. I.
Pratt & Whitney Co., Hartford, Conn.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Sloan & Chace Mfg. Co., Ltd, Newark, N. J.

Rings, Weldless
Dyson & Sons, Joseph, Cleveland, O.
Johnston & Jennings Co., Addison Road and Lake Shore R. R. Tracks, Cleveland, O.
Machinery Forging Co., Cleveland, O.

Riveters, Hydraulic
Chambersburg Engineering Co., Chambersburg, Pa.
Hanna Eng. Works, 1763 Elston Ave., Chicago, Ill.
Niles-Bement-Pond Co., 111 Broadway, New York.

Riveters, Pneumatic
Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill.
Hanna Eng. Works, 1763 Elston Ave., Chicago, Ill.
Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York.

Riveters, Steam
Hanna Eng. Works, 1763 Elston Ave., Chicago, Ill.

Riveting Machines
Bilton Mch. Tool Co., Bridgeport, Conn.
Blomquist-Eck Mch. Co., Cleveland, O.
Buffalo Forge Co., Buffalo, N. Y.
Grant Mfg. & Mch. Co., N. W. Station, Bridgeport, Conn.
Hanna Eng. Works, 1763 Elston Ave., Chicago, Ill.
High-Speed Hammer Co., Rochester, N. Y.
Niles-Bement-Pond Co., 111 Broadway, New York.
Shuster Co., F. B., New Haven, Conn.

Rivets, Standard and Special
Metal Specialty Mfg. Co., Waterbury, Conn.

Rolling Machines, Tapered Forging
Ajax Mfg. Co., Cleveland O.
Williams, White & Co., Moline, Ill.

Rolling Mill Machinery
Ajax Mfg. Co., Cleveland, O.
Blake & Johnson Co., Waterbury, Conn.
Cleveland Mch. & Mfg. Co., 4944 Hamilton Av., Cleveland, O.
Fawcus Machine Co., Pittsburgh, Pa.

Rope Dressing and Preservative
Cling-Surface Co., 1018 Niagara St., Buffalo, N. Y.
Link-Belt Company, Chicago, Ill.

Rope Drives
Link-Belt Company, Chicago, Ill.

Rules, Steel
Brown & Sharpe Mfg. Co., Providence, R. I.
Goodell-Pratt Co., Greenfield, Mass.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Keuffel & Esser Co., Hoboken, N. J.
Starrett Co., L. S., Athol, Mass.

Rust Preventives
Coats Mch. Tool Co., Inc., 30 Church St., New York.
Oakley Chemical Co., 26 Thames St., New York.

Safety Devices, Press, Lathe, Shaper, Etc.
Safety Engineering Co., Cleveland, O.

Sand Blast Equipment
Curtis Pneumatic Mchy. Co., 1568 Kienlen Ave., St. Louis, Mo.
Leiman Bros., 62 E. John St., New York.
Link-Belt Company, Chicago, Ill.

Saw Blades
Atkins & Co., Inc., E. C., Indianapolis, Ind.
Blum & Co., Julius, 510 W. 24th St., New York.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Disston & Sons, Inc., Henry, Philadelphia, Pa.
Goodell-Pratt Co., Greenfield, Mass.
Hammacher, Schlemmer & Co., 4th Av. and 13th St., New York.
Huther Bros. Saw Mfg. Co. 1108 University Ave., Rochester, N. Y.
Massachusetts Saw Works, Springfield, Mass.
Millers Falls Co., Millers Falls, Mass.
Montgomery & Co., Inc., 104 Fulton St., New York.
Napier Saw Works, Inc., Springfield, Mass.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Reliance Steel & Tool Co., Inc., 30 Church St., New York.
Simonds Mfg. Co., Fitchburg, Mass.
Starrett Co., L. S., Athol, Mass.
Thompson & Son Co., Henry G., New Haven, Conn.
West Haven Mfg. Co., New Haven, Conn.

Saw Frames, Hack
Atkins Co., Inc., E. C., Indianapolis, Ind.
Disston & Sons, Inc., Henry, Philadelphia, Pa.
Goodell-Pratt Co., Greenfield, Mass.
Hammacher, Schlemmer & Co., 4th Av. and 13th St., New York.
Massachusetts Saw Works, Springfield, Mass.
Millers Falls Co., Millers Falls, Mass.
Montgomery & Co., Inc., 104 Fulton St., New York.
Napier Saw Works, Inc., Springfield, Mass.
Simonds Mfg. Co., Fitchburg, Mass.
Starrett Co., L. S., Athol, Mass.
Thompson & Son Co., Henry G., New Haven, Conn.
Union Tool Co., Orange, Mass.
West Haven Mfg. Co., New Haven, Conn.

Saw Guards, Circular
Atkins & Co., Inc., E. C., Indianapolis, Ind.

Sawing Machines, Wood
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Crescent Mch. Co., 50 Main St., Leetonia, O.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.

Saws, Circular
Atkins & Co., Inc., E. C., Indianapolis, Ind.
Crescent Mch. Co., 50 Main St., Leetonia, O.
Disston & Sons, Inc., Henry, Philadelphia, Pa.
Huther Bros. Saw Mfg. Co., 1108 University Ave., Rochester, N. Y.
Napier Saw Works, Inc., Springfield, Mass.
Simonds Mfg. Co., Fitchburg, Mass.

Saws, Metal Band
Atkins & Co., Inc., E. C., Indianapolis, Ind.
Disston & Sons, Inc., Henry, Philadelphia, Pa.
Huther Bros. Saw Mfg. Co., 1108 University Ave., Rochester, N. Y.
Napier Saw Works, Inc., Springfield, Mass.
Thompson & Son Co., Henry G., New Haven, Conn.
West Haven Mfg. Co., New Haven, Conn.

Saws, Metal Band Machines
Armstrong-Blum Mfg. Co., 343 N. Francisco Ave., Chicago, Ill.
Racine Tool & Machine Co., Racine, Wis.
Thompson & Son Co., Henry G., New Haven, Conn.

Saws, Power Hack Machines
Armstrong-Blum Mfg. Co., 343 N. Francisco Ave., Chicago, Ill.
Atkins & Co., Inc., E. C., Indianapolis, Ind.
Coats Mch. Tool Co., Inc., 30 Church St., New York.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Goodell-Pratt Co., Greenfield, Mass.
Massachusetts Saw Works, Inc., Springfield, Mass.
Millers Falls Co., Millers Falls, Mass.
Napier Saw Works, Inc., Springfield, Mass.
Peerless Machine Co., Racine, Wis.
Racine Tool & Machine Co., Racine, Wis.
Thompson & Son Co., Henry G., New Haven, Conn.
Western Tool & Mfg. Co., Springfield, O.
West Haven Mfg. Co., New Haven, Conn.

Saws, Rotary Machines
Billings & Spencer Co., Hartford, Conn.
Burr & Son, John T., 429 Kent Ave., Brooklyn, N. Y.
Cochrane-Bly Co., Rochester, N. Y.
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.
Espen-Lucas Machine Works, Philadelphia, Pa.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Nutter & Barnes Co., Hinsdale, N. H.
Vandyck Churchill Co., 14 Broadway, New York.

Saw Sharpening Machines
Cochrane-Bly Co., Rochester, N. Y.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Nutter & Barnes Co., New Haven, Conn.

Saw Tables
Baker Bros., Toledo, O.
Crescent Mch. Co., 56 Main St., Leetonia, O.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.

Scales, Weighing
National Scale Co., Chicopee Falls, Mass.

Scraping Tables
New Britain Mch. Co., New Britain, Conn.

Screw Cutting Tools
See Taps and Dies.

Screw Driving Machines
Reynolds Pattern & Mch. Co., Massillon, O.

Screw Machines, Automatic
Brown & Sharpe Mfg. Co., Providence, R. I.
Chicago Automatic Mch. Co., Chicago, Ill.
Cincinnati Automatic Mch. Co., Oakley, Cincinnati, O.
Cleveland Automatic Mch. Co., Cleveland, O.
Fitchburg Automatic Mch. Works, Fitchburg, Mass.
Macnab Mchy. Co., John, 90 West St., New York.
National Acme Co., Cleveland, O.
New Britain Mch. Co., New Britain, Conn.
Pratt & Whitney Co., Hartford, Conn.

Screw Machines, Hand
See Lathes, Turret.
Acme Mch. Tool Co., Cincinnati, O.
Bardons & Oliver, Cleveland, O.
Biggs-Watterson Co., Cleveland, O.
Brown & Sharpe Mfg. Co., Providenc, R. I.
Dreses Machine Tool Co., Cincinnati, O.
Foster Machine Co., Elkhart, Ind.
Garvin Mch. Co., Spring and Varick Sts., New York.
Himoff Mch. Co., 45 Mills St., Astoria, N. Y.
Jones & Lamson Mch. Co., Springfield, Vt.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Pierce Mch. Tool Co., 617 W. Jackson Blvd., Chicago, Ill.
Potter & Johnston Mch. Co., Pawtucket, R. I.
Pratt & Whitney Co., Hartford, Conn.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Universal Mchy. Co., Milwaukee, Wis.
Warner & Swasey Co., Cleveland, O.
Wells & Son Co., F. E., Greenfield, Mass.
Wood Turret Mch. Co., Brazil, Ind.

Screw Machines, Multiple Spindle
Cincinnati Automatic Mch. Co., Oakley, Cincinnati, O.
Fitchburg Automatic Mch. Works, Fitchburg, Mass.
National Acme Co., Cleveland, O.
New Britain Mch. Co., New Britain, Conn.

Screw Machine Tools and Equipment
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Chicago Automatic Mch. Co., Chicago, Ill.
Cincinnati Automatic Mch. Co., Oakley, Cincinnati, O.
Cleveland Automatic Mch. Co., Cleveland, O.
Foster Mch. Co., Elkhart, Ind.
Garvin Mch. Co., Spring and Varick Sts., New York.
Harris Engineering Co., H. E., Bridgeport, Conn.
Himoff Mch. Co., 45 Mills St., Astoria, N. Y.
Jones & Lamson Mch. Co., Springfield, Vt.
Macnab Mchy. Co., John, 90 West St., New York.
National Acme Co., Cleveland, O.
New Britain Mch. Co., New Britain, Conn.
Oliver Machinery Co., 7 Coldbrook St., Grand Rapids, Mich.
Pierce Mch. Tool Co., 617 W. Jackson Blvd., Chicago, Ill.
Potter & Johnston Mch. Co., Pawtucket, R. I.
Pratt & Whitney Co., Hartford, Conn.
Warner & Swasey Co., Cleveland, O.
Wells & Son Co., F. E., Greenfield, Mass.
Wood Turret Mch. Co., Brazil, Ind.

Screw Machine Work
Albaugh-Dover Co., 2100 Marshall Blvd., Chicago, Ill.
Blum & Co., Julius, 510 W. 24th St., New York.
Brown Engineering Co., 133 N. 3d St., Reading, Pa.
Cincinnati Screw Co., Cincinnati, O.
Interstate Mch. Products Co., Inc., Rochester, N. Y.
Meisel Press Mfg. Co., 948 Dorchester Ave., Boston, Mass.
National Acme Co., Cleveland, O.
Ohmer Fare Register Co., Dayton, O.
Toledo Screw Products Co., Toledo, O.

Screw Plates
Bay State Tap & Die Co., Mansfield, Mass.
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Brubaker & Bros., W. L., Millersburg, Pa.
Butterfield & Co., Derby Line, Vt.
Card Mfg. Co., S. W., Mansfield, Mass.
Carpenter Tap & Die Co., J. M., Pawtucket, R. I.
Greenfield Tap & Die Corp., Greenfield, Mass.
Hart Mfg. Co., E. 20th St. and Marion Ave., Cleveland, O.
Morse Twist Drill & Mch. Co., New Bedford, Mass.
Hjorth Lathe & Tool Co., Boston, Mass.
Wells & Son Co., F. E., Greenfield, Mass.

Screws, Cap and Set
Allen Mfg. Co., Hartford, Conn.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
National Acme Co., Cleveland, O.
Toledo Screw Products Co., Toledo, O.

Screws, Machine
Allen Mfg. Co., Hartford, Conn.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
National Acme Co., Cleveland, O.
Toledo Screw Products Co., Toledo, O.

Screws, Special Lead, Feed, Etc.
Automatic Mch. Co., Bridgeport, Conn.

Second-hand Machinery, Etc.
Biggs-Watterson Co., Cleveland, O.
Brownell Machinery Co., Providence, R. I.
Cincinnati Planer Co., Cincinnati, O.
Davis Mch. Tool Co., Inc., Rochester, N. Y.
Davis Mch. Tool Co., W. F., 32 N. Clinton St., Chicago, Ill.
Essley Mchy. Co., E. L., Chicago, Ill.
Federal Mchy. Sales Co., 14 N. Jefferson St., Chicago, Ill.
Frasse & Co., Inc., Peter A., 417 Canal St., New York.
Gair Co., Robert, 50 Washington St., Brooklyn, N. Y.
Goodyear Tire & Rubber Co., Akron, O.
Gurney Elevator Co., 62 W. 45th St., New York.
Heppenstall Forge & Knife Co., Pittsburgh, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Hill, Clarke & Co., of Chicago, 625 Washington Blvd., Chicago, Ill.
Hudson Motor Car Co., Detroit, Mich.
Marshall & Huschart Mchy. Co., 17 S. Jefferson St., Chicago, Ill.
McDonough Mfg. Co., Eau Claire, Wis.
McShane Bell Foundry Co., Baltimore, Md.
Motch & Merryweather Mchy. Co., Cleveland, O.
New Jersey Mchy. Exchange, Newark, N. J.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Patterson Tool & Supply Co., Dayton, O.
Prentiss & Co., Inc., Henry, 149 Broadway, New York.
Puffer Mfg. Co., Winchester, Mass.
Riverside Machinery Depot, Detroit, Mich.
Simmons Mch. Co., 1001 Singer Bldg., New York.
Standard Metal Mfg. Co., Newark, N. J.
Strong, Homer, Rochester, N. Y.
Union Switch & Signal Co., Swissvale, Pa.
Vandyck Churchill Co., 149 Broadway, New York.
Walsh Mchy. Co., M. J., Milwaukee, Wis.
Worthington Pump & Mchy. Corp., 115 Broadway, New York.
Young, Corley & Dolan, Inc., 115 Broadway, New York.

Separators, Oil and Steam
Nickolson & Co., W. H., 112 Oregon St., Wilkes-Barre, Pa.

Set Screws, Safety
Allen Mfg. Co., Hartford, Conn.
Bristol Co., Waterbury, Conn.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Standard Pressed Steel Co., Philadelphia, Pa.

Shafting, Steel
Blum & Co., Julius, 510 W. 24th St., New York.
Brown Co., A. & F., 79 Barclay St., New York.
Cresson-Morris Co., Philadelphia, Pa.
Standard Pressed Steel Co., Philadelphia, Pa.

Shapers
American Tool Works Co., Cincinnati, O.
Cincinnati Shaper Co., Cincinnati, O.
Cochrane-Bly Co., Rochester, N. Y.
Davis Mch. Tool Co., Inc., Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Hendey Mch. Tool Co., Torrington, Conn.
Kelly Co., R. A., Xenia, O.
Morton Mfg. Co., Muskegon Heights, Mich.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Ohio Machine Tool Co., Kenton, O.
Potter & Johnston Mch. Co., Pawtucket, R. I.
Smith & Mills Co., Cincinnati, O.
Springfield Mch. Tool Co., 631 Southern Ave., Springfield, O.
Steptoe Co., John, Cincinnati, O.

Shapers, Vertical
Ingersoll-Rand Co., 11 Broadway, New York.
Pratt & Whitney Co., Hartford, Conn.

Shears, Rotary
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Niagara Mch. & Tool Works, Buffalo, N. Y.
Toledo Mch. & Tool Co., Toledo, O.

Shears, Squaring
Erie Foundry Co., Erie, Pa.

Sheet Metal Work
Littleford Bros., Cincinnati, O.

Sheet Metal Working Machinery, (See Presses)
Savage Co., Inc., W. J., Knoxville, Tenn.

Shell Making Machinery
Thurlow-Steel Works, Inc., Philadelphia, Pa.

Slide Rests
National Acme Co., Cleveland, O.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.

Slotters, Machine
Baker Bros., Toledo, O.
Dill Mch. Co., T. C., Philadelphia, Pa.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Niles-Bement-Pond Co., 111 Broadway, New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Slotters, Portable
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.

Sockets, Sleeves, Collets, Etc.
Billings & Spencer Co., Hartford, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Frasse & Co., Peter A., 417 Canal St., New York.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Montgomery & Co., Inc., 104 Fulton St., New York.
Morse Twist Drill & Machine Co., New Bedford, Mass.
National Twist Drill & Tool Co., Detroit, Mich.
Pratt & Whitney Co., Hartford, Conn.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Whitman & Barnes Mfg. Co., 1000 W. 120th St., Chicago, Ill.

Special Machinery and Tools
American Mch. & Foundry Co., 5520 2nd Ave., Brooklyn, N. Y.
Automatic Mch. Co., Bridgeport, Conn.
Automat Tool Works, 252 Greenwich St., New York.
Baird Mch. Co., Bridgeport, Conn.
Beaman & Smith Co., Providence, R. I.
Bilgram Mch. Works, 1231 Spring Garden St., Philadelphia, Pa.
Blake & Johnson Co., Waterbury, Conn.
Blanchard Machine Co., 64 State St., Cambridge, Mass.
Bliss Co., E. W., 5 Adams St., Brooklyn, N. Y.
Brown Co., A. & F., 79 Barclay St., New York.
Buffalo Foundry & Mch. Co. 10 Winchester Ave., Buffalo, N. Y.
Carroll Engineering Co., Dayton, O.
Columbus Die, Tool & Machine Co., Columbus, O.
Earle Gear & Mch. Co., 4705 Stenton Ave., Philadelphia, Pa.
Fawcus Machine Co., Pittsburgh, Pa.
Gardam & Sons, Inc., Wm., 108 Park Place, New York.
Garvin Mch. Co., Spring and Varick Sts., New York.
Gisholt Mch. Co., Madison, Wis.
Grant Mfg. & Mch. Co., N. W. Station, Bridgeport, Conn.
Hanna Engineering Works, 1763 Elston Ave., Chicago, Ill.
Hannifin Mfg. Co., Chicago, Ill.
Harris Engineering Co., H. E., Bridgeport, Conn.
Hetherington-McCabe Co., Piqua, O.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Horton & Sons Co., E., Windsor Locks, Conn.
Ingle Machine Co., Rochester, N. Y.
Krasberg Mfg. Co., 412 Orleans St., Chicago, Ill.
Langelier Mfg. Co., Providence, R. I.
Lucas Machine Tool Co., Cleveland, O.
Mehl Mch. Tool & Die Co., Roselle, N. J.
Meisel Press Mfg. Co., 948 Dorchester Ave., Boston, Mass.
Meisselbach-Catucci Mfg. Co., 27 Congress St., Newark, N. J.
Middlesex Mch. Works, Middletown, Conn.
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Mueller Mch. Tool Co., Cincinnati, O.
National Automatic Tool Co., Richmond, Ind.
National Machinery Co., Tiffin, O.
National Tool Co., Cleveland, O.
National Twist Drill & Tool Co., Detroit, Mich.
Nelson Tool Co., Inc., 781-783 E. 142nd St., New York.
New Britain Mch. Co., New Britain, Conn.
Newman Mfg. Co., Cincinnati, O.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
North Side Tool Works, Dayton, O.
Ohmer Fare Register Co., Dayton, O.
Pratt & Whitney Co., Hartford, Conn.
Reed-Prentice Co., F. E. Reed Dept. and Prentice Bros. Dept., Worcester, Mass.
Reliance Steel & Tool Co., Inc., 30 Church St., New York.
Shuster Co., F. B., New Haven, Conn.
Simonds Mfg. Co., Pittsburgh, Pa.
Slocum, Avram & Slocum Laboratories, Inc., 531 W. 21st St., New York.
S-P Mfg. Co., Cleveland, O.
Standard Engineering Co., Ellwood City, Pa.
Steel Products Engineering Co., Springfield, O.
Steiner Bros., Lima, O.
Swedish Gage Co., Inc., 16 W. 61st St., New York.
Taft-Peirce Mfg. Co., Woonsocket, R. I.
Taylor & Fenn Co., Hartford, Conn.
Taylor-Shantz Co., Rochester, N. Y.
T. C. M. Mfg. Co., Harrison, N. J.
Toledo Mch. & Tool Co., Toledo, O.
Treadwell Engineering Co., Easton, Pa.
Ulmer Co., J. C., Cleveland, O.
Windau Tool Co., Cleveland, O.

Speed Changing Devices
Moore & White Co., 2707-2737 N. 15th St., Philadelphia, Pa.

Spring Coiling and Forming Machinery
Baird Machine Co., Bridgeport, Conn.

Springs
Barnes Co., Wallace, South and Parallel Sts., Bristol, Conn.
Blum & Co., Julius, 510 W. 24th St., New York.
Kokomo Spring Co., Kokomo, Ind.

Sprocket Chains
Baldwin Chain & Mfg. Co., Worcester, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Caldwell & Son Co., H. W., 17th St. and Western Ave., Chicago, Ill.
Cullman Wheel Co., 1339 Altgeld St., Chicago, Ill.
Diamond Chain & Mfg. Co., 240 W. Georgia St., Indianapolis, Ind.
Link-Belt Company, Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.
Philadelphia Gear Works, Vine and 11th Sts., Philadelphia, Pa.
Union Chain & Mfg. Co., Seville, O.
Whitney Mfg. Co., Hartford, Conn.
Woburn Gear Works, Woburn, Mass.

Sprockets
Boston Gear Works, Norfolk Downs, Mass.
Cullman Wheel Co., 1339 Altgeld St., Chicago, Ill.
Link-Belt Co., Chicago, Ill.
Meisel Press Mfg. Co., 948 Dorchester Ave., Boston, Mass.
Philadelphia Gear Works, Vine and 11th Sts., Philadelphia, Pa.
Woburn Gear Works, Woburn, Mass.

Squaring Machines
Bickford Machine Co., Greenfield, Mass.
Erie Foundry Co., Erie, Pa.

Stampings, Sheet Metal
Acklin Stamping Co., 1657 Dorr St., Toledo, O.
American Tool & Mfg. Co., Urbana, O.
Blum & Co., Julius, 510 W. 24th St., New York.
Fox Gun Co., A. H., Philadelphia, Pa.
Globe Mch. & Stamping Co., Cleveland, O.
Lansing Stamping & Tool Co., Lansing, Mich.
Rockford Metal Specialty Co., Rockford, Ill.
Solar Metal Products Co., Inc., Columbus, O.

Stamps, Letters and Figures, Steel
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Matthews & Co., Jas. H., 3916 Forbes Field, Pittsburgh, Pa.
Newman Mfg. Co., Cincinnati, O.
Noble & Westbrook Mfg. Co., Hartford, Conn.
Pannier Bros. Stamp Co., Inc., Pittsburgh, Pa.
Schwerdtle Stamp Co., Bridgeport, Conn.

Steam Specialties
National Tube Co., Pittsburgh, Pa.
Reliance Gauge Column Co., 6008 Carnegie Ave., Cleveland, O.

Steel
Apex Steel Corporation, 50 Church St., New York.
Bethlehem Steel Co., South Bethlehem, Pa.
Blum & Co., Julius, 510 W. 24th St., New York.
Boker & Co., Inc., H., 101 Duane St., New York.
Camden Forge Co. Camden, N. J.
Colonial Steel Co., Pittsburgh, Pa.
Firth-Sterling Steel Co., McKeesport, Pa.
Frasse & Co., Inc., Peter A., 417 Canal St., New York.
Halcomb Steel Co., Syracuse, N. Y.
Hawkridge Bros. Co., Boston, Mass.
Heller Bros. Co., Newark, N. J.
Jessop & Sons, Inc., Wm., 91 John St., New York.
Johnston & Jennings Co., Addison Road and Lake Shore R. R. Tracks, Cleveland, O.
Latrobe Electric Steel Co., Latrobe, Pa.
Standard Alloys Co., Pittsburgh, Pa.
Vanadium-Alloys Steel Co., Pittsburgh, Pa.
Vulcan Crucible Steel Co., Aliquippa, Pa.

Steel, Cold Rolled Strip, Sheet and Wire
Driver-Harris Co., Harrison, N. J.

Steel, High Speed, Tool
Apex Steel Corporation, 50 Church St., New York.
Bethlehem Steel Co., South Bethlehem, Pa.
Blum & Co., Julius, 510 W. 24th St., New York.
Boker & Co., Inc., H., 101 Duane St., New York.
Colonial Steel Co., Pittsburgh, Pa.
Firth-Sterling Steel Co., McKeesport, Pa.
Frasse & Co., Inc., Peter A., 417 Canal St., New York.
Halcomb Steel Co., Syracuse, N. Y.
Hawkridge Bros. Co., Boston, Mass.
Haynes Stellite Co., Kokomo, Ind.
Heller Bros. Co., Newark, N. J.
Jessop & Sons, Inc., Wm., 91 John St., New York.
Latrobe Electric Steel Co., Latrobe, Pa.
Onondaga Steel Co., Inc., Syracuse, N. Y.
Reliance Steel & Tool Co., Inc., 30 Church St., New York.
Standard Alloys Co., Pittsburgh, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.
Vanadium-Alloys Steel Co., Pittsburgh, Pa.
Vulcan Crucible Steel Co., Aliquippa, Pa.

Steel, Machine
Apex Steel Corporation, 50 Church St., New York.
Bethlehm Steel Co., South Bethlehem, Pa.
Blum & Co., Julius, 510 W. 24th St., New York.
Boker & Co., Inc., H., 101 Duane St., New York.
Camden Forge Co., Camden, N. Y.
Colonial Steel Co., Pittsburgh, Pa.
Firth-Sterling Steel Co., McKeesport, Pa.
Halcomb Steel Co., Syracuse, N. Y.
Hawkridge Bros. Co., Boston, Mass.
Jessop & Sons, Inc., Wm., 91 John St., New York.
Latrobe Electric Steel Co., Latrobe, Pa.
Standard Alloys Co., Pittsburgh, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.
Standard Alloys Co., Pittsburgh, Pa.
Vanadium-Alloys Steel Co., Pittsburgh, Pa.
Vulcan Crucible Steel Co., Aliquippa, Pa.

Steel Shelving, Racks, Barrels, Tables, Etc.
Manufacturing Equipment & Eng. Co., Framingham, Mass.
National Scale Co., Chicopee Falls, Mass.
New Britain Mch. Co., New Britain, Conn.

Stellite
Haynes Stellite Co., Kokomo, Ind.

Stocks, Die
See Taps and Dies.

Stones, Oil
American Emery Wheel Works, Providence, R. I.
Carborundum Co., Niagara Falls, N. Y.
Norton Co., Worcester, Mass.
Vitrified Wheel Co., Westfield, Mass.

Stools, Steel
See Furniture, Shop and Drafting-room.

Straightening Machinery
Morse Twist Drill & Machine Co., New Bedford, Mass.
Niles-Bement-Pond Co., 111 Broadway, New York.
Shuster Co., F. B., New Haven, Conn.

Stud Setters, Opening
Errington Mechanical Laboratory, 39 Cortlandt St., New York.

Swaging Machines
Etna Machine Co., Toledo, O.
Excelsior Needle Co., Torrington, Conn.
Langelier Mfg. Co., Providence, R. I.

Switchboards
General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Switches
General Electric Co., Schenectady, N. Y.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Tachometers and Thermometers
Bristol Co., Waterbury, Conn.
Brown Instrument Co., Philadelphia, Pa.
Veeder Mfg. Co., 39 Sargeant St., Hartford, Conn.

Tapes, Measuring
Keuffel & Esser Co., Hoboken, N. J.
Starrett Co., L. S., Athol, Mass.
Ulmer Co., J. C., Cleveland, O.

Tapping Attachments and Devices
American Tool Works Co., Cincinnati, O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, 231 Ruby St., Rockford, Ill.
Beaman & Smith Co., Providence, R. I.
Bicknell-Thomas Co., Greenfield, Mass.
Cincinnati Bickford Tool Co., Oakley, Cincinnati, O.
Errington Mechanical Laboratory, 39 Cortlandt St., New York.
Geometric Tool Co., New Haven, Conn.
Hammond Mfg. Co., Cleveland, O.
Leland-Gifford Co., Worcester, Mass.
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Newman Mfg. Co., Cincinnati, O.
Peter Bros. Mfg. Co., 135 Railroad Ave., Algonquin, Ill.
Procunier, Wm. L., 549 Washington Blvd., Chicago, Ill.
Quint, A. E., Hartford, Conn.
Wells & Son Co., F. E., Greenfield, Mass.
Whitney Mfg. Co., Hartford, Conn.

Tapping Machines
Acme Mchy. Co., Cleveland, O.
Baker Bros., Toledo, O.
Fulton Foundry & Mch. Co., Brooklyn, N. Y.
Garvin Mch. Co., Spring and Varick Sts., New York.
Geometric Tool Co., New Haven, Conn.
Hammond Mfg. Co., Cleveland, O.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Harris Engineering Co. H. E., Bridgeport, Conn.
Langelier Mfg. Co., Providence, R. I.
Moline Tool Co., Moline, Ill.
National Mchy. Co., Tiffin, O.
Peter Bros. Mfg. Co., 135 Railroad Ave., Algonquin, Ill.
Procunier, Wm. L., 549 Washington Blvd., Chicago, Ill.
Rockford Drilling Mch. Co., Rockford, Ill.
Saunders' Sons, D., Yonkers, N. Y.

Taps and Dies
Bay State Tap & Die Co., Mansfield, Mass.
Besly & Co., Chas. H., 120-B N. Clinton St., Chicago, Ill.
Brubaker & Bros., W. L., Millersburg, Pa.
Butterfield & Co., Derby Line, Vt.
Card Mfg. Co., S. W., Mansfield, Mass.
Carpenter Tap & Die Co., J. M., Pawtucket, R. I.
Errington Mechanical Laboratory, 39 Cortlandt St., New York.
Geometric Tool Co., New Haven, Conn.
Greenfield Tap & Die Corp., Greenfield, Mass.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Hardinge Bros., Inc., Berteau and Ravenswood Aves., Chicago, Ill.
Harris Engineering Co., H. E., Bridgeport, Conn.
Hart Mfg. Co., E. 20th St. and Marion Ave., Cleveland, O.
Hjorth Lathe & Tool Co., Boston, Mass.
Morse Twist Drill & Machine Co., New Bedford, Mass.
National Acme Co., Cleveland, O.
Nicholson & Co., W. H., 112 Oregon St., Wilkes-Barre, Pa.
Pratt & Whitney Co., Hartford, Conn.
Reed Mfg. Co., Erie, Pa.
Reiff & Nestor, Lykens, Pa.
Reliance Steel & Tool Co., Inc., 30 Church St., New York.
Rogers Works, Inc., J. M., Gloucester City, N. J.
Saunders' Sons, D., Yonkers, N. Y.
Standard Tool Co. Cleveland, O.
Walworth Mfg. Co., Boston, Mass.
Wells & Son Co., F. E., Greenfield, Mass.

Taps, Collapsing
Errington Mechanical Laboratory, 39 Cortlandt St., New York.
Geometric Tool Co., New Haven, Conn.
Manufacturers' Equipment Co., 175 N. Jefferson St., Chicago, Ill.
Modern Tool Co., 2nd and State Sts., Erie, Pa.
Murchey Mch. & Tool Co., 34 Porter St., Detroit, Mich.
Victor Tool Co., Waynesboro, Pa.

Testing Outfits, Hydraulic
Metalwood Mfg. Co., Detroit, Mich.

Thread Cutting Machinery
Automatic Machine Co., Bridgeport, Conn.
Bickford Machine Co., Greenfield, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Geometric Tool Co., New Haven, Conn.
Greenfield Tap & Die Corp., Greenfield, Mass.
Lees-Bradner Co., Cleveland, O.
National Mchy. Co., Tiffin, O.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.
Wells & Son Co., F. E., Greenfield, Mass.

Thread Cutting Machines, Semi-automatic
Chicago Automatic Mch. Co., Chicago, Ill.
Macnab Mchy. Co., John, 90 West St., New York.
Newton Mch. Tool Works, Inc., 23rd and Vine Sts. Philadelphia, Pa.

Thread Cutting Tools
Rivett Lathe & Grinder Co., Brighton, Boston, Mass.

Thread Milling Machines
Bickford Mch. Co., Greenfield, Mass.
Biggs-Watterson Co., Cleveland, O.
Gisholt Mch. Co., Madison, Wis.
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Lees-Bradner Co., Cleveland, O.
Newton Mch. Tool Works, Inc., 23d and Vine Sts., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Smalley-General Co., Bay City, Mich.
Taft-Peirce Mfg. Co., Woonsocket, R. I.
T. C. M. Mfg. Co., Harrison, N. J.
Waltham Mch. Works, Waltham, Mass.

Thread Rolling Machines
Acme Mchy. Co., Cleveland, O.
Blake & Johnson Co., Waterbury, Conn.
National Mchy. Co., Tiffin, O.

Time Recorders, Workmen's Time on the Job
Gisholt Mch. Co., Madison, Wis.

Tire Welders and Benders
Williams, White & Co., Moline, Ill.

Tool Cases
Gerstner & Sons, H., Dayton, O.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
Starrett Co., L. S., Athol, Mass.
Union Tool Chest Works, 10 Railroad St., Rochester, N. Y.
Wedell & Boers, Detroit, Mich.

Tool Holders
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Gisholt Mch. Co., Madison, Wis.
Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York.
O. K. Tool Holder Co., Shelton, Conn.
Osgood Tool Co., J. L., Buffalo, N. Y.
Ready Tool Co., Bridgeport, Conn.
Western Tool & Mfg. Co., Springfield, O.
Williams & Co., J. H., 61 Richards St., Brooklyn, N. Y.
Windau Tool Co., Cleveland, O.

Tool Salvage
Detroit Reamer Salvage Co., Detroit, Mich.

Tracing Cloth and Paper
Keuffel & Esser Co., Hoboken, N. J.

Tracing Filing Cabinets
See Cabinets, Filing.

Tracks, Trolley and Overhead
Harrington, Son & Co., Inc., Edwin, Philadelphia, Pa.
Northern Engineering Works, Detroit, Mich.
Yale & Towne Mfg. Co., 9 E. 40th St., New York.

Transformers
Eck Dynamo & Motor Co., Belleville, N. J.
General Electric Co., Schenectady, N. Y.
Reliance Elec. & Eng. Co., 1056 Ivanhoe Road, Cleveland, O.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Transmission Machinery
See Hangers, Shafting, Pulleys, Clutches, Couplings, Belting, Chain, etc.

Trolleys and Tramways
Box & Co., Alfred, Philadelphia, Pa.
Curtis Pneumatic Mchy. Co., 1568 Kienlen Ave., St. Louis, Mo.
Wright Mfg. Co., Lisbon, O.
Yale & Towne Mfg. Co., 9 E. 40th St., New York

Trucks
Barrett-Cravens Co., 750 Transportation Bldg., Chicago, Ill.
Chase Foundry & Mfg. Co., Columbus, O.
Greenfield Tap & Die Corp., Greenfield, Mass.
National Scale Co., Chicopee Falls, Mass.
Transmission Ball Bearing Co., Inc., Buffalo, N. Y.

Trucks, Elevating
Barrett-Cravens Co., 750 Transportation Bldg., Chicago, Ill.
Chase Foundry & Mfg. Co., Columbus, O.
National Scale Co., Chicopee Falls, Mass.
Stuebing Truck Co., Cincinnati, O.
Transmission Ball Bearing Co., Inc., Buffalo, N. Y.

Tube Expanders
Watson-Stillman Co., 192 Fulton St., New York.

Tubing, Flexible
Almond Mfg. Co., T. R., 2 Maple Ave., Ashburnham, Mass.
Wheelock Mfg. Co., Wheelock, Vermont.

Tubing, Seamless Steel
Blum & Co., Julius, 510 W. 24th St., New York.
Frasse & Co., Inc., Peter A., 417 Canal St., New York.
National Tube Co., Pittsburgh, Pa.
Roux & Heyberger, 108 Rue Lafayette, Paris, France.
Standard Parts Co., Cleveland O.

Tubing, Steel
Blum & Co., Julius, 510 W. 24th St., New York.
Frasse & Co., Inc., Peter A., 417 Canal St., New York.
National Tube Co. Pittsburgh, Pa.
Standard Parts Co., Cleveland, O.

Tubing, Welded Steel
Empire Art Metal Co., Inc., College Point, N. Y.
Roux & Heyberger, 108 Rue Lafayette, Paris, France.

Tumbling Barrels
Abbott Ball Co., Elmwood, Hartford, Conn.
Baird Mch. Co., Bridgeport, Conn.
Globe Mch. & Stamping Co., Cleveland, O.
Royersford Fdry. & Mch. Co., 54 N. 5th St., Philadelphia, Pa.

Turntables
Canton Foundry & Mch. Co., Canton, O.
Chase Fdry. & Mfg. Co., Columbus, O.
Link-Belt Company, Chicago, Ill.

Turret Attachments
Almond Mfg. Co., T. R., 2 Maple Ave., Ashburnham, Mass.
Meisselbach-Catucci Mfg. Co., 27 Congress St., Newark, N. J.
Newman Mfg. Co., Cincinnati, O.
Phoenix Mfg. Co., Eau Claire, Wis.
Pierce Mch. Tool Co., 617 W. Jackson Blvd., Chicago, Ill.
Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y.

Turret Lathes, Vertical
Bullard Mch. Tool Co., Bridgeport, Conn.
Pratt & Whitney Co., Hartford, Conn.

Twist Drills
See Drills, Twist.

Unions
Dart Mfg Co., E. M., Providence, R. I.
National Tube Co., Pittsburgh, Pa.

Universal Joints
Baush Mch. Tool Co., 200 Wason Ave., Springfield, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Gray & Prior Mch. Co., 38 Suffield St., Hartford, Conn.

Valve Leathers
Graton & Knight Mfg. Co., Worcester, Mass.

Valves
Elmes Eng. Works, Chas. F., 222 N. Morgan St., Chicago, Ill.
Hydraulic Press Mfg. Co., 81 Lincoln Ave., Mt. Gilead, O.
Metalwood Mfg. Co., Detroit, Mich.
National Tube Co., Pittsburgh, Pa.
Watson-Stillman Co., 192 Fulton St., New York.

Varnish
Glidden Varnish Co., Cleveland, O.

Ventilating Apparatus
Buffalo Forge Co., Buffalo, N. Y.

Vise Stands
New Britain Mch. Co., New Britain, Conn.
Western Tool & Mfg. Co., Springfield, O.

Vises, Bench
Athol Mch. Co., Athol, Mass.
Billings & Spencer Co., Hartford, Conn.
Goodell-Pratt Co., Greenfield, Mass.
New Britain Mch. Co., New Britain, Conn.
Prentiss Vise Co., 106 Lafayette St., New York.
Reed Mfg. Co., Erie, Pa.
Western Tool & Mfg. Co., Springfield, O.

Vises, Drill
Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill.
Brown Engineering Co., 133 No. 3d St., Reading, Pa.
Carter & Hakes Co., Sterling Place, Winsted, Conn.
Graham Mfg. Co., Providence, R. I.
Skinner Chuck Co., New Britain, Conn.

Vises, Milling
New Jersey Mchy. Exchange, Newark, N. J.

Vises, Pipe
Bignall & Keeler Mch. Works, Edwardsville, Ill.
Butterfield & Co., Derby Line, Vt.
Curtis & Curtis Co., 8 Garden St., Bridgeport, Conn.
Reed Mfg. Co., Erie, Pa.
Saunders' Sons, D., Yonkers, N. Y.
Walworth Mfg. Co., Boston, Mass.
Wells & Son Co., F. E., Greenfield, Mass.
Williams & Co., J. H., 61 Richards St., Brooklyn, N. Y.

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